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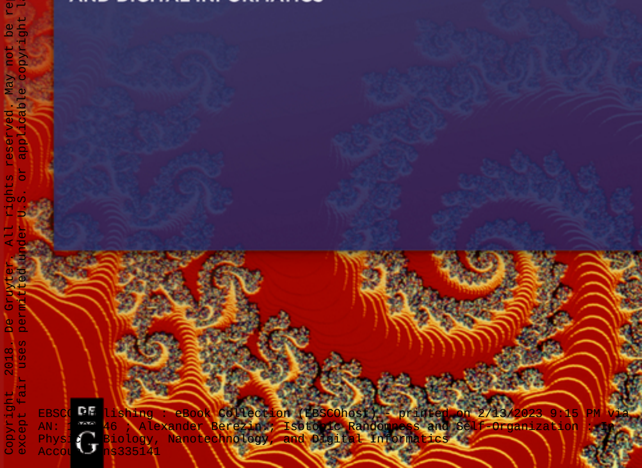
IN PHYSICS, BIOLOGY, NANOTECHNOLOGY, AND DIGITAL INFORMATICS



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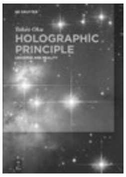

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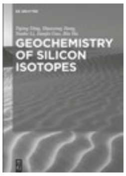

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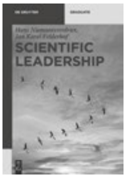

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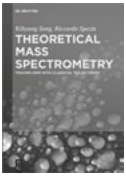

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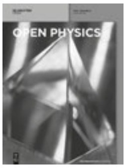

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Isotopic Randomness and Self-Organization

In Physics, Biology, Nanotechnology, and Digital Informatics

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About the Author

Alexander (Alex) Berezin, the author of this book is a professor (Emeritus) of Engineering Physics at McMaster University.

He is an internationally known inter-disciplinary academic scholar, active in many areas (quantum physics, electrodynamics, mathematics, engineering, biology, environmental science, sociology of science, etc.).

He holds PhD in Theoretical Physics (Quantum Mechanics) from Leningrad (now St. Petersburg) University, Russia. Apart from physics, he received an education in the History of Arts from the Hermitage Museum in Leningrad where my mother worked as a senior expert in arts and a curator of the French painting collection. From 1969 to 1974, he worked as a researcher (theoretical physicist) at the Ioffe Physical–Technical Institute of the Academy of Sciences of the USSR, Leningrad. From 1974 to 1977, he was a Docent (Associate Professor) of physics at the Naval Engineering Academy, Leningrad. In 1978, he emigrated with his family (wife and two children) to Canada. Between 1978 and 1980, he was a research associate at the Department of Physics, University of Alberta, Edmonton, Alberta. His last work (1980–2010) was a tenured professor at the Department of Engineering Physics, McMaster University, Hamilton, Ontario, and he retired in 2010. His present status is a Professor Emeritus and he lives in Toronto, remaining active in his writing and publishing.

Among other things, he is mostly known for the development of the concept of "*isotopicity*" that presents isotopic randomness of elements as a phenomenon of its own. This concept has a number of informational and biological implications well beyond what is traditionally considered by the physics and chemistry of isotopes. Of a particular impact is the idea of *isotopic genetic code* that was advanced in a number of his publications in recent decades.

His publication record: 160+ papers in major physical, chemical, biological, engineering, and interdisciplinary journals [e.g., *Physical Review*, *Journal of Theoretical Biology*, *Journal of Chemical Physics*, *Nature*, *Science Progress* (Oxford), *Interdisciplinary Science Reviews*, *Journal of Applied Physics*, *Medical Hypotheses*, *Kybernetes*, *Biotechnology and Bioengineering*, etc.], 65 articles in conference proceedings, three books, numerous newspaper, and magazine articles (100+) and numerous public talks.

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Preface

The cave you fear to enter holds the treasure you seek.
Joseph Campbell (1904–1987)

This book is written by a theoretical physicist (PhD in quantum physics) who for many years have studied and published on a broad range of radical and frontier ideas. The presentation in this book is aimed for the general audience and does not require any specialized background in science, except the familiarity with the most basic concepts (such as what are atoms or prime numbers). A common-sense curiosity and openness to new ideas is all what is needed to get across the ideas outlined in this book.

Back in 1990, I, the author of this book, has co-authored a paper "Quantum Mechanical Indeterminism as a Possible Manifestation of Microparticle Intelligence" (A.A. Berezin and R.S. Nakhmanson, Physics Essays, Vol. 3, pp. 331–339, 1990). Paper with such a provocative title has produced, quite expectedly, a mixed reaction both in a "quantum community" and outside of it, with a broad spectrum of (often emotional) comments. During my 50 years research carrier (my first paper on quantum physics was published in 1967), I have published numerous papers expanding various aspects of these ideas. Of a special emphasis were the ideas of isotopic self-organization in biology and outside of it. This book presents these ideas in a popular form for the general readership.

The book is aimed at those readers who are puzzled by the miracles of the physical world and are eager to look deeper what is (or may be) in the background of things and phenomena at all scales of existence. At those aspiring young (and not that young) minds who are hungry for the ideas and looking for the intellectual stimulation on the path of their own discoveries. Such are the ideas of "*isotopic biology*" as an alternative (or a compliment) to the "ordinary" carbon-based biology. Can, for example, ordering of isotopes in DNA chains carry an additional genetic information "over and above" what the common ordering of nucleotides is supposed to store? Can isotopic ordering in water lead to the often-claimed effects of "water memory"? Or can (also often claimed) "healing properties" of quartz crystals be indeed based on the formation of "*isotopic neural networks*" in crystalline structures?

This book is not a dry academic treatise for some sophisticated scholars, but an entertaining journey over the largely unexplored terrains. The book fuses together two main themes both of which are of the key importance for our existence. One is the Infinity, and, more specifically, the infinity of Prime Numbers. The other theme is the diversity of isotopes and the effects that are coming from it. We all are made of atoms (chemical elements) and atoms come in a form of isotopes (stable and radioactive). As a popular saying by Carl Sagan has it, "*We All Are Star Dust*" (chemical elements are created at the explosion of *Supernovae* stars). Do isotopes (isotopic randomness or "*isotopicity*") contribute to our consciousness in a significant way? Or, perhaps, isotopic randomness and isotopic chaos is a central facet of the consciousness dynamics?

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In-spite that these ideas were around for over 30 years, the informational ("digital") aspects of isotopes – in particular, their ability to form "*isotopic genetic code*" over-and-above the "ordinary" genetic code – so far were largely overlooked by the "mainstream" science. One of the goals of this book is to fill this gap. In following this goal, the book discusses the potential of isotopic diversity of chemical elements ("*isotopicity*") for such areas as "*water memory*" (the basis of homeopathy), "*healing crystals*" (why many people wear quartz crystals and claim some health and "spiritual" benefits from them), quantum foundations of consciousness, and our connections to a Greater Cosmos.

This book is highly inter-disciplinary and the book is full of ideas and hypotheses. They all are explained in a simple common-sense language that avoids high-level technicalities. In this way, I see its main value as a thought-provoking, mind-stimulating, and concept-expanding reading aimed at a broad category of people of all professions and persuasions who are interested in the fundamental issues of our existence. People, who are curious of "How the Universe Works" and are eager for the enlightenment and inspiration.

Thus, the two main themes of this book – the infinite set of Prime Numbers and isotopic randomness (*isotopicity*) – are considered as a conceptual whole, as two intertwingled intellectual spirals. The central premise of this book is that both of these themes (prime numbers and isotopes) are important for our biology and our spiritual life. The book presents these two themes in their synthetic unity as having a common ground in their informational ("digital") nature.

Most prefaces of books end with some words like "acknowledgements." My prime acknowledgement in this way is to my late wife Irene (1943–2005) with whom I have raised two wonderful children and whose love and care for over 37 years of our marriage has given me stability, energy, and motivations for my diverse scholarly pursuits in physics, metaphysics, arts, museums, travelling, and many other things we have accomplished together.

Likewise, I want to mention three other great ladies who in a significant way helped me to find my path in science in my formative years. My mother, Valentina Nikolaevna Berezina, 1912–1987 [in Russian language women's last names usually have "a" at the end], was a senior art expert and a curator of the French Painting collection at the Hermitage Museum in Leningrad (now Saint Petersburg) and to her, among all other things, I owe my interest in the history of art from the Antiquity to the modern times.

Her life-time friend Irina Leonidovna Sokolskaya (1906–1972), professor of physics at the Leningrad University, was my first encouragement to go to physics – a choice that I made in a secondary school and never have changed my mind. She was a friend of my mother for many, many years – I guess they knew each other since 1940s. She was the first person in my life who exposed me to the world of physics when I still was a child of, perhaps, 5 or 6 years old. In fact, I probably heard the word "physics" for the first time in connection with her. She and her husband, also a physicist, often visited us and invited us since I was a little boy. Conversations with them were invariably

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fascinating and interesting (for me – a schoolboy!). They were very much "dissidents," critical to the Soviet system, and I loved to hear them on that. As a physicist, Irina Leonidovna was experimentalist (mostly in the area of electron emission from crystals and surface physics) and she was a type of, perhaps, "Maria Curie." Very sharp, very intelligent with a good and penetrative mind. She was probably the most important person to direct me during my school years to physics and she predicted that I will be a theoretical physicist, at one time she said that I even "walk as a theoretician" ("*u tebya dazhe pokhodka teoretika*"). It must be said that my mother respected Irina Leonidovna greatly and fully supported her suggestion that I should go into physics. And so, I did.

My PhD supervisor Maria Ivanovna Petrashen (1906–1977), professor of theoretical and mathematical physics, has taught me a course in a second-year mathematics (an excellent course) and later on I was a student at her special theoretical course on Group Theory. This subject (which has a lot to do with quantum physics, symmetries in crystals, etc.) has so much attracted my interest that I asked MI if I can do a PhD in her research team (provided, of course, that I successfully pass the entrance examinations to a PhD program [called "*aspirantura*" in Russian], which I later did). She replied positively, and later on she became an official supervisor of my PhD work.

Like Irina Leonidovna, Maria Ivanovna was also a person who made a very strong and positive life-long impact on me. She was an excellent lady, who has suffered a lot in her life – some of her relatives have perished during the terror in 1930s in Gulag (I am not sure, but I think, her father – an engineer – was among the victims). Yet, Maria Ivanovna maintained kindness and generosity of heart and I remain forever thankful to her and feel happy that I had a great blessing to be her student.

In addition, many other people, whether they were professional scholars or not, have shown interest in my work and offered me here-and-there encouraging words and useful comments that often helped me along with my work and insights. I remain thankful to all of them, but in order not to disfavor anyone (because it is impossible for me to recall all of them), I shall refrain from giving any names here.

And even an occasional criticism and sometime an outright rejection of my scholarly offerings have, paradoxically, often stimulated me to sharpen my "metaphysical argumentation" and filled me with a zest of further "scholarly fights." Some of them were successful, some may not, but all were, in my view, well worth of fighting. And the standing possibility that, perhaps, some of the ideas explored in this book will be picked up and extended 50, or 100, or 1,000 years hence (or, perhaps in some Parallel Universe with a multidimensional time?) gives me another ("metaphysical," so to say) incentive to offer these thoughts to my readers.

How to read this book

This book is not a romantic novel that is supposed to be read in a single shot "from cover to cover." In fact, this book presents several different modes of reading. In that

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way – and with all due apologies for such an ambitious comparison – it stays more on side of such books as a Bible (who reads Bible in a single shot?) or, perhaps (a less ambitious comparison) on a side of various Handbooks-of-This-and-That. In short, "read-and-read-again" type of the books. It is a multi-level book that can be seen as a teasing smorgasbord of ideas for a variety of tastes.

The ideas presented in this book have various degrees of hypothezation (or some may prefer a term "speculativness"). For that, as an author, I, again, make no apology. No science, and almost no intellectual development, can do well without some measure of hypotheses and speculations.

Many issues discussed in this book have overlaps with each other and there may be textual repetitions and redundancies. Again, as the author and a long-time lecturer, I make no apology for that, recalling a well-known Russian saying "*Povtorenie mat' uchenija*" (Repetition is the Mother of Learning). Even one of the most-read books in the world (Bible) has many repetitions of the same or similar themes and messages.

The way the book is structured, it is "selective reading friendly," meaning that different chapters and section (essays) may well be read on their own or in any order. There is no need to read it straight "from cover-to-cover" and the ideas it discusses can well be absorbed in a different order. In case, some parts may seem a bit obscure and confusing, my suggestion to the reader is not to dwell too hard on them but keep going. Look primarily for the things and ideas that appear more lucid and clear.

In this book, the ideas of "*Digital Isotopicity*" and "*Universal Digital Code of Prime Numbers*" are inter-mixed in a variety of essays that can be read consecutively or selectively, depending on the tastes and interests of the reader.

Also, in my own experience, there are quite often more clarity is attained by the repetitive reading of the same passages two or more times. That can be done at different days, as most of the ideas presented in this book call for the reflections and meditations. And in no way, I mean to say that the reading of this book should be an "exclusive occupation" for the reader for several days or so. Of course, reading and watching other things can well alternate with it.

Practically any text that unfolds some ideas has both a "context" and a "subtext." Quite often, this may lead to ambiguities in understanding and misinterpretations. The way a reader reflects on the text may not be what the author has originally intended. On top of that, there is also constant on-going evolution of language and meaning of terms an (often broad) variety of interpretations due to various social, territorial, cultural, and demographic differences.

Thus, as an author, I humbly express my hope that if this book (in whatever form) will survive for some decades (say, 50 or 100 years), its content and the ideas it carries, will be "re-discovered" and "re-interpreted" by some future scholars and thinkers, would they still be humans (of *Homo Sapience* breed), or Intelligent Robots as our coming evolutionary descendants (personally, I see the second scenario as far more likely).

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A note about the notations used in this book

This book has a "digital spirit" in it. It talks about the infinite strings of Prime Numbers and strings of isotopes in long molecules such as DNA that carry the genetic information. To that end, we will discuss isotopic randomness and some effects related to isotopic diversity of chemical elements. I would presume that my readers have some core familiarity of what isotopes are, and that most chemical elements have two or more stable isotopes (e.g., oxygen has three: 16O, 17O and 18O and carbon has two: 12C and 13C). If that is somewhat forgotten, half an hour on the Web googling "isotopes" can provide all the basic facts. And in this book, in some kind of a departure from traditional chemical nomenclature, all isotopes, instead of being written in a traditional form as, say, 12(superscript)C, etc., are written as 12C, 17O, 28Si, etc. Likewise, I do not use subscripts for chemical formulas. Thus, I write water as H2O and silicon dioxide as SiO2.

In the present-day culture of digital messages, such as cell phone "texting," this is unlikely to produce much of a confusion or resistance. Also, and by the same reason of printing and texting simplicity (we live in a digital world nowadays!), this book avoids using superscripts to designate powers of numbers. Instead, the symbols such as 10E17 or 10^17 are used (it means 10 to the power 17). Thus, 10E3 = 10^3 = 1,000, 10E5 = 10^5 = 100,000, etc. For so-called "Tower Exponents" (used later in the book), notations such as 10^10^10 (or 10E10E10) mean 10 to the power 10^10 , that is 10 to the power 10,000,000,000 (10 billions). Huge numbers as they are, but we will talk a lot about them in connection with Platonic Reality.

We live in the age of digital informatics. Information is the major commodity of our entire civilization (Du Bravac, 2016). And we extend the ideas of information and "informatics" to areas well beyond of "informational electronics" as such. We talk about the informational content of human speech and music, we calculate the informational capacity of human genomes and genetic codes, and we discuss the dynamics of information at cosmological scales (Lloyd, 2002, 2006). And such active areas of intellectual and technological pursuits as Robotics, AI (Artificial Intelligence), Virtual and Simulated Realities (Johnson, 1994; Kurzweil, 1999, 2005; Bostrom, 2003, 2016; Berezin, 2006) – all, in different ways, have "information" and "informatics" as a key *modus operandi* of the on-going discourse.

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Foreword: Isotopicity – paradigm for twenty-first-century

This book discusses various aspects of isotopic diversity of the material world from the unique position of a singular principle ("*isotopicity*").

Everything that we can see and touch – including ourselves – is made of atoms and about 2/3 of all chemical elements have two or more stable isotopes. There are 254 known stable isotopes and 80 elements in the Periodical Table, which have at least one stable isotope. In total, 26 elements have one stable isotope. These elements are called monoisotopic. The number of radioactive isotopes – occurring naturally and created artificially – is much larger, some 2,400, or so.

The above facts are, of course, generally well known. However, from the start, there appears to be a somewhat curious "paradox" in the realm of science and technology.

On one hand, the existence of isotopes and their numerous applications are parts of the common knowledge, intensive, and versatile research activities, which go on for over a century, and as such, the science of isotopes forms a significant and well-visible corner of physics, chemistry, material science, to name just a few major outlets. There are several major industries and technologies that are critically dependent on isotopes. These are such socially and economically important areas as nuclear science and engineering, massive use of isotopes in medicine for treatment and diagnostics, isotopic geology (e.g., dating of minerals and sediments), pollution and radiation monitoring, forensics, and some other areas.

All these above-mentioned technologies form mega-billion businesses, employ many thousands of professionals of various skills and trainings, and, cumulatively, account for a substantial share of the modern economy. Likewise, it goes without saying that all aspects of isotopic science and technology produced a massive and ever-growing body of literature, shelves of books, and PhD dissertations with innumerous life-time research carriers dedicated to study of isotopes and their applications.

Yet, on the other hand, there seems to be little appreciation of isotopic diversity as a singular phenomenon of nature, a phenomenon of its own kind, which has a distinct and a unique signature with a broad range of manifestations in the material world. In a number of his publications, this author has introduced a notion of "isotopicity" as a unifying umbrella term for various effects related to isotopic self-organization, isotopic structuring, isotopic informatics, and "isotopic biology."

This book outlines numerous applications of isotopicity in engineering, material sciences, and nanotechnology. The list includes isotopic fiber-optics, isotopic random number generators, quantum computing, biomedical microtechnology, isotopic informatics, and "Isotopic Biology." The latter (isotopic biology) is the original concept proposed by the author of this book in a number of publications (some are listed below).

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The central premise of Isotopic Biology is the idea of "Isotopic Genetic Code" that can greatly amplify the information-carrying capacity of DNA structures. It is known that carbon has two stable isotopes, 12C (99%) and 13C (1%). Hence, an elementary combinatorial analysis leads to an enormously large number of possible isotopic permutations within chemically fixed structures. For example, a small segment of a DNA chain with just 1 million carbon atoms has about 10,000 randomly distributed 13C atoms. The number of isotopically distinguished distributions (the number of possible placements of the 10,000 atoms among 1,000,000 sites) is about 10^24000 [yes, "10" to the power 24000 (!)]. This is a far (far!) greater than the number of atoms in the Universe, which is estimated to be "only" about 10^90. Furthermore, if we include the spatial arrangements that can be produced by point substitutions in other stable isotopes, such as 16O by 17O and 18O, or 14N by 15N, etc., the possibilities for information transfer and information diversification carried parallel to "macros" information (such as the genetic transcription of codons or chromosomal crossover) increase even further (super exponentially).

This latter ("informational") aspect of isotopic diversity, is, in the view of this author, remains largely under-appreciated, and one of the goals of this book is to direct the attention of the research community to this "glaring gap."

This book has a "digital spirit" in it. That is pretty much conducive with the "Zeitgeist" of our "Digital Age."

In this regard, the book fuses together two main themes, both of which are of the key importance for our existence. One (prime theme) is the diversity of isotopes and the effects that are coming from it. The other is "Platonic Digital Infinity" and, more specifically, the infinity of Prime Numbers. The later (infinite string of prime numbers) forms an "Absolute Digital Code of the Universe," that resembles (in some metaphorical way) the physical codes of DNAs and, in particular, an "isotopic genetic code" that is outline in this book. The book discusses this analogy at several levels.

This book is not a dry academic text for some sophisticated scholars, but an entertaining journey over the largely unexplored terrains. It is written for the general public by an internationally known theoretical physicist, yet its author does not expect his readers to have a PhD in Theoretical Physics or anything similar. A common-sense curiosity is all what is needed. A few places that may appear somewhat more "technical" or "academic" may well be skipped without much loss to the central ideas this book ventures to present.

It is a highly inter-disciplinary text full of ideas and hypotheses. It talks about Quantum Consciousness, Prime Numbers, Infinite Sets ("Alephs") of Georg Cantor, Cosmology and Parallel Universes (how many of them? do we have "doubles" in Parallel Universes?), Multidimensionality and Time Loops, Spirituality and Meditations, Psychology, Alternative Medicine (Water Memory and Healing Crystals), "Universal Library of All Possible Books" (Jorge Luis Borges), and such radical ideas, as, "Living Cosmos and the Consciousness of the Sun" [e.g., discussion of the book "Sun of gOd" by Gregory Sams, where he presents the idea that our Sun is alive and conscious being (!)],

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Virtual and Simulated Realities (like a discourse "Are We Living in a Computer Simulation?"), Transhumanism, Morphogenetic Fields, and other "hot" ideas.

They all are explained in a common-sense language that avoids high-level technicalities. In this way, I see its main value as a thought-provoking, mind-stimulating, and concept-expanding reading aimed at a broad category of people who are passionate about the fundamental issues of our existence. People, who are curious of "How the Universe Works" and are eager for the enlightenment and inspiration.

The book is aimed at a broad audience of people, professionals, and amateurs of all brands, who are interested in science (physics, chemistry, biology, psychology, mathematics, etc), engineering, informatics and computer sciences, medicine (mainstream and alternative), environment, liberal arts, philosophy, sociology, futurology, evolution, consciousness, genetics, health, self-help, spirituality, "New Age" ideas, etc. in the context of Quantum Physics and Informatics. For the readers who are inclined for a deep and contemplative thinking, this book provides specific templates for the insightful meditations on the Infinity, Numbers, and our connections to the "Ideal Platonic World" of Numbers and Forms. The book is aimed at a broad variety of readers of all interests, professions and passions, students of all ages and disciplines, as well as all kinds of "knowledge enthusiasts" and "enlightenment seekers."

One of the last chapters of this book (Chapter 12) suggests a new vista on the elementary particle Neutron – one of the fundamental particles of matter. In fact, isotopic diversity (*isotopicity*) is a part of neutron physics, since isotopes of a given chemical element differ in the number of neutrons in their atomic nuclei. Hence, we can talk about "isotopicity" as a conceptual "sub-set" of "*neutronicity*" – the term that is introduced in Chapter 12. Consequently, the nature and quantum dynamics of Neutron is discussed within the notion of "*neutronicity*" as singular concept, similar to concept of "isotopicity." Thus, "isotopicity" and "neutronicity" form a conceptual tandem, a "Twin Pair." This chapter pays a special attention to the universal informational properties of Neutron as a basic particle of quantum dynamics at the cosmic level.

To summarize, this is a "Paradigm Shift" book (by the term introduced by Thomas Kuhn). Such original ideas as "*Isotopic Genetic Code*" and "*Digital Coding of the Universe*" by the infinite set of Prime Numbers, stand in the same line as the "Copernican Revolution" of the sixteenth century and the "Darwinian Revolution" of the nineteenth century.

As the author, I make no specific predictions of how long it will take for the science, and for the humanity at large, to absorb and creatively reflect on these ideas … To that effect, one esteemed colleague has recently conveyed to me that "your ideas are perhaps decades ahead of their time." In this spirit, I present this book to my readers.

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Synopsis

This book discusses various aspects of isotopic diversity of the material world from the unique position of a singular principle (“*isotopicity*”).

Everything that we can see and touch – including ourselves – is made of atoms, and about 2/3 of all chemical elements have two or more stable isotopes. There are 254 known stable isotopes and 80 elements in the Periodical Table which have at least one stable isotope. In total, 26 elements have one stable isotope. These elements are called monoisotopic. The number of radioactive isotopes – occurring naturally and created artificially – is much larger, some 2,400, or so.

The above facts are, of course, generally well known. However, from the beginning, there appears to be a somewhat curious “paradox” in the realm of science and technology.

On one hand, the existence of isotopes and their numerous applications are parts of the common knowledge, intensive, and versatile research activities, which go on for over a century, and as such, the science of isotopes forms a significant and well-visible corner of physics, chemistry, material science, to name just a few major outlets. There are several major industries and technologies that are critically dependent on isotopes. These are such socially and economically important areas as nuclear science and engineering, massive use of isotopes in medicine for treatment and diagnostics, isotopic geology (e.g., dating of minerals and sediments), pollution and radiation monitoring, forensics, and some other areas.

All these above-mentioned technologies form mega-billion businesses, employ many thousands of professionals of various skills and trainings, and, cumulatively, account for a substantial share of the modern economy. Likewise, it goes without saying that all aspects of isotopic science and technology produced a massive and ever-growing body of literature, shelves of books, and PhD dissertations with innumerous life-time research carriers dedicated to study of isotopes and their applications.

Yet, on the other hand, there seems to be little appreciation of isotopic diversity as a singular phenomenon of nature, a phenomenon of its own kind, which has a distinct and a unique signature with a broad range of manifestations in the material world. In a number of his publications, this author has introduced a notion of “*isotopicity*” as a unifying umbrella term for various effects related to isotopic self-organization, isotopic structuring, isotopic informatics, and “isotopic biology.”

This book outlines numerous applications of isotopicity in engineering, material sciences, and nanotechnology. The list includes isotopic fiber-optics, isotopic random number generators, quantum computing, biomedical microtechnology, isotopic informatics, and “Isotopic Biology.” The latter (isotopic biology) is the original concept proposed by the author of this book in a number of publications (some are listed below).

The central premise of Isotopic Biology is the idea of “Isotopic Genetic Code” that can greatly amplify the information-carrying capacity of DNA structures. It is known, that carbon has two stable isotopes, 12C (99%) and 13C (1%). Hence, an elementary

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combinatorial analysis leads to an enormously large number of possible isotopic permutations within chemically fixed structures. For example, a small segment of a DNA chain with just 1 million carbon atoms has about 10,000 randomly distributed 13C atoms. The number of isotopically distinguished distributions (the number of possible placements of the 10,000 atoms among 1,000,000 sites) is about 10^24000 [yes, "10" to the power 24000 (!)]. This is a far (far!) greater than the number of atoms in the Universe, which is estimated to be "only" about 10^90. Furthermore, if we include the spatial arrangements that can be produced by point substitutions in other stable isotopes, such as 16O by 17O and 18O, or 14N by 15N, etc., the possibilities for information transfer and information diversification carried parallel to "macros" information (such as the genetic transcription of codons or chromosomal crossover) increase even further (super exponentially).

This latter ("informational") aspect of isotopic diversity, is, in the view of this author, remains largely under-appreciated, and one of the goals of this book is to direct the attention of the research community to this "glaring gap."

This book has a "digital spirit" in it. That is pretty much conducive with the "Zeitgeist" of our "Digital Age."

In this regard, the book fuses together two main themes, both of which are of the key importance for our existence. One (prime theme) is the diversity of isotopes and the effects that are coming from it. The other is "Platonic Digital Infinity" and, more specifically, the infinity of Prime Numbers. The later (infinite string of prime numbers) forms an "Absolute Digital Code of the Universe," that resembles (in some metaphorical way) the physical codes of DNAs and, in particular, an "isotopic genetic code" that is outlined in this book. The book discusses this analogy at several levels.

This book is not a dry academic text for some sophisticated scholars, but an entertaining journey over the largely unexplored terrains. It is written for the general public by an internationally known theoretical physicist, yet its author does not expect his readers to have a PhD in Theoretical Physics or anything similar. A common-sense curiosity is all what is needed. A few places that may appear somewhat more "technical" or "academic" may well be skipped without much loss to the central ideas this book ventures to present.

It is a highly inter-disciplinary text full of ideas and hypotheses. It talks about Quantum Consciousness, Prime Numbers, Infinite Sets ("Alephs") of Georg Cantor, Cosmology, and Parallel Universes (how many of them? do we have "doubles" in Parallel Universes?), Multi-dimensionality and Time Loops, Spirituality and Meditations, Psychology, Alternative Medicine (Water Memory and Healing Crystals), "Universal Library of All Possible Books" (Jorge Luis Borges), and such radical ideas, as, "Living Cosmos and the Consciousness of the Sun" [e.g., discussion of the book "Sun of gOd" by Gregory Sams, where he presents the idea that our Sun is alive and conscious being (!)], Virtual and Simulated Realities (like a discourse "Are We Living in a Computer Simulation?"), Transhumanism, Morphogenetic Fields, and other "hot" ideas.

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They all are explained in a common-sense language that avoids high-level technicalities. In this way, I see its main value as a thought-provoking, mind-stimulating, and concept-expanding reading aimed at a broad category of people who are passionate about the fundamental issues of our existence. People, who are curious of "How the Universe Works" and are eager for the enlightenment and inspiration.

The book is aimed at a broad audience of people, professionals, and amateurs of all brands, who are interested in science (physics, chemistry, biology, psychology, mathematics, etc.), engineering, informatics and computer sciences, medicine (mainstream and alternative), environment, liberal arts, philosophy, sociology, futurology, evolution, consciousness, genetics, health, self-help, spirituality, "New Age" ideas, etc., in the context of Quantum Physics and Informatics. For the readers who are inclined for a deep and contemplative thinking, this book provides specific templates for the insightful meditations on the Infinity, Numbers, and our connections to the "Ideal Platonic World" of Numbers and Forms. The book is aimed at a broad variety of readers of all interests, professions and passions, students of all ages and disciplines, as well as all kinds of "knowledge enthusiasts" and "enlightenment seekers."

This is a "Paradigm Shift" book (by the term introduced by Thomas Kuhn). Such original ideas as "*Isotopic Genetic Code*" and "*Digital Coding of the Universe*" by the infinite set of Prime Numbers stand in the same line as the "Copernican Revolution" of the sixteenth century and the "Darwinian Revolution" of the nineteenth century.

This book is an introduction and opening to a new and a potentially "hot," perhaps mega-billion, area of research, and development activity along isotopic informatics and isotopic structuring – an area that branches into several key experimental and theoretical directions encompassing physics, chemistry, engineering, material science, informatics, nanotechnology, quantum computing, bio-medicine, psychology, and a few other lines.

As the author, I make no specific predictions of how long it will take for the science and the humanity at large to absorb and creatively reflect on these ideas .... To that effect, one esteemed colleague has recently conveyed to me that "your ideas are perhaps decades ahead of their time." In this spirit, I present this book to my readers.

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Contents

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EBSCOhost - printed on 2/13/2023 9:15 PM via . All use subject to https://www.ebsco.com/terms-of-use

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1 Introduction: Ideas and experts

The first problem for all of us, men and women, is not to learn, but to unlearn.
Gloria Steinem (b. 1934)

Aristotle maintained that women have fewer teeth than men; although he was twice married, it never occurred to him to verify this statement by examining his wives' mouths.
Bertrand Russell (1872–1970)

This book discusses classic philosophical and scientific theories related to metaphysics, or the nature of reality. It is not intended to convince the reader that any one theory is better than the other, or even provide the reader with tools that make such an evaluation for oneself. Rather, it is the common thread of this book that metaphysical inquiry is intellectually rewarding on its own and can bring valuable intellectual stimulations and deep spiritual insights.

So, what this book is all about? For many of us, philosophical and metaphysical contemplations and meditations on fundamental issues of existence form an important aspect of our intellectual life. They provide us with a venue for achieving inner peace and anchoring ourselves in a haven of spiritual stability among the world in turmoil with its nonstop tsunami of problems falling on us from all sides.

This book, to some degree, is based on the published works of the author in several interdisciplinary areas, and equips the reader with a navigational guide to many of the key issues that are of a fundamental importance in our existential serenity and psychological optimism.

The scientific and philosophical issues are presented in an easy and reader-friendly way that does not require any special background beyond commonsense knowledge of today. In its thrust and coverage, the book places itself equally in several nonfiction categories: general science; health and self-help; general interest; psychology, spirituality, and metaphysics; "new age", as well as philosophical narratives in a broad sense.

Normally, authors are supposed (and are expected) to care about the public acceptance and popularity of their books. After all, who does not want to get on a best-seller list? Well, I do not feel myself in this (albeit potential) club. As for what people may say about this book or for any of my other writings, I have only one common stamp as a reply – it does not concern me the slightest. In this book, I present my views and visions on infinity, prime numbers, atoms and isotopes, and the quantum universe the way "I" see them and if others may see them differently or do not see them at all – fine with me.

As an author, I well realize (as anyone else should) that the world neither begins nor ends with me. Sometime (quite rarely, though) books outlive their authors. There are millions upon millions of books that exist in this world. As Wikipedia says, The Library of Congress, which is the largest library in the world, holds some 160 million items and 38 million books on approximately 850 mi. (1,370 km) of bookshelves. And

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those most certainly not all the books ever published in the world as many books did not get even to the Library of Congress.

The total number of books ever published in the world is estimated at about 300 million and it grows at the rate of some 6,000 new book titles per day, or about over 2 million per year (to remind, there are 31 million seconds in a year, so counting all ever-published books "one-per-second" will take 10 years). And everyone of us (I mean, us, the authors) needs to find his or her own way to fit into this exponentially growing market (and I am not even adding to that zillions of Internet blogs and posts).

Some authors, even in the early days of book printing (say, in the sixteenth century), were already complaining of there being too many books. And yet, people keep writing and publishing. Of course, all authors desire that their books be read as wide as possible and attract a fair score of interested readers. So do I, without any second thought. Yet, the books have a life of their own, some become worldwide best-sellers, some go into oblivion. Curiously, even some great and world-known authors have written books that made a history, but also other books that almost nobody knows. Many examples of these can be found in the past, as well as in the present time.

Considering this, I make no predictions of any kind about this particular book and allow myself of no specific expectations. To quote the celebrated philosopher and logician Ludwig Wittgenstein (April 26, 1889 to April 29, 1951), with whom I share my birthday (mine is April 26, 1944), "if there ever will be a single reader of my book who will read it and gain insight from it, I will eternally be satisfied." (L. Wittgenstein, *Tractatus Logico-Philosophicus*, 1921)

A few words are due to "autobiographical aspects" of the book. This book is not my autobiography as such, yet some reminiscence on how these ideas were evolving and what (pretty mixed) response they produced is, in my view, may be of an interest to my readers.

So, where we begin?

Our age is centered on success and celebrities. This is what sells. All the social machinery and market forces are there to hook up people ("consumers") to the unceasing public hunger for the "star" and "superstar" news and gossips that are produced 24/7 by all forms of mass media with ever-growing sophistication. The younger generation is particularly vulnerable. The ideas about the infinity, universe, and our existence in it are safely put on a back seat. Those who talk about them are relegated to fringes, if not nutcases. This seems to be an overall picture of our brave new world.

Well, *almost overall*. Here and there, we observe cracks in such a gloomy picture. Human spirit often brakes through the straight jackets of mass media's brainwashing technologies and directs us to the search of other realities. As it is said, not by the bread alone (including quasi-intellectual junk food of all kinds) we are alive. Through all the daily pressures and personal concessions, our spirit often directs our hearts and aspirations to Higher Realms and exiting contemplations on matters Infinite and Eternal.

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This book is aimed at people who are looking for new and unusual mind-stimulating ideas. It is full of new and original ideas. The ideas that will lead the readers to further creative contemplations and deep insights. The book deals with a number of cross-disciplinary issues and thoughts and as such, it is aimed toward a broad and diverse audience.

The book is both "academic" and "popular". While its author is a "seasonal academic" (professor of theoretical physics and engineering), he, at the same time, has quite a vast experience of delivering talks to general audiences and a long record of media publications. The book is "all-inclusive" and is also a "cross-genre" – it can be read for the knowledge and insight as well as for excitement and entertainment.

The main quality (or, let us say, "an intellectual asset") that the author expects from the potential reader is not a PhD level in some science or anything like that. Instead, it is an open-minded curiosity and a desire to connect to the bigger multidimensional eternal universe and an infinite mind of the cosmos. That will likely put my readers in tune with the ideas presented in this book.

On this path of infinity, there should not be any failures or any terminal point for this matter. It is always a road of self-discovery and exciting awe. In this way, the reader has a broad choice of "resonance frequencies" on how to read this book and what to find in it.

Like with almost all "non-mainstream" writers, who venture to depart from the party line of the mainstream science, reaction to my work (and my published papers) over the years was almost invariably quite mixed – from the expression of almost an admiration (somebody called me a "visionary") to (quite frequent indeed) use of some far-less nice words that can be found in an advanced Oxford dictionary (I abstain from exact quotes).

To repeat, this book contains many repetitions and restatements of the same points. Perhaps, even same quotes may pop-up here and there more than once. So, what? For that, I assume no responsibility and make no apologies of any kind, same as professional artists do not normally apologize (or feel "guilty") that some of their pictures repeat the same theme. In fact, some of them regurgitate one and the same theme (or a small set of a few themes) for much of their entire artistic careers.

For those who decide to read this book (even partially and/or selectively), I have to say that, in my view, the ideas that I am discussing are conducive for fostering the capacity for a nonlinear, multifaceted, and "multidimensional" thinking. In other words, what is known as the willingness to think "outside box."

Yes, it is a bit of a heavy duty to deflect from the standard paths of the mainstream thinking, but that is what I was doing much of my life without any shadow of regrets about this. In this way, at least ideally, I always tried to follow one of the best mottos that I know. It traditionally quotes as "(Segui il tuo corso), e lascia dir le genti," which means follow you own path, no matter what anyone may say (Dante Alighieri, *Divina Comedia*, Purgatory, 5:13).

At the end of the book, there is a list of some of my publications as well as the titles of some other books that are mentioned in the text. Yet, some quotes and ideas used in the book were taken from a variety of web pages, including Wikipedia. In all

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these cases, I did a reasonable editing and validity checks, yet formal referencing in some such cases is impractical and often unrealistic.

All this is a reflection of the changing practice of modern scientific writing when numerous web sources provide an effective compensation to the incompleteness (or even lack) of a formal referencing. Nowadays, archives of most scholarly journals are available online in (almost) any point in the world, although some readers may still face problems of access (not everything is free in this world, at least not yet).

I did my best to explain in a popular way the terminologies and concepts that I am using in the text. However, it should be said that with the ever-increasing power of the Internet that we all witness daily (exponential Moore's Law!), and with such powerful search engines as Google (and an enormous volume of information on the web), any interested reader can easily go to the prime sources using the terms and names as key words for the search.

1.1 Informatics runs supreme

Almost everything that is around us is digital informatics. Information is the major commodity of our entire civilization (Du Bravac, 2016). And we extend the ideas of information and "informatics" to areas well beyond of "informational electronics" as such.

We talk about the informational content of human speech and music, we calculate the informational capacity of human genomes and genetic codes, and we discuss the dynamics of information at cosmological scales (Lloyd, 2002, 2006).

So far, practically all informational systems that are in use today are based on "electronics." That means that the processes with electrons (such as operating of transistors in computers and memory chips) are the major (and, for all practical purposes, the only) players in all these technologies.

Furthermore, such active areas of intellectual and technological pursuits as robotics, artificial intelligence (AI), and virtual and simulated realities (Johnson, 1994; Kurzweil, 1999, 2005; Bostrom, 2003, 2016) – all, in different ways – have "information" and "informatics" as a key *modus operandi* of the ongoing discourse. Not to mention that we ourselves ("humans") are becoming more and more "digital entities" with all ongoing advances in implanted chips and our love affair with iPods and cell phones. For many of us, these iPods and cell phones are almost becoming parts of our bodies and we walk, eat, sleep, and do all other things constantly connected to them! That eventually will likely make us "walking digital robots" (many signs of that around already).

And at the cosmological scales, the formation of the black holes and the and collapse of stars to the neutron stars determines the dynamics of cosmos in real time and provides a physical platform for the evolution and informational ascending. By the latter, we mean *negentropic* ("anti-entropic") processes of self-organization and biological morphogenesis, as well as the emergence of self-aware structures and consciousness (Berezin and Nakhmanson, 1990; Leff and Rex, 1990; Lloyd, 2002, 2006).

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1.2 Smartness of nature

The beginning of our discussion here is the principle of the creativity of nature (also known as the *parsimony principle*). A look at the world around us leaves no doubt that nature is unceasingly busy in devising all kind of systems and structures in all realms. At cosmic mega scales, we observe stars, galaxies, and galactic clusters that are million light years across.

The biological level (at least, the one that we presently know) extends over some 15 orders of magnitude from the smallest bacteria to the entire planetary ecosystem (Gaia), with an enormous variety of ever-evolving organisms and symbiotic structures of all varieties. Illustrations of these are, for example, correlated flocks of birds and schools of fish as well as a broad variety of social organizations in human societies. Likewise, at the (so called) nonorganic (physical) level, we have various self-organized structures and processes.

To repeat, from crystals and macroscopic-phase transitions, the correlated phenomena with high degree of coherency (such as superconductivity, superfluidity, and other cooperative phenomena) exist on many scales and take many forms. We observe self-organization at all levels and scales – from atoms and molecules to all lifeforms (from bacteria to humans and up (life forms more advanced than humans)) to the cosmic and super-cosmic (galactic) scales.

Furthermore, the ideas of biological (or quasi-biological) self-organization can be extended to the so-called “nonorganic” matter. For example, Alexander Cairns-Simth (1931–2016) in his book *Genetic Takeover and the Mineral Origins of Life* (Cairns-Smith, 1982) talks about some quasi-biological processes of self-organization and evolution occurring in natural clays, as if clays have some “inborn” instincts of survival and (quasi-Darwinian) evolution.

This book, as a prior work of Alexander Cairns-Smith, makes a particular emphasis on the role of isotopes and isotopic randomness (*isotopicity*) in the creative dynamics of nature. In view of the highly diverse biological world around us, we can conclude that our Mother Nature is highly imaginative and creative in using all available tools for its own ends.

There are likely some biological functions for practically all chemical elements of the periodical table (never mind, we may not know them all yet). Nature does not seem to miss any opportunity to use chemical diversity to the best possibilities. So, a similar question can be raised about isotopic diversity. Does nature efficiently utilize it in biology or in consciousness?

Our answer to this is that nature does indeed utilizes it (isotopic diversity), but we are yet to discover how exactly nature does this (that is, how nature utilizes isotopes). All that we have so far, are just plausible suggestions and indirect observations, but targeted experimental studies are still awaiting their future. More on this will be discussed later in this book.

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1.3 Making sense of the world

The said "smartness of nature" is reflected in our constant strive for understanding. People are eager to make sense of the world around them. Sources and tools for this (presumed or real) understanding are many. On one end, we find religious texts and practices, spiritual enlightenments, and metaphysical meditations, on the other end – scientific theories and models (such as Big Bang or self-organization theory and the chaos theory). People are looking for the "big synthesis" in many modes and forms.

Sometimes, it comes to using mixed metaphors combining religious (or spiritual) and scientific terminologies. Naming a recently discovered "Higgs boson" called the "God Particle" is just one example.

Likewise, the ideas along the line of *mathematics as a god* are discussed by many authors in a great variety of discourse modes (Dauben, 1977, 1979; Carloye, 1992; Davies, 1993; Tipler, 1994; Wolf, 1996; Plichta, 1997; Aczel, 2000; Livio, 2009).

Of particular interest is the intersection of the theory of infinite sets with theology and the idea of the infinity of god. Georg Cantor (1845–1918), founder of the theory of infinite sets, has identified some central points in this discourse in his correspondence with the key theologians of the time:

> ...he [Cantor] summarized the position commonly encountered in the seventeenth century: that the number could only be predicated of the finite. The infinite, or Absolute, in this view belonged uniquely to God. Uniquely predicated, it was also beyond determination, since once determined, the Absolute could no longer be regarded as infinite, but was necessarily finite by definition. Cantor's inquisitive 'how infinite' was an impossible question. To minds like Spinoza and Leibnitz, the infinite in this absolute sense was incomprehensible, as was God, and therefore any attempt to assign a basis for determining magnitudes other than merely potential ones was predestined to fail (Dauben, 1979, p. 123).

Thus, we express the view that the inquiry into the nature of physical foundations of the universe has a strong theological dimension (in spite that the ideas of "god" or "ultimate reality" have a broad variety of interpretations).

1.4 In the shadows of infinity

> *The fear of infinity is a form of myopia that destroys the possibility of seeing the actual infinite, even though it in its highest form has created and sustains us, and in its secondary transfinite forms occur all around us and even inhabits our minds.*
> Georg Cantor (1845–1918, German mathematician, founder of the theory of infinite sets, one of the cornerstone of modern mathematics)

> *Our knowledge can only be finite, while our ignorance must necessarily be infinite.*
> Karl Popper, Austrian–British philosopher (1902–1994), *Conjectures and Refutations*.
> (Karl Popper is generally regarded as one of the greatest philosophers of science of the twentieth century)

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All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed.Third, it is accepted as being self-evident.
Arthur Schopenhauer (1788–1860, German philosopher)

In the magnificent legacy of the great Spanish (Catalonian) artist Salvador Dali, one of his paintings stays most likely above all. This is his famous *The Persistence of Memory* that was painted by Dali (1904–1989) in 1931, at the age of 27, when he had many decades of his fantastic creativity still ahead of him. This breathtaking image, known to millions upon millions across the globe (also popularly known as "The Soft Watches" or "The Melting Watches"), has attained iconic status in the history or art of the twentieth century (Dali, 1942; Cowles, 1959; Descharnes and Neret, 2001; Salber, 2004).

As Dali's Russian-born wife and lifetime partner Gala so accurately and succinctly said, it is "a picture that, once seen, even for an instant, can never be forgotten." (Aguer et al., 2011)

It is pretty small for the typical museum standards (only 24 by 33 cm [9.5 by 13 in.]) and we can legitimately wonder what is the source of its mesmerizing power that had millions of its viewers so profoundly captivated. While there are books upon books offering a whole range of interpretations, for me it was always a coded image of the transcendence and infinity, an image in which a dichotomy of relativity (flowing and "liquid" time) and absoluteness (persistence and coexistence of all transient time moments) come into some eternal and atemporal unity.

A synthesis and antinomy of the decay and resurrection is what apparently drives so many people to it, not to mention quite a number of secondary imitations of the theme, as well as a big market of various household and kitschy items with similarities from T-shirts to alarm clocks and other gadgets. And the output of it can often be seen in many, sometime unusual, places from academic and business offices to artistic parlors and coffee shops.

(Because of copyright reasons, this picture is not reproduced in this book, but any interested reader can easily find this image [as well as other arts of Salvador Dali] on the web)

So, let me use this image as an key entry to the main topic of this book – the infinity and everything that goes along with it.

While the word *infinity* is among the most frequently used term, same time it is one of the most enigmatic term. Probably, the most enigmatic. Yet, thinking and contemplating about infinity quite often remains in the center of our meditations whether we consciously admit this or not. Some meditative techniques, particularly of eastern traditions, call for emptying you of all thoughts and as the teachings say will open your soul to the infinity of the universe. While not denouncing the legitimacy of such practices (everything has its place), this book suggests another alternative path: the path of analytic observation and intellectual reflection.

This author well realizes that it may not be an attractive path for all people (no book works "across the board", not even the Bible), but in his personal experience

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the path of intellectual contemplation certainly appeals to many. My discussion about these issues at numerous seminars, meet-up groups, and conferences convinced me to think deeply about things of infinity that may be an eye-opening experience to many. With these remarks, I offer this book to my readers.

So, what is this book about? The central aim of this is to unfold the notion of infinity in many of its specific forms and aspects as it appears over the course of history in human thinking, deep reflection, versatile scholarly pursuits by mathematicians and philosophers, and artistic imagery. The well-known words *In the beginning was the Word* (John 1:1), open a range of interpretations to the very word "word" (Logos). In particular, it can point to a number that has universal foundation and is the beginning of everything, even the universe itself. Later in this book, we will discuss the so-called "*Platonic Pressure Effect*" (PPE), which is a code term for the idea that the whole world (the universe) can eternally originate from the "urge" of the infinity of numbers to incarnate itself in what we call as the "world."

Curiously notice that the terms "word" and "world" differ in only one letter (in English). Likewise, in German "wort" and "welt" also sound pretty similar; I am sure, experts in linguistics can find close analogies in other languages, both modern and archaic. This generic similarity of the sounds may indicate some deep "metaphysical" communality of both these terms in human psyche (I did not do much search on this, but my guess is that some other thinkers and metaphysicians such as Carl Gustav Jung could make similar observations).

All this can open a deep contemplation and meditation if we can identify the infinite world of mathematics (ideal Platonic world of numbers and forms) with the idea of god of traditional religions. Some more thoughts on these ideas are discussed later in this book.

I would like to make it clear that I intend this book for philosophically inclined people and for people of all ages and persuasions, who have a taste and desire to contemplate about the matters infinite and eternal. And this, in my view, includes many people, perhaps millions upon millions, and not just "seasonal academicians" like me (apology for self-definition).

1.5 Mainstream and "fringe" science

No stones can ever fall from the sky, because there are no stones in the sky!

Antoine Lavoisier (1743–1794), the father of modern chemistry, when he was invited to chair a French Academy Committee to present his study reports of meteorites.

It is with some regret that I am putting here this quote. Is this not an irony of history Lavoisier said the above words (likely, under the pressure from some other members of this "committee")? However, let us take this well-known quote as a mere

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curiosity of a great scientist, the discoverer of oxygen, who lost his life by a guillotine during the French Revolution. "The Revolution does not need scientists" – as his judge allegedly said. Unfortunately, history repeats itself and other "revolutions" are often not better (e.g., deaths of many scientists and intellectuals in Stalin's gulags and Nazi camps). So, the truth often comes with pain.

And even apart from guillotines, similar blunders are common to the so-called "community of experts." More often than not "experts" and "academicians" are prone to the tunnel vision and extrapolate today's "common knowledge" to the future. In other words, apart from some exceptions, the so-called "experts" often fail to foresee the forthcoming changes and are pretty much resistive to anything that may overturn the apple cart for them (the way they see it, of course). There are numerous testimonies of such effects, following is just one short letter:

> When I entered Cornell in 1938, the curriculum in electrical engineering included only one semester of electronics. The faculty assured us that although we students were enthusiastic about ham radio, there was no future in electronics. All the jobs were in power engineering, power transmission and so on. Fortunately, I had learned from my high school experience not to be constrained by such rules and studied extra physics. Thus I learned Maxwell's equations (then actually opposed by the engineers) by listening to physics courses not in the electrical engineering curriculum. (Harry J. Lipkin, Weizmann Institute of Science, Israel [Physics Today, September 1990, p. 132]).

When I (the author of this book) was a student in the early 1960s, shortly after the discovery of lasers, I heard similar sentiments from learned academic heads that "lasers have no future" and "there is not much physics in them". Well, every frog knows its pond far better than the so-called "outsiders."

However, we have to go on with our quests to discover the universe. So, back to the depths of infinity and ultimate reality and meaning.

Our world, the world that we perceive, is enormously complex and diverse. Yet, despite all its diversities, it is still the case that all the stars and galaxies, crystals and minerals, and living creatures of all sizes and types, irrespective of our working definition of life, and ourselves included, are made of "just" several dozens of chemical elements. Thus, the amazing creativity of nature works on a rather limited resource base. It devises all its new structures and living beings without employing many chemical elements. This seems wasteful, but is this the case? Do all the one-day butterflies like us with all their gained experience really disappear without any trace and further meaning for the ongoing universe? Or, alternatively, does every single event, which has ever happened in the universe remain forever embedded in the overall cosmic dynamics? Could not the "past" really "coexist" with the "present" as the biologist Rupert Sheldrake suggests? (Sheldrake, 1988)

Two traditional diametrically opposite answers have been offered to these questions:

(1) Virtually everything has an eternal meaning
(2) The universe and human existence are meaningless

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Somewhat simplistically, these answers represent a “yes” and “no” for the quest for “Ultimate Reality and Meaning” (URAM) (Berezin, 1994b). First, “optimistic” viewpoint gives rise to various salvation theories; second, “pessimistic” one is exemplified by such classical myths such as *The Myth of Sisyphus* or the *Eternal Return* paradigm (Eliade, 1971). In fact, both positions are usually somewhat intermixed within a single metaphysical framework. This results in the dynamic coexistence of both URAM-positive and URAM-negative outcomes. For example, even within the most extreme materialistic doctrines of a purely random universe, the “only-matter-and-no-spirit” approach, there are often indications of basic universalities through concepts such as universal physical symmetries, primordial quantum vacuum, or intrinsically interwoven networks of “baby universes” as modern cosmology proposes (Weinberg, 1992).

No final solution “good for all” can likely be offered to this conundrum. Our purchase upon universal creativity (“URAM-positive” approach) will be considering “information” through an accumulated experience, which becomes “frozen” into the very fabric of the universe. Presupposed here is a human connectedness with the whole universe.

There is no impenetrable barrier between “natural” creativity and its human variety. Indications of this effort to explain our interest in being inherently connected to the whole universe and to have a place and significance in it would be the widespread idea of a supreme god in all major monotheistic religions, God-in-Nature (Albert Einstein); various polytheistic gods and goddesses concepts such as Gaia (James Lovelock); or the globally teleological, even Hegelian, idea of a Participatory Universe (John Archibald Wheeler).

My personal contribution to this ongoing effort to explain a universally creative dynamics is to focus on the informational aspects of the *isotopic diversity* of chemical elements as presented in many of my publications listed at the end of this book. To unify numerous aspects of isotopic diversity in physics, technology, engineering, informatics, biology, psychology, and other disciplines, I introduced an umbrella term “isotopicity” as a universal conceptual code for these ideas (Berezin, 1992b, 1994b, 1994c, 2015, 2016).

Isotopic diversity and its cognate concept of “isotopicity” (Berezin 1990b, 1992b, 1994b) is a subtle level of chemical diversity. This is one aspect of the ongoing study of physical foundations of mind–matter interactions, which is one of the most exciting topics in contemporary science. Recent literature on these interactions is abundant (Burgers, 1975; Herbert, 1985; Stapp, 1985; Utke, 1986; Jahn and Dunne, 1988; Penrose, 1989a, 1994; Radin and Nelson, 1989; Wolf, 1989, 1990, 1996; Berezin, 1990b, 1992a, 1992b, 1994a, 1994b; Berezin and Nakhmanson, 1990; Combs and Holland, 1990; Siler 1990; Stevens, 1990; Germine, 1991; Harris, 1991; Miller, 1991; Goswami, 1993; Radin, 2013). This list is certainly only partial and incomplete; many more books and papers can be added to it.

In this way, *isotopicity* provides a unifying heuristic link to connect organisms with atomic–molecular and, perhaps, with nuclear and subnuclear levels. It also

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mediates between the reductionist and holistic approaches to the mind–matter question both at the phenomenological and at the foundational level. The concepts used for this exploration of the nexus between our minds and matter will be *isotopic individuality* and *isotopic freedom* (Berezin, 1990b, 1994b).

Yet, if we really look without any pre-established bias at the real record of modern mainstream and established science regarding what it really can tell us about the most fundamental questions, the record does not look too encouraging. Modern scientific enterprises that are plagued with fads and fashions of the day, fierce competitions for research funding ("grantsmanship"), and (not that rare) data manipulation make it difficult for the non-mainstream novel ideas that do not fit into the "scientific correctness" of the day to get a proper hearing in the research community and even less to initiate any serious follow-up (Berezin, 1998a, 2001). Thus, the discussions on truly fundamental questions about the universe and our existence in it are generally relegated to the fringes or what can be called "metaphysical discourses". While here and there we can find some exceptions, but the author's experience says that these words pretty adequately describe the spirit of the modern "academia".

This is how the biologist Robert Lanza summarized the situation in his bestseller, *Biocentrism*. Following are the classic scienctific answers to basic questions:

> How did the Big Bang happen? – *Unknown*.
>
> What was the Big Bang? – *Unknown*.
>
> What, if anything, existed before the Big Bang? – *Unknown*.
>
> What is the nature of dark energy, which is the dominant entity of the cosmos? – *Unknown*.
>
> What is the nature of dark matter, which is the second most prevalent entity? – *Unknown*.
>
> How did life began? – *Unknown*.
>
> How did consciousness arise? – *Unknown*.
>
> What is the nature of consciousness? – *Unknown*.
>
> What is the fate of the universe; for example, will it keep expanding? – *Seemingly yes*.
>
> Why are the constants the way they are? – *Unknown*.
>
> Why are there exactly four forces? – *Unknown*.
>
> Is life further experienced after one's body dies? – *Unknown*.
>
> Which book provides the best answers? – *There is no single book*.
>
> Okay, so what can science tell us? A lot – there are libraries full of knowledge. All of it has to do with classifications and sub-classifications of all manner of objects, living and non-living, and categorizations of their properties, such as the ductility and strength of steel versus copper, and how processes work, such as how stars are born and how viruses replicate. In short, science seeks to discover the properties and processes within the cosmos. How to form metals into bridges, how to build an airplane, how to perform reconstructive surgery – science is peerless at the things we need to make everyday life easier. So those who ask science to provide the ultimate answers or to explain the fundamentals of existence are looking in the wrong place – it is like asking particle

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> physics to evaluate art. Scientists do not admit to this, however. Branches of science such as cosmology act as if science can indeed provide answers in the deepest bedrock areas of inquiry, and its success in the established pantheon of other endeavors has let all of us say, 'Go ahead, give it a go.' But thus far, it has had little or no success. (Lanza and Berman, 2009, pp 155–6)

We see from the above-mentioned list (many more items can be added to it) that "science" (or "Science" with capital "S") has an astonishingly poor performance in attempts to give definite answers to practically any *really* important quest of our existence. Even the only (rather weak and uncertain) "yes" in the above-mentioned list (will the universe keep expanding?) have loose ends (no definite proof of "eternal expansion" actually exists). Thus indeed, the record of science concerning fundamental questions of existence indeed seems quite miserable. And yet, in no way should the above-mentioned "devastating" quotation be taken as a discouragement of our continuous quests on these matters. However, the angle of these quests should not, perhaps, be confined to the mental straitjackets of the orthodoxies of the "mainstream science."

On a similar wavelength, British biologist Rupert Sheldrake, known for his "nonorthodox" theories of evolution and controversial *Morphic Resonance* hypothesis (*Nature Magazine* at one point suggested that his books should be burned) explains that contemporary science is based on the claim that all realities are either "material" or "physical". Within this position, there is no reality but material reality. Consciousness is a by-product of the physical activity of the brain. Matter is unconscious. Evolution is purposeless. God exists only as an idea in human minds, and hence in human heads.

In his recent book *Science Delusion* (2012) that apparently paraphrases the title of the earlier 2006 bestseller *God Delusion* by Richard Dawkins, Sheldrake outlines "10 key dogmas" (core believes) that are almost universally held among members of the mainstream scientific community. They are as follows:

(1) Everything is essentially mechanical. Dogs, for example, are complex mechanisms, rather than living organisms with goals of their own. Even people are machines, "lumbering robots", in Richard Dawkins's vivid phrase, with brains that are like genetically programmed computers.
(2) All matter is unconscious. It has no inner life or subjectivity or point of view. Even human consciousness is an illusion produced by the material activities of brains.
(3) The laws of nature are fixed. They are the same today as they were at the beginning, and they will stay the same forever.
(4) The total amount of matter and energy is always the same (with the exception of the Big Bang, when all matter and energy of the universe suddenly appeared – though nobody so far was able to provide any convincing physical argument on how exactly it could have happened).
(5) Nature is purposeless, and evolution has no goal or direction.
(6) All biological inheritance is material, carried in the genetic material, DNA, and in other material structures.

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(7) Minds are inside heads and are nothing but the activities of brains.
(8) Memories are stored as material traces in brains and are wiped out at death.
(9) Unexplained phenomena such as telepathy are illusory.
(10) Mechanistic medicine is the only kind that really works.
The following comments by Sheldrake explain the reasons why the above-mentioned beliefs are almost universally accepted as axioms within the mainstream science community.

He states that when you look at each of these scientifically, you see that every one of them can be questioned. As Sheldrake says,

> these beliefs are so powerful, not because most scientists think about them critically but because they don’t. The facts of science are real enough; so are the techniques that scientists use, and the technologies based on them. But the belief system that governs conventional scientific thinking is an act of faith, grounded in a nineteenth-century ideology. Together, these beliefs make up the philosophy or ideology of materialism, whose central assumption is that everything is essentially material or physical, even minds. This belief-system became dominant within science in the late nineteenth century, and is now taken for granted (Sheldrake 2012, pp. 6–9)

As far as the nature of consciousness is concerned, the above-mentioned premises 2,7, and 8 (and, to some extent 9) fall into the center of this discussion. In spite of the fact that for many people the above-mentioned dogmas seem obvious and unquestionable, in many cultural traditions we can find long-standing aspects, which are in strong disagreement with them.

Especially point 2 (claiming that all matter is unconscious) stands against almost all native and spiritual traditions. They all are rich of rituals and worships of what we commonly see as inanimate objects that are void of life and less so consciousness. For point 7 (“minds are inside brains”), we humans, do not generally have an up-front intuition that our consciousness (mind) is “inside” our brains. In fact, with our knowledge of anatomy, we may not even know that we have brains. It points toward that in some cultures it was a widespread thought that consciousness is located in the heart.

All the above-mentioned dogmas do not necessarily deny the usefulness of the mainstream science in the progress of our understanding of some sides of consciousness and intelligence. Yet for the most part, the reductionistic inferences drawn from the mainstream science are as a rule built around informational and energetic characteristics and metaphors.

So, psychologically, for the majority of the “mainstream” scientists to question any of the above-mentioned dogmas is the same as to question the articles of faith in a religious congregation (we all know the consequences of this). It is so much more convenient to accept them as axioms than to let any “intruders” dig under these “established truths”. This, in my view, is the prime reason of the peer review (PR) intolerance to the new (and often seemingly “radical”) ideas.

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1.6 Peer review and suppression of new ideas

Any fool can criticize, condemn and complain and most fools do.
Benjamin Franklin (1706–1790)

So, psychologically, questioning majority of the "mainstream" scientists about any of the above-mentioned dogmas is the same as to question the articles of faith in a religious congregation (we all know the consequences of this). It is so much more convenient to accept them as axioms than to let any "intruders" dig under these "established truths". This, in my view (and in the view of many other people), is the prime reason of the "peer-review" intolerance to the new (and often seemingly "radical") ideas (Savan, 1988; Horrobin, 1990; Arnold, 1992; Forsdyke, 1993; Gordon, 1993; Berezin, 1998a, 2001; Osmond, 1983).

However, alas, there is more to it. There is quite a tricky item here called "integrity". Well, most people intuitively know what is meant by "integrity," and most of us strive to keep ours. We normally get very upset and may be even ashamed when our "integrity" is questioned. However, the boundaries here are pretty fuzzy. Our other emotions and desires can easily interfere here. And whether we like it or not, among our prime emotions are vices such as fear, greed, jealousy, envy, arrogance, and self-aggrandizement (list can go on and on) that are often peculiarly mixed with our "superiority" and/or "inferiority" complexes. For sure, it is granted that we all may have them in different levels and brands, but again the question: Who can claim a complete immunity of all (of even any) of them?

And here is where the *anonymity* of "peer review" ("Anonymous Peer Review", APR) makes it a dirty job on humans who are involved in this process. Yes, anonymity can corrupt as it often does, and the PR is no exception (Berezin, 1998a, 2001). People protected by the veil of anonymity may well have a temptation of letting all (or some) of the above-mentioned emotions to take the lead. It opens the door for a "classic triad" of narcissistic symptoms – grandiosity, which is the need for admiration and lack of empathy.

And when the so-tempted people (peer reviewers) see something that looks "unusual" or is at odds with the accepted dogmas and paradigms (the way they see it), the predictable reaction instantly sets in. Something like: "If I have never heard of this (idea, hypotheses), it just cannot be true." And by default, it must be false! And who is this "author" (or a grand applicant) trying to tell me ("Me"!) something that I do not know? To *me* – who is an expert of the highest class! And, of course, the result is standard – reject, do not publish, and do not fund.

However, on top of the above-mentioned reaction that is grounded on the "superiority complex" (and, perhaps, overinflated ego and self-aggrandizement), something else may creep in here. In spite that (usually, at least), peer reviewer gives a reject verdict on a *rational* basis (or so it appears to him or her); on the *intuitive* (or, say, subconscious [Freud?]) level something else may be looming deep down in the

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peer reviewer’s mind. This is a kind of fear complex“but what if this author (or an idea) can indeed turn out right?” How than it may reflect on me, on my reputation, and so on? And here we should notice that no “anonymity” is absolute, leaks may and do happen. And even peer reviewers themselves are not bound by the oath of silence.

There are many critical articles and letters about the suppression of new ideas and enforcing the conformism by the “APR”. Any interested reader can find a lot of such materials on the web.

Enough to mention is a telling title of one (relatively old) letter: “Peer Review and the Axe Murderers,” Michael Kenward, *New Scientist*, May 31, 1984, p. 13.

Adding to this, often “crazy ideas” are dismissed in an open literature as well. There is a whole industry with magazines such as *Sceptic Inquirer* and “big names” dedicated to the shredding of new and speculative ideas. An example is a curious editorial in *Nature* magazine (September 24, 1981) written by the then *Nature* editor Sir John Maddox titled *A Book for Burning* where it was suggested (perhaps, allegorically, but still) that Sheldrake’s book on morphic resonance should be burnt. Of course, Giordano Bruno and Galileo may well come to our mind in this regard, in the world of Heinrich Heine, “Where they burn books, they will end up burning people.”

So far, in suppressing new and innovative ideas, “APR” (Who and where it was invented?) follows the often-practiced recipe:

> The mass trials have been a great success, comrades. In the future, there will be fewer but better Russians. (Greta Garbo in “Ninotchka”, 1939)

1.7 Myth of “experts”

Let us hear from the “experts” – that is the people who, by definition, should know better:

> *Inventions reached their limit long ago, and I see no hope for further development.*
> Julius Frontinus (famous Roman engineer, first century AD)

> *I think there is a world market for maybe five computers.*
> Thomas Watson (1874–1956, Chairman of IBM, 1943).

> *Computers in the future may weigh no more than 1.5 tons.*
> *Popular Mechanics*, forecasting the relentless march of science, 1949

> *Radio has no future. X-rays will be prove to be a hoax.Heavier-than-air flying machines are impossible.*
> Lord Kelvin (1824–1907, President of the Royal Society)

The above-mentioned remarkable quotes (many more like them are around) show that even “top people” who are supposed to “know better” are capable of making

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utterly wrong claims, especially in the area of predictions. However, to be fair to some of them, it should be noted that Lord Kelvin (William Thomson), a great scientist with many major contributions to physics and thermodynamics (e.g., absolute temperature scale and “degree Kelvin”), has later recounted his statement about X-rays quoted earlier and even had his own hands X-ray scanned.

And it is with some regret that I am putting Lavoisier’s quote here. Is that not an irony of history that Lavoisier said the above-mentioned words (likely, under the pressure from other members of this “committee”)? But let us take this well-known quote as a mere curiosity of a great scientist, who was the discoverer of oxygen, who lost his life on a guillotine during the French Revolution. “The Revolution does not need scientists” – as his judge allegedly said.

Unfortunately, history repeats itself and other “revolutions” are often not much better (e.g., destruction of many scientists and intellectuals in Stalin’s gulags or Nazi camps). So, the truth often comes with pain.

Yes, nowadays those “radical” grant applicants whose proposals were scorned and dust-binned by “anonymous APR” are normally not burned on stakes or sent to a guillotine... Yes, perhaps... But, again, what about some outstanding biologists who – yes! – were *physically* eliminated (shot, died in Gulag) who dared to oppose Trofim Lysenko and his gang not that long ago! (terrorism of “*Lysenkovschina*” in *Soviet biology* lasted till mid 1960s!).

For some people who may be nourishing new and original ideas for years and whose proposals were dust-binned by the APR, psychological and personal trauma may be so acute (plus, a possible feeling of shame and personal failure) that they, perhaps, may prefer a guillotine or some equivalent of such a “final solution”. I am personally unaware of suicides due to negative decisions of APR, but will not be surprised if such cases do indeed exist.

And even leaving aside Gulags and guillotines, similar blunders are common to the so-called “community of experts”. More often than not “experts” and “academicians” are prone to the tunnel vision and extrapolate today’s “common knowledge” to the future. In other words, apart from some exceptions, the so-called “experts” often fail to foresee the forthcoming changes and are pretty much resistive to anything that may overturn the apple cart for them (the way *they* see it, of course). There are numerous testimonies of such effects, here is just one short letter:

> When I entered Cornell in 1938, the curriculum in electrical engineering included only one semester of electronics. The faculty assured us that although we students were enthusiastic about ham radio, there was no future in electronics. All the jobs were in power engineering, power transmission and so on. Fortunately, I had learned from my high school experience not to be constrained by such rules and studied extra physics. Thus, I learned Maxwell’s equations (then actually opposed by the engineers) by listening to physics courses not in the electrical engineering curriculum. (Harry J. Lipkin, Weizmann Institute of Science, Israel [Physics Today, September 1990, p. 132]).

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When I (the author of these lines) was a student in early 1960s, shortly after the discovery of lasers, I heard similar sentiments from learned academic heads that “lasers have no future” and “there is not much physics in them”. Well, every frog knows its pond far better than the so called “outsiders.”

And sometime, “nonexperts” do even better than the “real” experts. Here is another pair of contrasting quotes:

> We cannot control atomic energy to the extent which would be of any value commercially, and I believe we are not likely ever to be able to do so. (Ernest Rutherford [1871–1937], his speech to the British Association for the Advancement of Science [1933])

> The phenomenon of radio-activity leads us straight to the problem of releasing the inner energy of the atom (...) The greatest task of contemporary physics is to extract from the atom its latent energy – to tear open a plug so that energy should well up all its might. Then it will become possible to replace coal and petrol by atomic energy which will become our basic fuel and motive power. (Leon Trotsky [Lev Davidovich Bronstein, 1879–1940], his speech on March 1, 1926)

These two above-mentioned quotations, which were spoken at about the same time and came from two different individuals who both are world renowned (though for quite different reasons), could not be more diametrically opposed to each another. The great physicist Ernest Rutherford, the discoverer of the atomic nucleus, expressed his disbelief in nuclear energy just a few years prior to the discovery of the first nuclear reactor. And the second quotation, if the signature was removed from it, could well be thought of as coming from someone like Enrico Fermi, who was among the first designers of the first working reactor.

A fairly similar collection of contradictory quotations showing all grades of pessimism and optimism can be found nowadays on the issues of the so-called “cold fusion” and on such controversial topics such as “water memory” or foundations of “alternative medicine” (“energy medicine”).

1.8 “Experts” versus “rebels”

> *Faced with the choice between changing one’s mind and proving that there is no need to do so, almost everyone gets busy on the proof.*
> John Kenneth Galbraith (1908–2006)

Yes, the record of science concerning the fundamental questions of existence indeed seems quite miserable. And yet, in no way should the above-mentioned “devastating” quotations be taken as a discouragement of our continuous quests on these matters. However, the angle of these quests should not, perhaps, be confined to the mental straitjackets of the orthodoxies of mainstream science. To that end, recent (and often fascinating) speculations regarding the “world as simulated reality” and such ideas as the “matrix” and artificial (machine-based) consciousness have stirred a high-level philosophical discourse that are actively discussed in media and entertainments.

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To this effect, I have always been, and I remain, on the side of those who believe that unusual and off-mainstream ideas and suggestions should be heard and studied rather than dismissed outright as "rubbish" without even being permitted for a hearing. The history of science provides many confirmations on this. It is full of examples of premature dismissals and the ridiculing of unorthodox ideas because they did not fit, as in the famous Lavoisier's quote mentioned above "no stones can ever fall from the sky".

In my short article "Radical ideas should not be prematurely dismissed" (*American Physical Society News*, 1994), I concluded with an episode on how one of the founders of quantum physics, Niels Bohr, once replied to a reporter who was teasing him. This reporter asked Bohr about the horseshoe nailed over the door of his summer cottage. "Surely, Professor Bohr, you don't believe such nonsense as a horseshoe bringing luck to its owner?" To this, Bohr replied, "Of course, I don't. But they say it works even if you don't believe it."

1.9 Winner-take-all society

The dominant paradigm of the society is reflected in many (and often peculiar) ways in psychology and behavior of individual members of the society. This means, basically, all of us. Apart from some exceptions, the mentality ("Zeitgeist") of the modern globalist society is dominated by the cult of celebrities, the worship of success and conquest, and an almost unquestionable acceptance of the "Winner-Take-All" *modus operandi* (Robert H. Frank and Philip J. Cook, *The Winner-Take-All Society: Why the Few at the Top get So Much More Than the Rest of Us*, New York: Penguin, 1996).

Some dissent voices that are notwithstanding, we take it as a self-event axiom that "people on top" are entitled and deserve to have much more (so, so much, much more!) than the rest of us. Any newsstand at the supermarket counter demonstrates this without any trace of doubt.

And understandably, this "get-to-the-top" social call slips down to many (perhaps most) of our institutions, business models, and the overall culture in a broad sense. To this list, we can include arts, music, fashions, entertainments, sports, publishing, and – to a large degree, at least – such intellectual activities as scientific research (natural sciences, medical and health research, etc.) and perhaps even areas such as sociology and philosophy.

Granted, not all of us react similarly to the above-mentioned factors of social conditioning and there is a broad spectrum of individual responses. Yet none of us lives in a total isolation of all these impacts. We all live in a world full of teasing temptations and forbidden fruits.

And how it all reflects on our ethical and moral stance, our integrity, and our judgment on the worth of others when we are called to make such a judgment. In

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science, to render such a judgment is what we usually call "peer review," which (with some rare exceptions) is at the core of the modern research funding system.

1.10 Physics and cultural studies: Alan Sokal fails to convince me

As an example of the "Peer Review" controversy, here is my earlier (1996) essay on so-called *Alan Sokal Spoof.*

(1) Any scientist who plans and performs an experiment is running a risk, especially if the experiment is unusual and uses such a nonstandard research tool as a spoof.

Alan Sokal, professor of physics at New York University, claims that he has successfully demonstrated incompetence by the so-called social critics of science ("deconstructivists"). He submitted to the journal, *Social Text*, an article proposing some radical and far-reaching approaches to some "hot" and contentious issues of novel physics in an ostensibly postmodernist-friendly context (Sokal, 1996a).

His article made a number of superficially interesting points on alleged links between quantum gravity, chaos theory, holism, interconnectedness, cultural studies, feminism, and so on.

This article is well written, stuffed with extensive comments, contains a rich bibliography, and aims to project the impression of a high-level academic sophistication.

(2) Immediately after the article was published, Alan Sokal publicly refuted it as a deliberate spoof (Sokal, 1996b). While tipping his hands, he explains the motives behind his "experiment." His original article contains some crude (so he says) blunders, the absurdity of which should be clear to any qualified physicist. He argues that the fact that this scientifically unsound article slipped easily through the PR process in *Social Text* demonstrates the incompetence of the "holistic–feminist–deconstructivist" paradigm as a mode of inquiry. The new agistic silliness of the latter package is, therefore, proven beyond doubt. The case is closed now.

(3) I feel that the results of his experiments are far less convincing than what he originally intended; his parody, though clever and amusing, fails to dismiss the substance of the criticism raised by many of the scholars he quotes.

(4) In the beginning of the eighteenth century, Jonathan Swift in *Gulliver Travels* made a brilliant attempt to ridicule the physics of his archrival, Newton. Even though Swift's description of scientists in Laputa is among the best pieces of satire in the world's literature, his parody certainly failed to stop the development of experimental science.

Likewise, Alan Sokal's acknowledged his hopes to portray the recent constructivist criticism as an anti-intellectual and scientifically unsound movement,

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which is not likely to crush it. The problems addressed by the cultural critics are too serious to be dismissed by a spoof. Even if the spoof is written by a talented individual.

(5) As a physicist, if I were to review Sokal's paper, I would quite likely view several of the bold assumptions that the paper contains as utterly speculative (e.g., the claimed links between gravity and hypothetical Sheldrake's morphogenetic field).

Nevertheless, I still would consider them as relatively peripheral transgressions and perhaps even leave them "as is" in order to let the author to argue his views in full. Most of what Sokal says about quantum nonlocalities, Planck-scale cosmology , catastrophe theory, and so on, falls reasonably well within the range of the ongoing debate in numerous "mainstream" papers.

(6) Yes, there are some few crude (deliberate, as we know now) "traps" in his *Social Text* opus, but not at a significantly higher concentration than often can be found in "normal" peer-reviewed articles in physics journals.

PR notwithstanding, cases of hair raising unprofessionalism, or frivolous violations of the established laws are not completely rare in the mainstream technical literature, including the "best quality" journals.

Submission of papers to an academic journal is based on trust. Or at least, it should be so. When a physicist with an international reputation submits his transdisciplinary thoughts to a non-physics journal, the editors have reason to take it at face va1ue.

Correspondingly, Sokal's accusations of the social scientists' "intellectual laziness" (Sokal, 1996b) are pointless.

(7) His spoof demonstrates nothing of substance. Regardless of Sokal's subsequent recant, his original article is an interesting, thought provoking, and a bibliographically resourceful text. It certainly is not going to be the last word in a deconstructivist discourse and perhaps even will add fuel to it. If so, Alan Sokal should be credited for his efforts, even if his original intentions were different. In my opinion, the goal of Sokal's experiment, which on his own admission was to demonstrate the spectacular credulity of the editorial board of the *Social Text*, has not been reached. His article is far less a parody than he himself apparently believes.

1.11 Prime numbers and isotopes: digital relatives

The book that I offer now to my readers has several themes. As an interdisciplinary scientist for much of my academic carrier, I was always thrilled to connect seemingly disjoint topics. And most important, to look for the common aspects in them. The two major themes of this book are (1) the infinity of prime numbers, and (2) the role of the diversity of isotopes (*isotopicity*) in biology, creativity, spirituality, and in some

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areas of alternative medicine, primarily in homeopathy (water memory) and healing crystals.

Being rather active in the above-mentioned areas with more than 50 research publications in major science journals, I now venture to suggest some common grounds for two of the above-mentioned areas, (1) and (2). The common grounds, that, I believe, so far were overlooked or not clearly emphasized. So, what can be a strong conceptual link between the prime numbers and isotopes? What make these two, so to say, "metaphysical relatives?"

For the clue, we have to first of all look at the time we live in. We have several "titles" for it, but one that is probably most often used is "digital age". Not a day (and for many, not even a minute) can we spent without touching or using something "digital". Computers, cell phones, online banking, photo cameras, credit cards … you name, and a lot more, all is profoundly "digital."

While the original meaning of the word "digit" is finger, a reminder on how we count small items using our fingers is now extended to mean long digital strings such as 00101001110101001, which is an efficient way to keep and carry the information by electronic devices. And that is what makes prime numbers and isotopes "generic relatives." In short, isotopes of carbon, oxygen, and other elements incorporated in genetic structures (e.g.,DNA) can be "read" as digital entities that affect all informational processes in the living systems. Likewise, prime numbers that pop up here and there on the infinite number line 1, 2 ,3, 4, 5, 6, 7, 8, 9, 10, 11,…[to infinity] act as "digital milestones" in the infinite Platonic world of numbers. More on these connections will be discussed later in this book.

The review of the "*isotopicity principle*" (developed by this author in a series of papers) begins with a reminder that the information carrying strings in all living systems (at all levels of complexity) operate on the combinations of several base units that, in turn, consist of several key chemical elements. The prime elements in DNA and RNA bases are hydrogen (H), oxygen (O), carbon (C), nitrogen (N), and phosphorous (P). Out of these five key elements, only phosphorous has a single stable isotope, whereas all other elements have either two (H, C, N) or three (O) stable isotopes. Natural hydrogen is a mixture of light (one proton) H (99.985 %) and a heavy (proton + neutron) deuterium (0.015%), carbon is a mixture of C12 (98.89%) and C13 (1.11%), oxygen has 3 stable isotopes: O16 (99.756%), O17 (0.039%), and O18 (0.205%), and nitrogen has 2 stable isotopes: N14 (99.64%) and N15 (0.36%).

Elementary combinatorial analysis leads to an enormously large number of possible isotopic permutations within chemically fixed structures. For example, a small segment (less than 1 mm) of a DNA string with 1 million carbon atoms has about 10,000 randomly distributed C13 atoms. The number of isotopically distinguished distributions (the number of possible placements of the 10,000 atoms among 1,000,000 sites) is about 10E24000 (yes, 10 to the power 24,000 [!]). This is a far (far !) greater than the number of atoms in the universe; the latter is estimated to be "only" between 10E90 and 10E100.

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Furthermore, if we include the spatial arrangements that can be produced by point substitutions in other stable isotopes, such as O16 by O17 and O18, or N14 by N15, the possibilities for information transfer and information diversification carried parallel to “macros” information (such as the genetic transcription of codons or chromosomal crossover) increase enormously (“tower exponentially”: here we can recall the famous “Skewes number” [10^10^10^34], which is explained in many Google posts).

Thus, the information coded in the distribution of isotopes can, by many orders of magnitude, increase the information capacity of genetic structures in comparison with what is contained in the “regular” combinations of prime bases (codons). This is the central idea of the “isotopic genetic code” as was argued by this author in many of his publications.

In this context, the key quest can be formulated in the following way:

Can isotopic permutations in DNA chains enhance the information-carrying capacity of DNA segments over and above what is carried by the “regular” chemical diversity? In other words, can different stable isotopes of the key elements (H, C, O, N) be “read” as distinct “letters” of the genetic alphabet? (To remind – isotopes of the same element are macroscopically different in mass, magnetic moments, vibrational frequencies, etc.).

The book further discusses the mathematical and physical analogy of information-carrying isotopic strings (*digital isotopicity*) and the infinite string of prime numbers that, according to numerous authors, forms an absolute (“Platonic”) code for the self-organizational dynamics of the universe.

1.12 Isotopicity meme

In the view of this author, the idea of *isotopicity* has a quality and nature of meme. The concept of meme was introduced by Richard Dawkins in 1976 in his book *The Selfish Gene* as an efficient working metaphor in discussing the propagation of almost anything in the human society, from fashions to popular current language idioms and house decorations. While the origin of this concept lies in the evolutionary biology as a vehicle for propagation of (generally useful) mutations, its use can be extended to many other areas, including fashions, dominant architectural styles, and even popular, or “cool” (at time) conversational idioms. From physics standpoint, the dynamics of meme propagation has similarity with propagation of light waves according to *Huygens principle* (each point of the light front becomes a source of the secondary emission). Our conceptual framework calls for the connection of these ideas to the notions of mathematical Platonism and Jungian archetypes.

Although in a wider sense, the term *isotopicity* can refer to both stable and radioactive isotopes, in the present book we are focusing primarily on stable isotopic diversity. Two complimentary sides of isotopic diversity are of key interest at the micro- and nano-level. These are (1) isotopic randomness and (2) *isotopic correlations*.

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Chapter summary

The so-called “mainstream science” does not, and most likely cannot, provide satisfactory answers to major quests about the universe and our life. For this, our better bet is to turn to metaphysics and philosophical contemplations. We usually get more ideas on the nature of time, space, and eternity from the artistic imagery than from science. One example is of an iconic picture *Persistence of Memory* (Soft Watches) by Salvador Dali. The infinity of prime numbers as an eternal digital code of the universe, gives us an anchor to hold on. The ideas centered around the notion of ultimate reality and meaning (URAM) open another broad avenue for our meditative reflections. Connections between the ideal Platonic world and our physical and biological existence in the material bodies can be amplified by the ideas of *isotopicity* and isotopic genetic code as discussed further in the book.

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2 Quantum metaphysics

Without a trace of irony, I can say I have been blessed with brilliant enemies.
I owe them a great debt, because they redoubled my energies and drove me in new directions.
Edward Osborne Wilson (b. 1929, an American biologist and author)

This book reflects on a number of ideas and issues related to our existence and our experience in the infinite universe. I feel that I can make my narrative more strong and impactful if I draw it, at least partially, based on my own experience as an "unorthodox" (or "nonorthodox") quantum physicist. For that matter, in the following paragraphs, I present a miniautobiography primarily focused on how the ideas presented in this book have stemmed from my work of 50 years in quantum physics (my first paper on quantum physics was published in 1967, at the age of 23).

Now, after reading the aforementioned passage, most likely the natural reaction will be "if this guy aims so high, he is likely just bragging." I don't mind such an initial reaction and well understand it. I am well aware that any scientist who attempts to write a summary of his (or her – let me be fully "politically correct" in my expressions) work can be accused in self-gratification, blowing up his (her) own importance, or committing some other similar transgressions. In no way, I claim an exception from anything of that kind. But so be it – I believe unfolding the ideas in this book will be more engaging and penetrative if I connect these with my own personal path in science. And my readers, no matter how close or how far they may be to (or from) the so-called professional science, will draw a stronger long-term effect from my presentation if I expose my own history of how these ideas came out of my own work.

2.1 Quantum roller coaster of a nonorthodox physicist

Since I don't have any scientific reputation to lose, I can say what I please without giving a damn about what the professionals think of it.
Arthur C Clarke (1917–2008)

Whenever you find yourself on the side of the majority, it is time to pause and reflect.
Mark Twain (1835–1910)

You will never reach your destination if you stop and throw stones at every dog that barks.
Winston Churchill (1874–1965)

First of all – and without claiming any badge of honor – let me explain what I mean (or usually meant) by a "nonorthodox physicist" or a "nonorthodox" scientist in any

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area of study. There are many of us – here and there; now and in the past; and, hopefully, in the future too. What does it mean to be a “nonorthodox”? Is it a self-definition or is it something that “others” have to tell about you? Well, probably, a bit of both. And also, who are the “others” to “admit” you to such a club? I mean the club of nonorthodoxy. And like in any club, there are various grades and ranks that may be awarded or assigned to the members, formally and informally.

Well, like always, the best way to introduce a concept is to start with examples. Who are (were) the “nonorthodoxians” of the first order? People known to the whole world for their “crazy” or “weird” ideas? (or no, no, I am begging my readers to count myself among them, all I want it to point to some generic similarity!).

Probably, the best household name here to start with will be *Nikola Tesla* (1856–1943). Almost everybody knows who he was, and so there is no need for me to introduce him. Dozens (or, perhaps, hundreds?) of books about him and among his “peer group” he still was quite lucky – the unit of the magnetic field is called after him (Tesla, T). It is a pretty sizable unit; the magnetic field of 1 T (one Tesla) is produced by big industrial magnets. The Earth’s magnetic field is about 5 × 10^−5 T or 50 mkT (mkT, *microtesla*).

Other “nonorthodoxians” may probably be a bit less known, but some of them are still quite often mentioned. As for the units named after them they were not so lucky. Nothing is named after them (not yet, at least). The “peer group” is quite large here: people like *Wilhelm Reich* (1897–1957), with his ideas of “*Orgon*” as a universal bioenergy; *Louis Kervran* (1901–1983), who suggested that plants can transmute chemical elements – a kind of a precursory to the “cold fusion” activity that still goes on nowadays; *Immanuel Velikovsky* (1895–1979), with his ideas that the Earth and solar system came through major planetary rearrangement in the historical time (actually, his book on that was among top bestsellers for years); or the French immunologist *Jacques Benveniste* (1935–2004), with his experiments on “*water memory*” that (indirectly) seemed to support homeopathy. Many (many!) more names can be added to this list.

All of them had hard time with the (so-called) mainstream science (“academic”) community. That is, for example, a comment on Louis Kervran (Wikipedia): “Kervran proposed that nuclear transmutation occurs in living organisms, which he called ‘biological transmutation.’ Proponents of biological transmutations fall outside mainstream physics and are not part of the scientific discourse.” Again, who and by whose authority determines what are the limits of “mainstream physics” or what is the “allowed” scientific discourse?

Any interested reader can find similar comments on any (many!) of such people who are collectively labeled as “pseudoscientists” (other words are often used as well, “crackpots” is among the most favorite).

Yet there are words of dissent in a qualified defense of “unorthodox” claims and ideas. Philosopher Paul Feyerabend (1924–1994) in his book *Against Method* posits

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that the "consistency criterion" in science is biased toward orthodox views ("think as we are"). Instead of outright upfront dismissal and rejection, new and radical ideas should be given much more investigative hearing than they usually have. Especially, that the history of science so clearly demonstrates that some (actually, quite many!) of the theories and ideas that originally were ignored, dismissed, and ridiculed were, in fact, later found not only to be true as such but also became major contributions to our knowledge of the world.

One of the best examples of that is the hypothesis of the continental drift that was proposed by Alfred Wegener (1880–1930) in 1912. At that time, it was almost unanimously rejected by the scientific community, but later (on the basis of geological evidence) was accepted as one of the prime corner-stones of the modern geophysics. Never mind that similar ideas were voiced centuries before; for example, a Flemish cartographer Abraham Ortelius in 1596 has noticed that the shapes of the shorelines of West Africa and East South America seem to make a good match and suggested that these continents were at one time connected. Later, a number of philosophers and scholars (e.g., Alexander von Humboldt, 1769–1859) said the same thing.

Now, let me take my turn and talk a bit about my own path in science. Please don't mind a few repetitions that may pop up along the way.

My entry to the physics world was probably quite typical – nothing that extraordinary, except a few curious ("crazy"?) exceptions in my school years. For example, when I was about 10 or so, I was in a summer camp where I met my friend Sergey Mamaev (who later became a known particle physics theorist). While we did there most of the stuff other 10-year-old kids do, we also did something extra. We have learned (by heart!) the entire periodic table of elements (100 or so of them), which was known in Russian as "Mendeleev's table." I must admit that now, at the age of over 70, I will not be able to reproduce it by memory (and who can?) but at that camp time (and later) me and Sergey were known as "Ah… these are the boys who learned Mendeleev's table." Of course, many people know by heart a lot longer things than that (poems, stories, etc.) but what I and Sergey did was, I believe, relatively unusual and with all due humility I now can recall this as my first try in the "nonorthodox club."

Then the university years started, and both I and Sergey had no second thought where we wanted to be; of course, theoretical physics at the Faculty of Physics at Leningrad (now Saint Petersburg) University. Again, not claiming any superiority (there were some 40 or 50 students theoreticians at the department of theoretical physics in any particular year), we both have made it there, to the department that at that time was headed by the academician Vladimir Fock (1898–1974) who made outstanding contributions to quantum physics (Hartree–Fock method for calculating the atomic structure) and coauthored some papers with Paul Dirac – one of the key figures in the quantum world.

Yet, my and Sergey's paths were somewhat parted – I went to the subsection of quantum mechanics (theory of atoms, molecules, and crystals), while Sergey's choice

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was high-energy physics (elementary particle physics) and he went to become a well-known theoretician in this field. Unfortunately, he passed away in 1985 at the age of only 41.

My first work as a graduate student was published in 1967, at the age of 23. This was the same year that I got married to a wonderful woman Irene (1943–2005) with whom I had 37 years of a happy life till she passed away of cancer in April 2005. She was also a graduate student in biology and went on to become a successful biomedical scientist and an experienced electron microscopy researcher. In the USSR at this time, the term "graduate student" was not used and we were called "aspirants." The successful completion of "aspirantura" leads to a science degree called "Candidate of (discipline's name)." Correspondingly I and Irene both ended up as the candidate of physical-mathematical sciences and candidate of biological sciences, respectively. We both defended our theses in 1970, two months apart from each other. In the Western (American and Canadian) academic system, our candidate degrees were counted as PhD degrees.

Now I want briefly to give an overview of my research work for my entire active research carrier (1967 to approximately 2011) and to indicate metaphysical and philosophical overtones in many (practically all) research projects I was involved with. Without unduly bragging or self-glorification, I still want to state that it was perhaps in the nature of my personality to venture to the speculative and hypothetical domains in any of my work that went along. So to say, I had (and still have) an urge and propensity to always look "outside the box" in any problem I was dealing with.

My interests and involvement with what "mainstream science" usually counts as "fringe issues" (other terms are often used as well) has put me into the category of "nonorthodox" scientists who often come up with the ideas that "do not fit." Without claiming any specific honor in this regard, I believe that the "peer group" to which with all due humility I see myself belonging includes authors such as Ervin Laszlo, Rupert Sheldrake, (late) Michael Talbot, Danah Zohar, Deepak Chopra, Amit Goswami, or Fred Alan Wolf (apology to many others whom I am not naming here). These are all the people with superb credentials and ideas. Yet they are often facing the fierce criticism and skepticism that comes mostly (but not exclusively) from those members of the science community who believe that the aforementioned people went "too far."

Over my research career I got quite a share of the similar inputs. I feel no regrets about such (critical and often dismissive) comments. On the contrary, I always took them as a kind of a compliment that often stimulated me to go even more decisively with the ideas I was pursuing. In fact, I remain thankful to many of my critics ("peer reviewers" and others) who were dismissive to my work along "esoteric" and "metaphysical" lines as the opposition from such people ("experts") has actually simulated me to go even more decisively and creatively with the ideas I was throwing out (on homeopathy, "healing crystals" and alike).

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As for the menu of the scientific problems that came along in my carrier as a theoretical physicist, I consider myself quite lucky. Some of these problems were, so to say, "assigned" to me by the supervisors of the research groups I was working in. Yet some (actually, the majority) of the problems I was working on were of my own finding and persuasion. Again, without claiming any specific honors for that, I think that many theoretical physicists work on the issues that are coming from their own choice and interest, rather than on something that was "delegated" upon them from some superiors. No one have "assigned" to the young Albert Einstein when he was employed as a clerk at the Swiss Patent Bureau to work on the relativity theory. One of his known quotes reads: "I have no special talent. I am only passionately curious" (Albert Einstein, Brainy Quotes). Perhaps, many (if not most) theoretical physicists can say the same about themselves.

Now, I want to give, for the interested readers, a brief scope of my work in science. My goal is to show that a good share of it has later led me to some "metaphysical reflections" and (if I may say so) "esoteric insights." As the reader may find, I was pretty lucky in this regard. Most of my engagements with physical problems that came along my way gave me some grounds for contemplation on the issues reflected in this book. I do not attribute that to any special talents (I claim none of them for myself), but to the "karmic path" of my life-track that led me this way.

My first work in physics (actually, my Master and PhD work) was on the quantum theory of color centers in crystals. We all know that many crystals come in a wide variety of shapes and colors. Popular crystals such as quartz (i.e., silicon dioxide, SiO_2) have many versions with various color shades (rose, blue, gold, etc.) and these colors are due to some impurities (additional atoms) in the crystal lattice of quartz. The supervisor of my PhD work was a great theoretical physicist and mathematician, Maria Ivanovna Petrashen (1906–1977), from whom I learned many key lessons that helped me along the way in my work in science. Probably the most important directive was always to go your own way and do not conform to the crowd.

My PhD study on color centers was focused on various quantum processes that occur in these crystals at the atomic level; for example, processes such as energy transfer between centers, an electron jumps from a center to another, or processes induced by the external radiation and the interactions with positrons (positron annihilation). This work that was largely done under the aegis of the Leningrad University has resulted in a number of publications:

Berezin, 1969; Berezin and Kirii, 1970; Petrashen, Abarenkov, Berezin and Evarestov, 1970; Berezin, 1971a, 1971b; Berezin and Evarestov, 1971; Berezin, 1972a, 1972b, 1972c; Kashkai, Berezin and Arseneva-Geil, 1972; Kashkai et al., 1972; Berezin, 1975, 1976, 1977, 1978.

Thinking about crystals and quantum processes in them has also moved me to the contemplations about the "secret life of crystals," if I can use this metaphysical (and somewhat esoteric) expression here.

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From the early stages of my work in physics, I started to see crystals as alternative life forms that have "inner world" of their own. Many years later these ideas translated into my work of "isotopic neural networks" in crystals to explain at a quantum level the "healing properties" of crystals (why people often wear quartz and other crystals). My key papers on isotopic neural networks were published in 1980s and 1990s and will be briefly overviewed later in this book.

Another angle of that was my work on the *positron annihilation* on color centers that was done in early 1970s. Positrons are "antielectrons" that, so to say, belong to "antiworld" and the physicists call them "antimatter." Positrons were predicted in 1928 by the great physicist Paul Dirac (1902–1984) and shortly after they were discovered experimentally (in 1931). A positron is not different from an electron except the opposite sign of electric charge – an electron has negative charge, and a positron – positive (signs of charges as "positive" or "negative" are a completely arbitrary agreement, it could well be the other way around). When a positron ("antiparticle") meets an electron, they annihilate (destroy) each other and their energy is emitted as two gamma-quants (two high-energy photons, particles of light).

Later these analogies of "positron antiworld" have aligned along the ideas of infinity (positive and negative) and the parallel universes in which the direction of time can be opposite to ours (Berezin, 2004c). I will talk more about multidimensional time and time loops later in this book.

The process opposite to positron annihilation is the creation of electron–positron pairs from the energy of photons. Thus, photons (particles of light) can create matter and antimatter. Light (a pure energy) can create the material world. This directly resonates with various creation narratives of traditional religions and aboriginal cultures, more on that later in this book.

After defending my PhD dissertation, I found a research position at the Institute of Semiconductors of the Academy of Science, which later amalgamated with the world-famous *Fiztech* (full name: "A. F. Ioffe Physical-Technical Institute of the Academy of Sciences of the USSR") in Leningrad (now Saint Petersburg).

My work at that time at *Fiztekh* was a mixed blessing. On the one hand, there were all the typical adjustments of the first professional job, while, on the other hand, there was all the excitement, drive, and enthusiasm of the youth. Specifically, I worked at the Laboratory of Thermoelectricity, which was composed of some 50 or so people. I did my best to stay away from all the internal cat fights in the laboratory (almost any lab anywhere in the world has them) and worked mostly at home, coming to the institute as a rule once or twice a week (a kind of de facto privilege theoretical physicists usually had, although it was not a part of any official policy). The work I was assigned to do concerned a theoretical study of the conductivity mechanisms of crystalline boron (called beta-boron).

Boron was an amazingly interesting and challenging topic for me and it resulted in a few publications, most of them with experimentalists:

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Berezin et al., 1971; Berezin et al., 1972a, 1972b; Arsen'eva-Geil', Berezin, and Mel'nikova, 1973; Berezin, 1973; Berezin et al., 1973a, 1973b, 1973c, 1974a, 1974b; Golikova et al., 1976; Berezin and Trunov, 1977; Berezin et al., 1977.

This way, boron was my second major research involvement during my life in Russia (USSR).

However, when I moved to Canada and was working at McMaster University, this "beta-boron saga" turned out to be the bridge to my work on isotopes and the *isotopicity* concept with its applications to "water memory," homeopathy, "healing crystals," and physics of consciousness. As my "research karma" had it, my involvement with studies of boron later was the prime reason that my attention was drawn to the studies of isotopes, isotopic randomness, and isotopic engineering. In the following lines, I discuss how my transition from boron to "isotopicity" unfolded.

Boron is the fifth element in the periodic table, its atomic number is $Z = 5$, and it has two stable isotopes 10B and 11B, with an approximate ratio one to five in the natural abundance of these isotopes (Berezin, 1984e). When I started working on boron, I did not pay attention to the fact that it has two isotopes; this was somehow out of my scope at that time. What is interesting and peculiar about beta-boron is that it has a very complicated crystal structure with an elementary cell consisting of 105 atoms with different coordination numbers. Normally, one would expect a complex crystal structure for compounds of several different chemical elements. However, crystalline boron is an exception in this regard – it has a very complex crystal structure based on fivefold (icosahedral) symmetry even in its elementary form (it is a single chemical element and not a compound with any other chemical element). In short, it was a fascinating material to study theoretically; I was truly excited about the work I was doing.

It should be noted that the pentagonal (so-called fivefold) symmetry is relatively uncommon in crystalline structures (apart from the recently discovered "pentagonal quasicrystals"). At the same time, it often can be found in nature (e.g., many flowers have five petals, we have five fingers, etc.), and the study of fivefold symmetry has a long cultural tradition (De Freitas, 1992; Verheyen, 1992). One of the five ideal platonic solids, dodecahedron, has fivefold symmetry (pictures of five platonic solids can easily be found on the Web). Needless to add that "5" is a prime number – the only prime number that forms a "prime triplet" (3–5–7).

My more targeted focus was on the mechanism(s) of electrical conductivity in boron. Some ideas that were around at that time about the nature of electrical conductivity in boron were pointing to the presence of the so-called hopping conductivity in it. The term hopping conductivity means that electrons move through a crystal lattice via consecutive hopping (jumps) between some localized (or quasilocalized) states in it. The said "hoppings" happen by the mechanism of quantum tunneling, to which I have dedicated several of my publications in 1980s (Berezin, 1983, 1984a, 1984b, 1984c, 1984d; Berezin and Jamroz, 1984). This later helped me to formulate the idea of neutron hopping in the theory of consciousness (Berezin, 1992a).

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To form the hopping type of conductivity, the crystal needs some form of disorder to produce centers of electronic localization, such as the disorder introduced by randomly located impurity atoms or some other distortions. Such a disorder destroys the pure periodicity of the crystal lattice (the "translational invariance") and that, according to quantum mechanics, can lead to the formation of trapping centers, and these are the regions where the electrons can temporarily reside (centers of quasilocalization). It is about the same as our ability to skip over puddles of water after heavy rain by jumping via some stones or dry spots. That is how you can envision the hopping conductivity process.

As such, hopping conductivity was found experimentally and studied extensively, experimentally, and theoretically for so-called doped semiconductors. The latter means semiconductors containing impurities (Berezin, 1981). An example is Si(P) that is crystalline silicon with phosphorous atoms incorporated in a crystal lattice. It is one of the prime materials for the semiconductor transistors. In such systems, electrons can hop (jump) between the impurities. But what about pure boron, which contains no significant concentration of impurities? What can cause the formation of centers of localization in this case?

In 1981, just a year after I joined McMaster University as an (associate) professor of engineering physics, I attended a conference on boron in Uppsala, Sweden, where I presented a talk on the electrical properties of boron. In the discussion of the possible cause of the hopping conductivity in boron, somebody (I do not remember exactly who) made a passing remark that because boron has two stable isotopes (10B and 11B), their random location may indeed account for the formation of centers of localization. This, in turn, could account for the hopping conductivity in crystalline boron.

Upon returning to Canada, when I was working on a paper for the follow-up journal issue for this conference, I mentioned this idea in just a few words (Berezin, 1981b), where I discussed possible sources of disorder leading to electronic localization in boron. The quote from the said paper mentioned isotopic disorder among a few other options: "in a crystal with a very complex unit cell, even a small perturbation (e.g. that is due to residual impurities, to dislocations, to thermal vibrations or even, as in boron, to a random distribution of the 10B and 11B isotopes among the lattice sites) is able to create the degree of disorder sufficient for the occurrence of the quasi-localization and hopping conductivity."

Later I thought more about isotopic randomness in this context, and that is how my general interest in *isotopicity* was awakened. Of course, I realize that the seed idea in this case was not entirely mine (who was this anonymous conference participant who made this passing remark?).

To that effect, I believe that somewhat similar occurrences are quite common in science. Perhaps, sometimes "big ideas" can indeed be triggered by some conversations over a coffee or a beer, when people may not even exactly know each other. Or maybe some other, totally random, inputs can put a researcher onto a line of thinking that may later take many years to mature into a cohesive major idea or a hypothesis

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(recall the proverbial apple that allegedly has fallen on Newton's head and that led him to the law of the universal gravity).

Thus, I believe that I "owe" to my work on boron my later interests in the water memory, principles of homeopathy, and "healing crystals." That is how a single chemical element with an atomic number 5 (a prime number, by the way!) turned out to be a trigger of some "esoteric" and "new age" work. In addition, as was just mentioned, fivefold (pentagonal) symmetry of boron crystals points directly to ideal platonic solids. There are five such platonic solids and two of them known as icosahedron and dodecahedron have fivefold symmetry. This gives (in my view, at least) another connection to the ideal platonic world of numbers and forms.

Altogether, there are just five ideal platonic solids. They are known as tetrahedron, octahedron, hexahedron (cube), icosahedron, and dodecahedron. These are the only bodies that can be fully symmetrically inscribed inside a sphere. Fully symmetrically means that all their vertices (corner points) are exactly equivalent and each of these figures looks exactly the same if you look from any of their corners. The most known of them is, of course, a cube: you can look at it from any of its eight corners and it looks exactly the same. The images of these five platonic solids can be easily found on the Web.

The tetrahedron has four triangular faces, the octahedron has eight triangular faces, the cube has six square faces, the icosahedron has 20 triangular faces, and the dodecahedron has 12 pentagonal faces. We can mention that the pentagonal symmetry has many interesting implications and applications (De Freitas, 1992; Verheyen, 1992).

In Greek philosophy, each of these solids is associated with five prime elements: tetrahedron with fire, octahedron with air, cube with earth, icosahedron with water, and dodecahedron with the universe.

Then from crystals and symmetries my "research karma" has moved me to spell out some ideas along biological quests.

My first publication on the idea of isotopic in biology had a somewhat provocative title, Berezin, A.A. (1984e). "Can Life be Based on a Single Chemical Substance?", *Die Naturwissenschaften*, Vol. 71, 45 (Berezin, 1984e).

This short (one page) paper proposed a (speculative) idea that the isotopic diversity in such a simple compound as water can lead to the information-bearing structures and be a foundation of some alternative quasibiological activity. We have to recall here that water (H_2O) can be in six isotopic forms, due to all cross-combinations of two stable isotopes of hydrogen (H and D) and three isotopes of oxygen (^{16}O, ^{17}O, and ^{18}O). That opens up an enormous potential for the information content that can be stored and transmitted by isotopic combinations (different isotopes can be "read" as different letters of a quantum alphabet).

My later work on isotopes, isotopic engineering and isotopic biology (in particular, an idea of "isotopic genetic code"), and other aspects of "isotopicity" has resulted

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in numerous publications referred in the bibliography of this book (all of those are not quoted here).

In 1978, my family and I have immigrated to Canada and as my luck (or Karma?) have it, I had two consecutive university positions. I don't want to claim any special merits on my part in this regard – it was just a combination of a good luck and, perhaps, a fair economic situation in Canada in the end of 1970s and the beginning of 1980s (that is no longer the case nowadays, when many professional immigrants drive cabs or work at coffee shops).

My first position was a research associate at the Department of Physics, University of Alberta, Edmonton (for about 2 years) and then at the Department of Engineering Physics, McMaster University, Hamilton, Ontario where (as my luck had it) I got a tenured faculty position that was going to last for 30 years, for the rest of my formal research carrier (1980–2010).

My first research involvement in Canada was the work on the photovoltaic solar cells that resulted in a few publications (Berezin and Weichman, 1981, 1982; Fujinaka and Berezin, 1983; Sunatori and Berezin, 1984).

Worldwide research activity in solar cells is well understandable in the context of the alternative energy sources and sustainability. Of course, the source of the energy in this case is the Sun itself –no intermediaries, just the clean sunlight converted into electrical power. While this book is not the place for me to discuss technical details and the challenges of solar cell industry (anyone interested can easily find a plenty of information on the Web), I want to pay a tribute to the major player here – the Sun.

Thus, it appears, perhaps, somewhat providentially (at least, for me), that my work on solar cells (how to get a free clan energy from the Sun) has later "resonated" with the ideas of living sun that I discuss in this book (Sections 7.4 and 7.11) in connection with a book *Son of gOd* by Gregory Sams (2009).

The Sun unceasingly and generously sends us its energy and it is central and most important thing on which the life on this planet rests (including ourselves, of course). And I am certainly not the only person to see the Sun as a living being. Millions around, before and now, feel this way. Yet, my work on solar cells and my interest in the physics of Sun (how the Sun produces its energy) contribute to the realization of two things – two, so to say, "personal discoveries" (of course, in no way claim any "real" discoveries here; many people share the same):

(1) That energy of the Sun is produced by nuclear processes involving isotopes of hydrogen (H), carbon (C), oxygen (O), and nitrogen (N). However, these are precisely the same elements that are the key elements to our biology! In this way, we, indeed, are "children of the Sun" – and this not just a figure of speech or a nice metaphor – but the real fact!
(2) Realization that the Sun itself may be alive – a living system with consciousness of its own! And this, again, more than just a modern reinterpretation of ancient and traditional views about the Sun. Recently, a physicist Gregory Sams in his book *Sun of gOd* gave a scientific overview of this idea on the basis of quantum physics

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and chaos theory (theory of self-organization). The Sun in not only a self-regulating system, but also does its “work” consciously and purposely (Sams, 2009). Later in the book, I will discuss these ideas in more details.

Another interesting phenomenon that I have studied is the so-called Anderson localization (named so after a theoretical physicist Philip Anderson, b. 1923). It is a quantum effect when a sufficient degree of disorder in a crystal makes some electrons be trapped (localized) on impurities like golf balls in the holes at the golf course. What this has to do with a human mind and spirituality? Well, it does. As I have argued in my books (Berezin, 2015, 2016), similar effects can work in the transitions between localized (“normal”) and delocalized (“cosmic”) consciousness and be related to our meditations in the spirit of oneness and transcendence of time and Infinity. More on that later in this book (in Chapter 7).

My work on the use of the *catastrophe theory* (De Sa and Berezin, 1989; Berezin, 1989c, 1990c, 1991c, 1993a, 1993b) has led me to appreciate the ideas of singularity in various physical and social phenomena. Catastrophe theory was proposed by the French mathematician Rene Thom (1923–2002) to describe various sharp (“singular”) transitions in various systems and situations. It has much to do with phase transitions, chaos theory, and singularities. This line of my research has led me to study the ideas of transhumanism and simulation (“are we computer simulations?”). This line of thought was reflected in my paper *Simulation Argument in the Context of Ultimate Reality and Meaning* (Berezin, 2006) that is discussed in Section 11.10.

There are other connections of my work in physics with the issues of infinity and topics of this book. They are discussed in the subsequent chapters.

2.2 Holomovement of David Bohm

David Bohm (1917–1992), one of the key players of quantum physics (like the author of this book), is somewhat “off-line” from the “mainstream” physics. One of his many contributions is the idea of “holomovement.” Other terms that are used here are “undivided wholeness” and “implicit order.” This idea emphasizes the interconnectedness of consciousness and the universe as undivided whole.

As Bohm (1980) says, “Not only is everything changing, but all is flux. That is to say, what is the process of becoming itself, while all objects, events, entities, conditions, structures, etc., are forms that can be abstracted from this process”.

The term holomovement is one of many neologisms that Bohm coined in his search to overcome the limitations of the standard Copenhagen interpretation of quantum mechanics. This approach involved not just a critique of the assumptions of the standard model, but also a set of new concepts in physics that move beyond the conventional language of quantum mechanics.

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The ideas of “holomovement” and “holographic universe” (Utke, 1986; Sharpe, 1993; Talbot, 2011) resonate with ideas of “quantum entanglement” and universal connectedness between the objects and events (Grib and Rodrigues, 1999). More on this in the chapter on consciousness (Chapter 7).

2.3 Quantum consciousness by Roger Penrose

Quantum consciousness is a popular topic today and many people put their share to it. Ideas of Roger Penrose and his collaborator Stuart Hameroff (b. 1947) are among the most advanced and mathematically developed. The central premise of it is that each elementary act of consciousness results from the “reduction of the quantum wave function” (Penrose, 1994, 1996; 1989a, 1989b). This happens in certain microstructures of the brain that Penrose and Hameroff call “microtubules.”

This is how Hameroff summarizes this theory:

> The nature of consciousness remains deeply mysterious and profoundly important, with existential, medical and spiritual implication. We know what it is like to be conscious – to have awareness, a conscious “mind”, but who, or what, are “we” who know such things? How is the subjective nature of phenomenal experience – our “inner life” – to be explained in scientific terms? What consciousness actually is, and how it comes about remain own. The general assumption in modern science and philosophy – the “standard model” – is that consciousness emerges from complex computation among brain neurons, computation whose currency is seen as neuronal firings (“spikes”) and synaptic transmissions, equated with binary “bits” in digital computing. Consciousness is presumed to “emerge” from complex neuronal computation, and to have arisen during biological evolution as an adaptation of living systems, extrinsic to the makeup of the universe. On the other hand, spiritual and contemplative traditions, and some scientists and philosophers consider consciousness to be intrinsic, “woven into the fabric of the universe”. In these views, conscious precursors and Platonic forms preceded biology, existing all along in the fine scale structure of reality. My research involves a theory of consciousness which can bridge these two approaches, a theory developed over the past 20 years with eminent British physicist Sir Roger Penrose. Called “orchestrated objective reduction” (“Orch OR”), it suggests consciousness arises from quantum vibrations in protein polymers called microtubules inside the brain’s neurons, vibrations which interfere, “collapse” and resonate across scale, control neuronal firings, generate consciousness, and connect ultimately to “deeper order” ripples in spacetime geometry. Consciousness is more like music than computation (Stuart Hameroff, Internet posting)

It appears that this scenario attempts to make some reconciliation of the reductionistic and wholistic viewpoints. Perhaps “reductionism” (consciousness inside “matter”) and “wholism” (consciousness as “cosmic phenomena”) do indeed form a complimentary set (“two sides of the same coin”) rather than be philosophical opposites to each other. Perhaps, future developments will bring new insights to these ideas (more on consciousness later in this book, Chapter 7).

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2.4 Parallel universes and quantum computing

Ideas of the parallel universes have a long history and discussed in more detail later in this book. Here we notice that some physicists (David Deutsch, Seth Lloyd, and few others) came up with relating the idea of parallel universes with quantum computing.

The latter (quantum computing) is an area of theoretical and experimental physics that is actively advancing these days.

The fascinating point of connecting parallel universes theories and quantum computing is the hypotheses that quantum computers make their calculations in different parallel universes. In other words, the process of calculations is shared between diferent parallel universe and that is what makes quantum computers so fast, many orders of magnitude faster that the best "ordinary" computers of today.

All the aforementioned theories – "holomovement" of David Bohm, "quantum consciousness" of Roger Penrose, and "quantum computing in parallel universes" of David Deutsch and others (parallel universes) lie at border of physics and metaphysics – the philosophical credo that I share.

In Section 4.6 (Chapter 4) we will return to quantum computing in connection with the factorization of long integer numbers (the basis of the security codes for bank transactions).

2.5 My Einstein number is four

My scientific supervisor in my "aspirantura" (as they called PhD programs in Russia), Maria Ivanovna Petrashen, was a kind and truly intelligent woman and it was a pleasure to do a work under her mentorship. She gave me a very gentle guidance such that at times it appeared as if I was almost left on my own. In other words, I did my PhD (in Russian "kandidatskaja dissertatzija") almost entirely myself with a minimal supervising from her side. Nonetheless, retroactively, I see that her influence on me was instrumental in the development of my own style of research. It also equipped me (to a good degree, I hope) with ability to distinguish between what is important and what is not (of course, such ability cannot be absolute and I was (and am) making mistakes in this regard as anyone else). More about Maria Ivanovna in my essay "Lady Physicists in My Life" (More about Maria Ivanovna in the Preface to this book).

When I was about to defend my dissertation work (in May 1970), I had 9 or 10 publications of which in only two Maria Ivanovna was my c-author, along with two other people (this is the two-part review in the journal *Physica Status Solidi* titled "Calculations of the Electronic Structure of Colour Centres in Ionic Crystals," 1970, Vol. 40. pp. 9–29 [Part 1] and 433–460 [Part 2], the authors are M.I. Petrashen, I.V. Abarenkov, A.A. Berezin, and R.A. Evarestov). So, I have a joint paper with M.I. Petrashen and now I can discuss a curious item that I call my Einstein number is four. What is this?

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The idea was introduced by the world-famous prolific mathematician and science maverick Paul Erdos (1913–1996) who wrote around 1,500 papers, almost all of them on number theory. He was one of the most strangely behaving people in the history of science. Originally of Jewish-Hungarian origin, for the most part of his life he did not have permanent job and permanent residence and with his only suitcase traveled from one university to another on various short-term visiting positions (my next chapter is about him). He usually stayed at houses of other mathematicians, both professional and amateurs, with many of whom he wrote joint papers. Altogether, there were 507 people coauthoring papers with him. To all these people, Erdos assigned "Erdos number (EN) = 1." Those people who have coauthored papers with any of these 507 people (but did not have papers coauthored with Erdos directly) were assigned "EN = 2" (about 6,100 such people). Likewise, those people who had coauthored papers with people having EN = 2 (but not with Erdos himself or anyone with EN = 1) were assigned EN = 3, and so on. The number of such "EN = 3" people is unknown to me, but I can safely presume they are in dozens of thousands. For himself Erdos has assigned EN zero (EN = 0). By the same token any author has his/her own "my number" equal to zero.

Following the same procedure we can talk about *any name number*, each time it will refer to a number of steps needed to come from (say) me to any given scientist. Thus, we can talk about "Einstein number," "Dirac number," "Heisenberg number," and so on. For example, I asked myself what is my own "Einstein number?" Well, I have a paper coauthored with M.I. Petrashen (quoted earlier). For some years, Maria Ivanovna worked with a great Russian theoretical physicist Vladimir Alexandrovich Fock (1898–1974) whose lectures I attended at several occasions. While I did not have any papers coauthored directly with V.A. Fock, Maria Ivanovna had several such papers. Thus, my "Petrashen number = 1" and my "Fock number = 2." Then, there is a paper "On Quantum Electrodynamics" whose authors are P.A. Dirac, V.A. Fock, and B. Podolsky (the paper in *Physikal Zeitshrift USSR*, vol. 2, No. 6, pp. 468–479, 1932). This gives me "Dirac number = 3." Because B. Podolsky has a joint paper with Albert Einstein, my "Einstein number = 4" (the paper in question is the famous paper on what later became know as "Einstein–Podolsky–Rosen paradox" or "EPR paradox"; its full reference is A. Einstein, B. Podolsky, N. Rosen, "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?", *Physical Review*, Vol. 47, p. 777, 1935).

Of course, any author who has papers coauthored with other people can try to "reach" some known scientists through different "paths"; sometime different paths have different *who-ever number*, but, of course, we always want to find the shortest path. The smaller your "great person number," the better it looks. I don't know what will be my "Maxwell number," or "Boltzmann number" (etc.), but assuming they had numerous coauthors, it probably will not be a very large number, perhaps less than 10. So, should I be particularly "proud" that my "Einstein number" is as small as 4 (?).

Well, not really. Almost anyone (who wrote research papers in coauthorship) can attempt to figure out his/her *who-ever* number and most likely it will not be a very large

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one; in fact, it will almost never be greater than 10. The same is true for the "shack-hand number": in how many steps I can "shack hands" with (say) Adolph Hitler? Well, here is a try. Over my work at McMaster I shook hands with (several) visiting Nobel Prize laureates, all of whom, of course, shook hands with the King of Sweden (at the Nobel Prize award ceremony), thus my "Swedish King number = 2." The King of Sweden, undoubtedly, shook hands with almost all key political figures and in one or two steps I can reach, say, Chamberlain, who, as we all know, exchanged shack-hand with Hitler during the (in)famous Munchen accord of 1938. Thus, my "Hitler number" is probably not more than 5. It is not that I (or anyone else for this matter) is particularly proud of this; this is just a curious example how mathematics works.

And if my example with Hitler in not particular cheering, here is another one. In my young years, I lived with my mother and our close family friend was a lady by the name Maria Vladimirovna Stepanova (1892–1977). She was a very dear person to me and replacing me a grandmother (Babushka). In her young years she was a medical nurse ("Sestra Miloserdija" –"sister of compassion") in Russian Military Hospital during the First World War. At some occasion, Russian Tsar Nicolas II (Nikolaj Vtoroj) and Tsarina Alexandra have visited this hospital and shook hands with all people there, including Maria. Therefore, my "Nikolaj Vtoroj number = 2" and in 2 or 3 more steps I most certainly shook hands with Queen Victoria and with less than 10 steps I shook hands with Napoleon – just go down by Russian tsars to Alexander I (Alexander Pervyj) who shook hands with Napoleon at their famous meeting at Tilsit in 1807.

Chapter summary

This is the personal story of the author whose work for many years in the "mainstream physics" has gradually drifted him toward more "esoteric" quests such as the digital nature of consciousness, "water memory," and "healing crystals." The central idea is that what we normally understand as "consciousness" is not limited just to "us," but is a universal cosmic phenomenon that exists at all levels, from microparticles to stars and galaxies.

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3 Integers and primes

> *God may not play dice with the Universe, but something strange is going on with the Prime Numbers.*
> Paul Erdos (1913–1996, a celebrated number theorist)

For many of us philosophical and metaphysical contemplations and meditations on fundamental issues of existence form an important aspect ofour intellectual life. They provide us with a venue for achieving the inner peace and anchoring ourselves in a haven of spiritual stability of the world in turmoil with its nonstop tsunami of problems falling on us from all sides.

There is nothing more fundamental in our life and our thinking than numbers. “Everything is Number,” said the Greek philosopher Pythagoras about 2,600 years ago. As an idea (or some say, a “philosophical category”), *number* – as it is important for us – beats even concepts such as “space” and “time”. And what is more fundamental than “space” and “time,” we are prompt to ask. Yet in our mental world practically everything goes in numbers. Everything is countable and everything counts. From the two central items of our existence in this world – money and age – we count them nonstop, consciously, and subconsciously to things such as counting the number of “calories” we eat – all come in numbers.

Contemplation of *infinity of numbers* and the *infinity of prime numbers*, in particular, may be a tricky activity for some people. Many of us are much better of or are much easier with contemplation of the infinity of space and time – for this, we have rather straightforward mental images. We exist in space and time and it is “our” realm. But numbers? Sometimes, I hear people saying that numbers for them are cold and distant, they feel disengaged from them. However, when you start talking with them about infinite patterns that numbers “hide” in them (such as the intricate pattern of prime numbers or infinite fractal wiggles of Mandelbrot set), their souls and spirits instantly become brightened and uplifted – it is like a sunrise for them – with this promise, we begin our journey to the number world, the journey of infinity.

3.1 Infinity over infinity

All of us virtually from the age of almost zero learn to count. One, two, three ... – 1, 2, 3, 4, 5 ... At what age did we do it for the first time? That is what we call integer numbers. And a curious child wonders and asks the following questions: What if the numbers are run out? Is there a largest number? Many of us, when we were kids, tried to count to a thousand or a million just to find out if there is an end to it. The end of numbers, we mean.

Well, soon our worries were over – we learnt (or told by adults) that there is no “largest number,” they will run forever, larger and larger. As simple as it may be, but

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that is probably our first encounter with an idea of infinity (in-finity, this is *not* "finity"). This is probably even before we start wondering about the infinity of space and time.

So, 1, 2, 3, and on ... But then we learn of a bit stranger thing – zero. That is what we write as "0" – an empty hole that is. Why we need it? Try to live about it. Count 1, 2, 3, 4, 5, 6, 7, 8, 9 ... And now what? Yes, 10. Easy for us, but the world took centuries of resistance to adopt the idea of "zero". Charles Seife in his book *Zero: The Biography of a Dangerous Idea* (Seife, 2000) tells many stories on how such a simple idea as "zero" (What can be more simple than "nothing"?) had a hard ride and a lot of resistance through the course of history.

And then we learn about negative numbers, –1, –2, –3 ... and it turns out that they also run to infinity. Negative infinity in this case. Then there are complex (remember? – square root of minus one, called "*i*-number," "imaginary one"), real, rational, and irrational numbers, and other high stuffs such as transcendental numbers. No, I am not going to bother you, my reader, with these stuffs now. Back to integer numbers, 1, 2, 3... they are simple and lovely. How to equally share 6 apples between 3 kids. How many apples each gets? Simple? But now take 7 apples. Harder? And here we are getting (in kindergarten, perhaps) that not everything can be shared equally if the numbers do not play to the right way.

The problem is division. Odd and even numbers. Four basic operations of the arithmetic: addition, subtraction, multiplication, and division. Any calculator has it. For any two numbers, we can do any of these four operations. Easy. Except, of course, division by zero: 5/0 will not work. Error message. Because the result will be, formally at least, the infinity, calculator does not have it. Only in our philosophical and metaphysical mind we can have it, that is, the idea of infinity.

Then, of course, there are fractions. Such as 1/2, 2/3, 5/16, 17/12, 137/25, and so on. Many of them. Infinity. These all are the ratios of two integer numbers, "p" and "q." Hence, we call them *rational numbers*. It seems that there are lots more of them than integers. Indeed, between any two integers, we can squeeze an *infinite* (!) number of fractions. Like between 0 and 1: we can place 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 2/11, 5/13.... Any fraction p/q will make it between 0 and 1 for as long as $p<q$. Thus, there is infinity of fractions between 0 and 1. And so is between 2 and 3, 3 and 4, 4 and 5, and so on. Very tempting to say that there should be a lot more (infinitely more) fractions than integers. *Not so*! Actually, both infinities (integers and reals) are of the "same size," as Georg Cantor has proven hundred years ago. Both these infinities are infinite sets of the same size, or, as mathematicians say, of the same "cardinality". The aleph-zero cardinality.

The most enlightening and exciting feature here is that there are higher ranks of infinity, infinite sets that are called Aleph-one, Aleph-two, and so on. Actually, there are "infinity of infinities" that, to say, form an infinite set of "nested infinities" such as an infinite tower of "Russian dolls." Many books on these, for example, Amir D. Aczel's *The Mystery of Aleph: Mathematics, the Kabbalah, and the Search for Infinity*, Four Walls Eight Windows, New York, London, 2000, not to mention numerous web resources. (There is more on this in Chapter 11, "Infinity Reloaded" of this book).

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3.2 Prime of primes

Now, after talking about the “infinity of integers”, we can go to the next best thing – prime numbers (Dickson, 1952, 1960; Schroeder, 1986; Ribenboim, 1989). These are indeed the celebrities among all integers. To understand what these are, all we need is to know how to multiply numbers. For example, $4 = 2 \times 2$, $10 = 2 \times 5$, $12 = 2 \times 2 \times 3$, and so on. For “10,” the numbers “2” and “5” are called “factors.” And the whole process of splitting an integer number on its factors is called “factorization.” Simple? For sure ... but wait a minute, things can get more metaphysical and exciting as we will go along. So, hold on for further contemplations to unfold.

Any number can be divided by 1. This is trivial and of no interest. Half of numbers, even numbers, 2, 4, 6, 8 ... can be divided by 2; one-third of all numbers, 3, 6, 9, 12 ... can be divided by 3. And so on. And here we mean the division without a remainder. And like those proverbial kids sharing apples, 7 or 11 cannot be divided by any other number without a remainder. They are *prime numbers*. All numbers that are not primes are called composite, they are always products of two or more primes, for example, $14 = 2 \times 7$, $55 = 5 \times 11$, $126 = 2 \times 3 \times 3 \times 7$, $5423 = 11 \times 17 \times 29$, and so on (infinity of possible examples).

So, the prime number is an integer that can be “divided” only by 1 (that it is trivial) and by itself (that is also trivial, of course $7/7 = 1$). Now, here is the list. Just a few prime numbers – those that are less than 120. Here they are as follows:

2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113...

These (the primes) are the numbers that cannot be split into two or more factors. All the factors they have are themselves and “1”, for example, $23 = 1 \times 23$. Thus, “1” is a trivial factor to any number and hence number “1” is not counted among primes. As was just said, all integers that are not primes are called *composite* numbers, the first few are as follows: 4, 6, 8, 9, 10, 12, 14, 15, 16 ....They all are the products of two or more primes. If you take any prime number of apples you cannot equally divide them between children.

There are many curiosities in the world of prime numbers. The first that they are all odd numbers. All except “2.” This may seem a bit “odd” (no pun). If you have 2 apples, yes, you can divide them equally between two kids. And yet, we do not count “2” as a composite, it is a prime, the only even prime number; it has no other factors except “1” and itself, $2 = 1 \times 2$. And all other even numbers have “2” as a factor, once or more, for example, $32 = 2 \times 2 \times 2 \times 2 \times 2$, and so on.

So, we can easily count that there are 25 prime numbers less than 100, making it one-quarter (1/4) of all integers up to 100. That is 25%. From this, it seems tempting to conclude that 1/4 of all integers are primes. But this is a false conclusion. In reality, primes are getting more and more diluted as we move along the number line. There are 168 primes less than 1,000 and 78,498 primes less than 1,000,000, that is, less

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than 8%. And then the proportion of primes gradually decreases and mathematicians long ago figured out some equations that show how this proportion decreases with N.

Although, primes seem to pop-up randomly along the integer numbers line (1, 2, 3, 4, 5, 6, 7 …), statistically they follow the so-called prime number theorem. It states that, in average, the total number of primes less than "N" is f(N) = N/ln(N). That is N divided by the natural logarithm of "N."

To remind, the natural logarithm is taken by the basis of "e" number ("e" is an irrational number, e = 2.718281828 …). And by the rule of basic calculus, ln(e) = 1, ln(2) = 0.693147 …, ln(10) = 2.302585 … and so on(any pocket calculator can make this).

All these data about the prime numbers (and much more) can be easily found on the web. Thus, I abstain from going into too much details, especially remembering the "ground rule" for book publishing: "Every mathematical equation in a book would cut the book's sale in half," as Stephen Hawking says in the introduction to his *A Brief History of Time* (although, I personally not quite agree with such a harsh warning and presume that my readers are not totally ignorant about basic calculus, so I may use some simple formulas here and there.

Looking at the above-mentioned string of primes, we can be puzzled by a few things. The first: How "2" (an even number!) is a prime? Never mind, it is. Prime is a number that is divided only by 1 and itself. The number "2" satisfies that, so it is the only even prime number.

Another, a bit trickier puzzle (that is often asked) is: Why the number "1" is not on the list? It is divided by "1" and itself, of course! Yet, the inclusion of "1" to the list of primes would invalidate key theorems regarding the prime numbers and therefore the mathematicians do not count "1" among primes. Number "1" (unit) is a special number that is neither prime nor composite.

The next curiosity is that "2" and "3" are the only consecutive primes. All primes (except "2") are odd and any odd and even numbers always alternate. Also, 3, 5, and 7 are the only "prime triplet", nowhere else on the number line, three primes can be found for a similar triplet, a close cluster of odd–even–odd–even–odd type.

Other universally known fact is that there are infinitely many primes. The list of primes never ends. This was proven 2,300 years ago by the great Greek mathematician Euclid. This proof is very simple and almost any text on mathematics has this. Yet, I will repeat it here. The way Euclid figured the infinity of the prime numbers is called "proof from the opposite." It is also known as *reductio ad absurdum* (reduction to absurdity) method. It is quite often used in mathematics and logic. You have to presume that the opposite of what you want to prove is true and then demonstrate that such a presumption leads to a logical inconsistency.

So, Euclid says, "let us presume that the number of primes is finite and, if so, there must be a largest prime number, let us call it P." Then let us make the *product* of *all* prime numbers up to P, and add "1" to it. Such a product (product of all primes up to P) is called *primorial* (not to be confused with the term "primordial" – the latter means "eternal," "existing from the beginning of time"). Primorial is usually

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designated as "#," instead of "!" sign for the "ordinary" factorial. So, the primordial of P is as follows:

$$P\# = 2 \times 3 \times 5 \times 7 \times 11 \times 13 \times 17 \times 19 \times 23 \times \ldots \times P$$

Now, add, as Euclid did, "1" to the P#

Call this number "N(P)." Of course, N(P) is an integer number, here it is as follows:

$$N(P) = P\# + 1 = 2 \times 3 \times 5 \times 7 \times 11 \times 13 \times 17 \times 19 \times 23 \times \ \ldots \times P + 1$$

Certainly, by its very construction, the number N(P) is larger than P (actually, much, much larger!), but by our assumption it *cannot* be prime (because we presumed that "P" is the *largest* prime). Hence, N(P) must be a composite.

But a composite number is always a product of two or more prime numbers. All prime numbers (there is a finite number of them according to our "assumption") are included in the above-mentioned P. So, let us try to divide N(P) by all prime numbers from 2 to P (the largest prime by our assumption). *But it won't work!* Because of this, "+1," a division of N(P) by 2, 3, 5, and so on (up to P) will always leave a remainder 1/prime. Hence "N(P)" cannot be a composite and we have to conclude that *either* "N(P)" is itself a prime *or* there is some prime *larger* than P that will divide "N(P)" without a remainder. But both such cases contradict our prime assumption that P is the largest prime number. And the inevitable conclusion from this logic is that there is *no* largest prime number and that means that there are *infinitely many* prime numbers. As mathematicians say, "QE.D" (an abbreviation for the Latin phrase "quod erat demonstrandum," "that which was to be demonstrated," a notation that is often placed at the end of a mathematical proof to indicate its completion).

Euclid came up with this proof in third century bc The question for historians remain if other advanced previous civilizations (Egyptian, Babylonian, etc.) did know that the number of primes in an infinite or even had a clear concept of a "prime number." Maybe they did, but I as an author did not investigate this point and left it as an exercise for a curious reader.

Prime numbers can be, of course, of any length. Here a few examples of long(er) primes.

Ten random 30 digit primes:

671998030559713968361666935769

282174488599599500573849980909

521419622856657689423872613771

362736035870515331128527330659

115756986668303657898962467957

590872612825179551336102196593

564819669946735512444543556507

513821217024129243948411056803

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416064700201658306196320137931

280829369862134719390036617067

Ten random 100 digit primes:

2074722246773485207821695222107608587480996474721117292752992589912196
6847505496583100844167325500 77

2367495770217142995264827948666809233066409497699870112003149352380375
124855230068487109373226251983

1814159566819970307982681716822107016038920170504391457462563485198126 9
167351672602156195234297140 31

5371393606024775251256550436773565977406724269152942136415762782810562 55
413159907490742601073750350 1

6513516734600035718300327211250928237178281758494417357560086828416863
929270451437126021949850746381

5628290459057877291809182450381238927697314822133923421169378062922140 0
814987344241331120328548122 93

2908511952812557872434704820397229928450530253990158990550731991011846
571635621025786879881561814989

2193992993218604310884461864618001945131790925282531768679169054389241
527895222169476723691605898517

5202642720986189087034837832337828472969800910926501361967872059486 04
571314545011671248868500469142 3

7212610147295474909544523785043492409969382148186765460082500085393 51
955652592145558870542302075142 1

Looking at these examples (many more can be found on the web), we notice that all primes are ending only on 1, 3, 7, and 9. Of course, it is easy to see why. All numbers ending with 0, 2, 4, 6, or 8 are even and are divided by 2 and all numbers that end with 5 are divided by 5. This is a trivial consequence of our decimal (10 digit) arithmetic.

To put the above-mentioned numbers in a more vivid prospect, let us compare them with other "big" numbers. For example, a body of a typical adult human has about 10^28 atoms (this is 10 followed by 28 zeros). Another way of saying this is "ten billion billion billion." Of this, almost 2/3 of all atoms is hydrogen, 1/4 is oxygen, and about 1/10 is carbon. These three elements add up to 99% of the total atomic count in our bodies.

Next big number will be the total number of all atoms in the universe. Including all stars, galaxies, and everything else. Here the estimate is less precise, yet it is about 10^80 (plus minus a few orders of magnitude).

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For human imagination, 10^28 and 10^80 do not look much different. These two are beyond our perceptual facilities to grasp it in any vivid way. Yet, any of the above 100-digit primes are much (much!) bigger than the number of atoms in the universe. But this, certainly, is not the end.

There are prime numbers with 1,000; or a million; or a trillion digits. Actually, with *any* number of digits (there is no end to prime numbers).

As of January 2017, the largest known prime number is the 2^74207281 – 1 (that is "2" to the power 74,207,281 minus 1). It has 22,338,618 digits. Of course, we can't write it in a complete form, if written on a type with regular size fonts, the type will be some 50 km (30 mi.) long. Following are the *first* and the *last* 120 digits of it:

300376418084606182052986098359166050056875863030301484843941693345547723219067994296893655300772688320448214882399426727... (22,338,378 digits omitted)

717774014762912462113646879425801445107393100212927181629335931494239018213879217671164956287190498687010073391086436351

As we see, it indeed ends in "1", one of the 4 allowed ending digits for all primes are greater than "2". This number belongs to a special class of primes called "Mersenne primes," named after a French theologian, philosopher, mathematician, and music theorist, Marin Mersenne (1588–1648) who is also known as the "father of acoustics." All Mersenne primes have the form of some power of "2" minus 1. This power should be a prime itself. For example, 2^3 –1 = 7 (prime), 2^5 –1 = 31 (prime), and 2^7 – 1 = 127 (prime). However, not all prime powers of 2 minus 1 make primes, for example, 2^11 – 1 = 2,047 = 23×89 (composite number, the product of two primes).

There is no doubt that the above-mentioned record will soon be beaten (unless already is) and even longer primes will be discovered. It seems as a useless exercise to look for such huge prime numbers. But in fact it is not, there are interesting applications for them, so the search for them will likely to continue, perhaps, with invention of functional *quantum computers*.

There are also some interesting happenings in the so-called "factorizational spectra". The latter term means all prime factors of a given composite number. This is similar to how optical spectral analysis decomposes a white light on underlying colors (rainbows and prisms come to mind). For example, take two *consecutive* composite numbers: 714 and 715. Their factor decompositions are 714 = 2×3×7×17 and 715 = 5×11×13. Therefore, the *product* of these two *consecutive* numbers is the same as the product of all primes from 2 to 17: 714×715 = 2×3×5×7×11×13×17 (!). We don't know if there are other, much larger, pairs of consecutive integers that will make the same trick (so far, computer search failed to find such pairs).

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3.3 Twin primes and prime deserts

One of the most fascinating problems in the world of prime numbers is the so-called "twin primes." They produce a lot of excitement and interest that runs not just among professional mathematicians (a relatively small community on a global scale), but also among millions of curious amateurs and spiritually inclined people of all ages. The key topic here is the so-called "Twin Prime Conjecture."

Here is what it is. Looking at the list of prime numbers, it is impossible not to notice that there are quite many prime pairs separated by just one integer. Especially, in the beginning of the list of primes, prime pairs appear quite often. Right away among the numbers that are less than 100 we see: 11–13, 17–19, 29–31, 41–43, 59–61, and 71–73. So "twins" make about half of all primes among the first 100 integers (12 out of 25). Later the proportion of twins decreases but they always pop-up quite often. Apparently, prime numbers, similar to us, like to form couples. We can only wonder about the ("metaphysical") reasons why prime numbers are doing this (tend to form "couples").

One may further be puzzled why we are not listing 3–5 and 5–7 as "twin primes." But this is a special case, where "5" belongs to two twin primes. This 3–5–7 is the *only prime triplet*, using the popular French expression, "Ménage à Trois" ("Love Triangle").

From this, we can go to the famous "twin prime conjecture." The term "conjecture" in mathematics means some statement that is believed to be true, but it not (yet) proven rigorously like the above-mentioned Euclid's proof of the infinity of prime numbers. Looking at the table of prime numbers, we indeed find many twin primes. And in view of the logical simplicity of the Euclid's proof (it is elementary and practically anybody can follow it without much difficulty), one may think that it may be equally easy to proof (to demonstrate) that there is infinity of twin primes.

Unfortunately (or, perhaps, fortunately?) it is *not* the case. So far, nobody was able to proof that there are infinity of twin primes, even it is almost certainly so. But "almost" does not count in mathematics. In mathematics, you can't say "I am 99.9% sure this is so." Only 100% is counted as a true value, anything less is just a good guess or a pipe dream. And why I just said "or, perhaps, fortunately"? Well, this is because *if and when* the twin prime conjecture will be proven (and thus becomes "twin prime *theorem*"), this lucky mathematician will get Golden Laurels Awards and worldwide glory. Because of some historical curiosity, there are no Nobel Prizes in mathematics, but all other higher awards will be undoubtedly handed over to such a mathematician.

In fact, we are moving there. To twin prime conjecture, I mean. In 2013, China-born American mathematician Yitang Zhang (b. 1955) has *proven* a key theorem on the path of twin prime conjecture. And his proof produced an instant excitement in the world's mathematical community and well beyond it. It also made headlines. So, what was the fuss about?

Among many things we know about prime numbers, two are of key importance. Both are *proven* theorems. The first is the Euclid's proof that there are infinite number of primes. The second is that the proportion of primes ever decreases as we move

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along the number line. This means that the average distance between primes (called "prime gap," or "prime desert") gets larger and larger. However, *average* means that some gaps may be larger than the average, whereas some others may be smaller. It is like an average house price in a city: some houses may cost less, some more than the average. Same with almost anything.

It is known that the gaps between two *consecutive* primes, P(n) and P(n+1), can be arbitrary large. Here "P(n)" means nth prime if we count primes from the beginning (2, 3, 5, 7, 11, 13, 17, etc.). For example, P(4) = 7, P(5) = 11, and so on. Let us designate the gap between two consecutive P(n+1) and P(n) as G(n); G(n) = P(n+1) – P(n). It was proven long ago that G(n) can be arbitrarily large. In other words, for *any* number N, it is possible to find a gap exceeding N. This means there are gaps between primes larger than 1,000, or a 1,000,000,000, or billion, trillion, or any other number for this matter. But what about small gaps? For *twin primes*, G = 2 (for example, 13–11 = 2, 19–17 = 2, etc.). Is the gap G=2 occurs infinitely often?

And here is the snag. *The twin prime conjecture is not proven*. Not yet, at least. So, we cannot say with 100% certainty (and mathematicians won't settle for anything less) that there are infinitely many gaps G = 2. And if it is not, then there is only a finite number of gaps G = 2; this would mean that there is a largest pair of twin primes somewhere on the number line. While this seems highly unlikely (that there is the largest pair of twin primes), we did not yet rigorously proved it otherwise.

Furthermore, it was not even proven that there are infinitely many gaps of *any* finite size. And if not, that would mean that gaps will get bigger and bigger as we move along the number line. In other words, in this case, there won't be any finite number N so there will be *infinitely many* gaps smaller than N. So, among the world's mathematicians, this whole issue was hanging around as an open challenge, which was neither proven nor disproved.

However, this maverick mathematician Yitang Zhang has proven in 2013 a key theorem. It states that there is indeed some number N that is less than 70,000,000 (seventy million) that there are infinitely many inter-prime gaps smaller than N. That is, infinitely many gaps G < N. In mathematics, there is an enormous difference between a theorem and a conjecture. A *theorem* is a statement that is already proven. Proven rigorously. No doubts remain. But a *conjecture* is only something that is plausible, likely, but not yet proven without a shadow of a doubt.

And the difference between certainty and plausibility is truly critical. To give another example, we can quest if it is possible to fly on a broomstick. Witches, they say, do this. Or, a flying carpet. But speaking seriously, do we have a proof? Some probably will deny it out of hands as not much more than fairy tales. Impossible, it is. However, what if it is possible to find some anti-gravity material, make a broom or a carpet out of it, and here you are! Welcome on board!

But back to Zhang's proof.

The number N = 70,000,000 seems very, very far from G = 2 that will prove twin prime conjecture and will make it a twin prime theorem. But no matter how far

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70,000,000 is from 2, it is a *finite number*. For mathematicians, it is an enormous difference. This means, if we travel along the number line, facing larger and larger gaps, gaps even larger than the number of atoms in the universe, there still always will be pairs of primes with difference less than 70,000,000.

And further progress has been made since 2013. Many mathematicians jumped on Zhang's proof trying to improve his estimate for N. The latest advancement reported in the time of this writing (March 2018) is N < 247. This means that *for sure* there is some number less than 247 so that there are infinitely many primes separated by this (truly small!) number.

That may make us dwell on the metaphysical significance of these results. What it gives for our contemplations on the matters of infinity? Let us think of prime numbers as some living entities. Then even after enormous light-years long, deserts (prime gaps) void of even a single prime, we still will (forever!) keep finding "prime couples" – pairs of primes separated by less than just 247 (nothing in comparison with infinity). Is it not an image of eternal love among primes? All what remains for us here is to hope on the coming proof of the twin prime conjecture.

At the beginning of 2007, two distributed computing projects, *Twin Prime Search* and *PrimeGrid*, have produced several record-largest twin primes. As of September 2016, the current largest twin prime pair known is 2996863034895. 21290000 ± 1 with 388,342 decimal digits. It was discovered in September 2016.

As of September 2016, the current largest twin prime pair known is as follows:

> 2996863034895 ... 2^1290000 ± 1 with 388,342 decimal digits. It was discovered in September 2016.

There is no doubt that this record will be beaten, unless already it is.

There are 808,675,888,577,436 twin prime pairs below 10^18. In view of this, it seems highly unlikely that there is "the largest" pair of twin primes and the common logic should tell us that the number of twin primes is infinite (even that, as yet, not formally proven).

But 70,000,000 is not the end of the story.

In November 2013, a young British mathematician James Maynard (born June 9, 1987) has improved Zhang's method of reducing the value of "N" from 70,000,000 to mere 600; to express it formally as follows:

For "n" –> infinity, lim inf [p(n + 1) – p(n)] ≤ 600

In other words, Maynard showed that there are infinitely many prime gaps at 600 long. In other words, there are infinitely many pairs of primes separated by the interval less than 600.

Note: The above-mentioned results should not be confused with the *proven fact* that there are *infinitely many prime gaps* ("prime deserts") of *any* given length, as was above-mentioned.

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3.4 Prime gaps and superfactorials

My reader can now wonder: What kind of a “metaphysical excitement” the above-mentioned discoveries of Zhang’s can bring? Well, meditations and intellectual reflections on this can open up windows of infinity for us. How? Let us introduce two more members to our “prime number team.” These are (1) *superfactorials* and (2) *tower exponents* (Berezin, 1987g, 2015, 2016). While they are close relatives, they are not exactly the same.

Superfactorial:

Recall the definition of *factorial*. This is simple. The factorial of a positive integer number N (written as N!) is a product of all numbers up to N. That is 1! = 1, 2! = 1×2 = 2, 3! = 1×2×3 = 6, 4! = 1×2×3×4 = 24, 5! = 1×2×3×4×5 = 120, and so on. Factorial grows quickly with N. Very quickly. Factorial of 100 (that is 100!) has 158 digits. Here it is as the following:

100! = 9332621544394415268169923885626670049071596826438162146859296389
52175999932299156089414639761565182862536979208272237582511852109168640
00000000000000000000000

It has 24 zeros at the end and 30 zeros in total. Its size or the order 10^158 is a lot more than the number of electrons in the universe (it is about 10^80 or 10^90 – estimates vary).

Yet, we can offer something even better. A far faster growing function. Actually, there are many such functions. Perhaps, infinitely many. The following example just shows one such function called “superfactorial” (Berezin, 1987g, 2015, 2016).

It works like this: Take a factorial of N, that is N! That forms a tower (tower exponent) as (N!)^(N!)^ … ^(N!) where the number of “(N!)” is itself N! Call this function a “superfactorial”; in my paper (Berezin, 1987g), I used a symbol “$” for this. Thus:

N$ = as (N!)^(N!)^ … ^(N!) where the number of “(N!)” is itself N!

This is in the beginning of this trail:

1$ = 1 (trivial), 2$ = (2!)^(2!) = 4 … seems to be not much (so far).

But let us make the next one, 3$. Recall that 3! is 6. So, 3$ = 6^6^6^6^6^6, stack of six “6”, and it has to be calculated from right to left. Any calculator will give you 6^6 = 46656, so we can rewrite 3$ as 6^6^6^6^46656. But the attempt to go to the next step is to calculate 6^46656, which gives an error message. Pocket calculator cannot make it. And we are still far from the end, this “6^46656” is just the top 3 floors of a tower of 6 “6th” that make 3$. And the next step to make 3$ is to “write” 6^ [6^46656], which would surely take us to nirvana! (And there are still 2 more floors to go!)

In fact, 3$ is well beyond human imagination, if the whole universe will be filled with cramped paper, it will not be enough to just *write* down this number! And this is

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still just a modest 3$. And we can wonder about 4$ (stack of 24 of "24"), or 5$ (stack of 120 of "120"), or 100$ (stack of 100! of "100!").

And yet, we are still at the very beginning. No matter how unimaginably big 100$ is, we can ask the same question about N$ when N itself is some huge (tower exponential) number. For instance, what about $ (100$), which is *superfactorial* of 100$. To "make" it (certainly, only formally, no way to make it "really"!), we have to first calculate 100$ and *then* make a stack of *this number* that will *itself* be *this number* tall.

And certainly, we can "recycle" such an operation, such as making a 3-step iteration [(100$) $] $, and so on. And of course, instead of "100," we can take any other number, say, 1,000, or 1,000,000, or billion, trillion, and so on (no limit here).

3.5 Twin primes: Eternal lovers

And how the *prime numbers* and the results of Yitang Zhang fit here? Well, through the *excitement of the infinity meditation*, I would venture to say. One known and rigorously proven result of the number theory is that there are "gaps" between two consecutive primes of any length. They are known as "prime deserts", intervals on the number line (1, 2, 3 ... to infinity) that do not contain even a single prime (Maier, 1981).

This means that if we "find" a gap of length, say, (100$)$ on a number line, there still will be infinitely many gaps of much larger length (say, [1,000$]$, etc.) somewhere ahead on the number line.

And yet (and here are the drums of a spiritual dance bang!), there will be infinitely many *prime couples* (close primes, and most likely prime twins) after *any* (!) such (enormously large) gap. Such is the power of infinity as it revealed to us in all what we know about the prime numbers and their infinitely tricky pattern. Close primes (and most likely, prime twins), such as eternal loving couples, will be showing up *forever* (!), even after all enormously large prime gaps. Can we see it as an image (or a symbol) of eternal metaphysical love in the ideal Platonic world of numbers?

To illustrate this, let us imagine that all integers (1, 2, 3, 4, 5 ...) are placed one-by-one on an infinite straight line with (say) 3 mm apart (typical distance between letters of a printed text). Somewhere on this line, there will be a "prime gap" of, say, [(100$)$]$ length. Such a gap will be zillions upon zillions times longer than the size of the universe (the "big bang" universe the way we know it now). Not a single prime number exists in this ultra-long gap! *And yet*, after this gap is over, there will be a "prime couple" (or a "prime twin") nicely sitting together as a pair of two doves in love! Isn't it charming? And there are *infinitely many* even longer prime gaps ahead and after them there are still *infinitely many* such tight prime couples sitting together. Such is the power of infinity of prime numbers!

And for those who may like quantum-based metaphysical analogies, I can point to an interesting example from the singular potentials quantum physics. This strange "affinity" ("attraction") of prime numbers to each other through the enormous spaces

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of prime gaps is, perhaps, metaphysically similar to the “paradoxical” case of a repulsive potential that has a bound state. This example was found in the early years of quantum mechanics by the two great names, John von Neumann (1903–1957) and Eugene Wigner (1902–1995) who were only 27 when this paper was published (von Neumann and Wigner, 1929). They interpreted this peculiar result by saying that the particle in a strongly repulsive singular potential runs to infinity with an unlimited (super-luminal) speed. It “reaches the infinity” in a finite time and then is “reflected back” from infinity,” thus forming the bonded state (generally, quantum mechanics does not allow bound states in the repulsive potentials).

And in spite this, twin prime conjecture so far remains unproven as a rigorous theorem, but all means and all logics of the universe, it must be true. To suggest the opposite would mean that there *must* be the “largest” twin prime pair and then the question will be what exactly this largest twin prime pair is. As was stated a few paragraphs earlier, the largest known (as of September 2016) twin prime pair has 388,342 decimal digits. This means, it is about 10^388342. To remind, the volume of the (big bang) universe is “only” 10^90 mm^3, which is incomparably smaller than the said twin prime pair. Thus, it is almost impossible to believe that there can be the “largest” twin prime pair – never mind the mathematicians are still struggling to find a formal proof of the twin prime conjecture.

Thus, we can safely assume that there is not only infinitely many primes (proven fact), but also an infinitely many twin primes (“prime couples”!) as a metaphysical symbol of the eternal love in the ideal Platonic world.

3.6 Tower exponential meditations

As meditative exercise for those who love mathematical contemplations, I would like to provide the following “mathematically oriented spiritual meditation.” It can be put in a context of the “infinity of twin primes as eternal lovers in the Platonic world” (previous essay).

The famous motto ascribed to Pythagoras that “everything is a number” always had a strong resonance in me. I can say about myself that the allure of numbers (and “games” the numbers play) was always one of my strongest fascinations. No, I am not a gambler of any kind, never was one and, hopefully, never will be. My “love for numbers” is totally elsewhere. What I mean by numbers is actually the number theory. Topics such as distributions and patterns of prime numbers, factorizations of integer numbers, exponential functions, and Cantor set theory (nested infinities) were always a part of my own search for higher truths and quest for “ultimate reality and meaning.”

In fact, I have several scholarly papers published in the journal with exactly the same title (URAM journal – *Ultimate Reality and Meaning*, published by the University of Toronto Press). These papers are listed in the bibliography in the end of this book (Berezin, 1996, 1998b, 2004c, 2006).

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And as for my fascination with numbers and number theory, I am most certainly not alone in this. In fact, I am in a pretty good company. These Platonic realities that have infinitely rich and unchangeable patterns have fascinated many people. Some spent their entire lives pursuing their interest in numbers, in particular prime numbers.

For example, Bernhard Riemann (1826–1866) had such a keen and passionate interest in prime numbers (and the so–called zeta-function related to their distribution) that one of his biographers has called it "prime obsession" (Derbyshire, 2004). Along this line, I was interested in the life and work of one of the greatest number theorists Paul Erdos, see my essay about him in Chapter 4 of this book.

As for my own "prime obsession," I have to confess that I do not have much expertise or professional training in the details of complicated mathematical proofs in number theory or other areas of abstract mathematics. My, somewhat amateur, interest (or more precisely – a curiosity) in numbers and patterns comes from some kind of an artistic sense of "awe" with many fascinating findings and results in the number theory and the theory of sets by Georg Cantor (for example, the famous "continuum problem"). In this regard, I have a somewhat eclectic, perhaps, a "surrealistic" take on all this, this is one of the reason I decided to include in this book an extended essay on the art of Salvador Dali (Chapter 10).

Quite a while ago, I became interested in the so-called "tower exponential numbers" and even made some contribution to this issue by publishing a short (2 page) article called *super super large numbers* in the *Journal of Recreational Mathematics* (Berezin, 1987g). In the title of this article the word "super" was used twice, which apparently made one popular author to include this paper into his list of "the 10 strangest mathematical titles ever published" (Pickover, 2001, chapter 43). In this ranking, my paper got 4th place out of ten, not too bad an achievement (!), perhaps a bronze medal (assuming the first three are platinum, gold, and silver).

Yes, receiving bronze and silver medals are great! Bronze medal will be fine with me, especially that bronze is an alloy of copper (2 stable isotopes) and tin ("isotopicity champion" with 10 stable isotopes). And for me, an admirer of isotopicity and isotopic randomness to get a gold medal (for anything, never mind a Nobel Prize) would be almost an insult (!), since isotopically poor gold has only one stable isotope (197Au) and, hence, no isotopic randomness – what a disgrace (!).

This is what I wrote in my 1987 paper "Super-Super Large Numbers (Berezin, in a somewhat edited form, with few updates and additions):

Those who like curious mathematical phantoms should appreciate the tower exponentiation (*superexponentiation*). The best-known example of it is, of course, the so-called Skewes number named so after the South African mathematician Stanley Skewes (1899–1988) and published two consecutive papers (Skewes, 1933, 1955). Written as a (decimal) tower exponent the Skewes number looks like the following:

$$K = 10\text{^}10\text{^}10\text{^}34. \quad (3.1)$$

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Such multistorey numbers should be calculated "from up to down," or "from right to left" when they are written in a single line ("digital texting"!). The first step is to raise the upper "10" to the power 34, and so on; the sign of exponentiation (^) is used for typographical convenience. The above "K" is obviously a very large number. It made Skewes famous. It makes the number of electrons in the entire universe (which is "only" about l0^100) look ridiculously small.

But it is now known that it is not that large – some recent advances turned "K" into a mathematical dwarf. However, to appreciate these recent developments, one needs to know a bit of modern mathematics. My purpose here is to cook something that does not require more than the commonly known functions and elementary operations (exponentiation and factorial).

It is an easy game, which is open to anyone, to write on a limited space (e.g., on a page of a pocket notebook) as a large number as one could possibly imagine. A typical (but in no way unique) try may look like the following:

Define the function that I call a superfactorial. Instead of the traditional sign for the factorial ("!"), I suggest to use a sign "$" for the superfactorial – not because my love for dollars (no, money is not my love affair), but for the sheer reason that the choice of characters on the QWERTY keyboard is pretty scarce. The definition of a superfactorial for any positive integer "N" is the following:

N$ = (N!)^(N!)^(N!)^ ... ^(N!), [term N! repeated N! times]. (3.2)

There is a generalization of the factorial for all real non-integer numbers (this generalization is called gamma function), but I will not deal with it here, so take "N" to be (any) positive integer. And, of course, there is infinity of positive integers (countable infinity or "aleph naught" as Georg Cantor has called it). And, again, I have to make a disclaimer that I do not know if I am the first who introduced this definition for the superfactorial (Berezin, 1987g) as given by the above formula (3.2), regardless of what sign, $ or what, may be used for it. And if, perhaps, somebody else did it before me, I do not know that, neither much care, as the last thing I care are "priority claims". As for the latter, I personally, leave sufferings and fights over priority claims to those people who have an ample vanity, or megalomania – something which, I believe, is not my thing, or ever was.

To appreciate how fast N$ grows, one can easily find that 1$ = 1^1 = 1 and 2$ = 2^2 = 4, but 3$ is already a number (6^6^6^6^6^6) that is enormously greater than the Skewes number "K". And 4$ is a 24-storey tower of 24^24^24^...^24, where "24" repeated 24 times, as such, the value of 4$ is well beyond the capacity of a human imagination. Likewise, 5$ is a 120-tall stack (tower) of "120," 6$ is 720-level stack of "720," and so on.

Then, what about N$ where N is itself a "large" number, for example, how large K$, or say,(K!)$? ("K" is the Skewes number defined earlier). Furthermore, the operation $ itself can, in turn, be looped M times using the following recursive definition:

NS^M = (... (N$)$)$)...)$ [operation $ repeated M times]. (3.3)

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(For example, N$^2 = (N$)$, N$^3 = ((N$)$)$, etc.). Just to stop on something, I will stop here on B = K$^K where both "N" and "M" are sets equal to the above-mentioned Skewes number. The reader can, of course, easily beat this record by continuing the above-mentioned cycling, for example, using the above K$^K as a new "seed" number, defining new loop operations in the same spirit, and so on. The number of ways how this can be done is by itself a tower exponent (!).

There is, perhaps, not that much "end use" for the numbers so produced. Nevertheless, it is an exercise that will likely give a quick satisfaction (through the sense of "possession"?) with just the most simple (and certainly inexpensive) mathematical tools. Or, perhaps, one can think how the universe will look like, say, at a scale of 100$ m, or 1,000$, or K$ m (etc., etc., etc. – ad infinitum.).

And, of course, the above superfactorial N$ is not the champion of this game. Lot of other mathematical constructs can beat it to the ground. For example, there are so-called arrow notations that are discussed by many authors, in particular by Donald Knuth (Knuth, 1976). He uses the "arrow notations" to illustrate the fantastically fast growth of some functions. One vertical arrow (↑) means a simple power, for example, 3↑3 = 3^3 = 3E3 = 27, or 4↑ 4 = 4^4 = 4^4 = 4E4 = 256, and so on. However, two arrows together mean a tower exponential, 3↑↑3 = 3^3^3 = 3^27 = 7,625,597,484,987 (this number is over 7 trillions) and in order to write down 4↑↑4 = 4^4^4^4 = 4^4^256 paper will not be sufficient in the world (it has over 10E153 digits – much more than the number of atoms in the universe). As with my superfactorial, the calculation of such numbers always proceeds from right to the left. Operation with three vertical arrows is defined recursively, for example,

$$5\uparrow\uparrow\uparrow 3 = 5\uparrow\uparrow(5\uparrow\uparrow 5) \qquad (3.4)$$

In the above-mentioned line, "5" is repeated 3 times with 2 sets of double vertical arrows in between "5s." The general rule is that the number N↑↑...↑M with "n" arrows is calculated as N↑↑...↑(N↑↑...↑(N...N)...), where "N" is repeated "M" times with "M-1" sets of "n-1" arrows in between "Ns." Of course, the number of opening brackets ["("] and closing brackets [")"] brackets should be the same. The general definition looks like the following:

$$N\uparrow\uparrow\ldots\uparrow M = N\uparrow\uparrow\ldots\uparrow(N\uparrow\uparrow\ldots\uparrow(N\ldots N)\uparrow\uparrow\ldots\uparrow N) \text{ ["N" repeated "M" times]}$$

where there are "n" arrows in the left-hand side of the above-mentioned equation and "n-1" arrows after each "N" in the right-hand side of this equation.

After such a definition, Knuth then considers an example with four arrows and he calls it a "very small" (sic-!) example. He takes the number Y=10↑↑↑↑3 (four vertical arrows), which is equal to

$$Y = 10\uparrow\uparrow\uparrow\uparrow 3 = 10\uparrow\uparrow\uparrow(10\uparrow\uparrow\uparrow 10), \qquad (3.5)$$

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The right-hand side of this formula expresses “Y” by three “10s” with two sets of triple arrows in between. This expression may not look particularly impressive, but when we proceed with its actual evaluation, the result turns out to be mind-boggling. There is no way that Y can be calculated in a common meaning of the word “calculated.” In order to go (at least formally) for spelling out “Y” in more details, we first have to evaluate (10↑↑↑10). Applying the above-mentioned definition, we express “Y” by the following (crazy-looking?) formula:

$$(10\uparrow\uparrow\uparrow 10) = 10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow(10\uparrow\uparrow 10)))))))). \qquad (3.6)$$

Even typing this formula in a single line requires careful counting of all “10s” (there are 10 of them) and sets of *two* vertical arrows (there are 9 such sets) and all brackets. The formula has 8 opening brackets [“(“], and to be mathematically correct, it likewise needs 8 closing brackets [“)”] in the end. So, in order to start “working out” the formula (3.6), we begin from the right end of it and the first item we have to deal with is (10↑↑10). Even just this first step already leads us to a 10-storey stack of “10s,” which we elsewhere also designated as T(10). This is a tower exponential number, which is enormously greater than the Skewes number, or anything else that can be contemplated in a physical world. And this is just the first step of doing the formula (3.6), which itself is just a first step in “calculating” Y (!).

The next step in doing formula (3.6) leads us to 10↑↑T(10), which is 10 to the power of not just T(10), but to the power expressed by a stack of “10” that is T(10) tall (!). And T(10) is much, much greater than the size of the Big Bang Universe (BBU) expressed in any units (!). And we are still far from the end of doing even formula (3.6), not to mention “Y” itself (!). Donald Knuth (Knuth, 1976) makes some more comments on the enormous, incomprehensible, size of “Y” and concludes by saying that no matter how fantastically great “Y” is, we should pause and notice that “on the other hand, it is (still) very small as finite numbers go. We might have used (10↑↑↑10) arrows instead of just four, but even that would not get us much further – almost all finite numbers are larger than this.”

In other words, *any* finite number that can be defined by *any* formula of this kind will always be “infinitely small” in comparison with infinity. And here we talk about countable infinity (*aleph-naught* set) of the theory of infinite sets of Georg Cantor.

As was mentioned earlier, there is virtually no end to the ways how numbers such as (3.5) can be beaten by much higher “records.” For example, just as an entertaining “experiment,” I can offer the following mental exercise:

First, define an *integer* “F” (which is a HUGE power of 10) as follows:

$$F = 10\uparrow\uparrow\uparrow\ldots\uparrow\uparrow\uparrow 10 \qquad (3.7)$$

(1) where the number of (↑) in the above-mentioned line is 10↑↑↑…↑↑↑10
(2) where the number of (↑) in the above-mentioned line is 10↑↑↑…↑↑↑10

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(3) where the number of (↑) in the above-mentioned line is 10↑↑↑...↑↑↑10

. . . .

. . . .

The above-mentioned line is repeated, say 1,000 times, the last lines will be as follows:

999 where the number of (↑) in the above-mentioned line is 10↑↑↑...↑↑↑10

1,000 where the number of (↑) in the above-mentioned line is 10↑↑↑...↑↑↑10

where the number of arrows (↑) in the *last* (1,000th) line is 10↑↑↑↑↑↑10.

Note: In the above-mentioned stack of lines, we should proceed from bottom-up; the first step is to "calculate" the "plug-in" seed ("10↑↑↑↑↑↑10") from the last line (of course, we can do it only symbolically, because nobody can do it in any "real" meaning) and then "use" this number as the number of vertical arrows in the 1,000th line, then using the "so obtained" number to be a number of arrows in the 999th line, and so on – to the 1st line and, finally, to the formula (3.7). Needless to say that in the above-mentioned "exercise" we, instead of having just 1,000 lines, could have taken a million, or a billion or *any*-lion (trillion, zillion, etc.) or such lines (!). Later, I will return to this example in connection with an issue of eternal return and exact copies of ourselves (and our entire "visible universe") in enormously remote depths of the (likely infinite) cosmos.

NOW, let us define another *integer* number "H" as follows:

$$H = \mathrm{Ent}[\exp(F)], \tag{3.8}$$

where "Ent" means integer part of a ([real) number, for example, Ent(183.5439) = 183. Exponential function "exp" of integer number is never an integer itself, so we have to use operator "Ent" (French "entire"). Exponents of all integer (and all rational) numbers are transcendental numbers whose infinite digital strings never come to periodical cycles.

Now we note that no matter how fantastically huge this number "H" is, it is still an *integer* and the question can be asked, for example, what are the last 100 decimal digits of it (because it was defined through the "exp" function, it is highly unlikely that it ends in a string of 100 zeros, while, of course "F" itself is a "1" followed by a fantastically long tail of zeros).

Certainly, in defining the above-mentioned "F," it is possible to take any other number of lines instead of just a thousand of them (e.g., 10↑↑↑↑↑↑10 number of lines), as well as to take any other number of arrows in the line starting with the word *where*. I wrote down the above-mentioned example just to be specific. Anyone can easily "beat" me in this game, for example, by taking the "seed" number in formula (3.7) to be "H" (from [3.8]) and recycling the whole procedure above from line (3.7) to (3.8) and over again, and over again, and over again...(!)

And yet the questions such as "what is the last 100 (or 1,000, or million) *last* decimal digits of H are"? or What is the last, say, 100 digits of the first prime number

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greater than H"? (etc., etc.) These are fully logically (and mathematically) legitimate questions. Owing to enormous super-astronomical values of "H-type" numbers, the correct answers to the above-mentioned questions may forever be beyond our capacity to find; yet these answers do exist and they are exact and unique (for each specifically stated question).

So, in my view at least, we cannot refer here to Gödel's undecidability theorem and claim that these questions are "in principle" unanswerable (there may be some, yet perhaps unknown, mathematical methods of finding the last few digits of tower exponential numbers without "calculating" the entire number).

So, again, who knows? Maybe, some advancement in quantum computing will sooner or later open an opportunity for us to get exact and precise answers to these kind of questions even for numbers like the above-mentioned "H"? At least, this last remark relieves me from the responsibility of wrong predictions that quantum computing (or any other future method) will turn out powerful enough to crack any digits of any "H," which may be defined by the above-mentioned (or similar) procedures.

Chapter summary

In spite that most people know since school what the prime numbers are, there are many details and puzzles that are less known. For example, what are the "twin primes" and how many of them are there? (The famous "*twin prime conjecture*"). Why "twin primes" produce so much fascination among so many people such that any progress in this regard makes worldwide headlines? Why primes, like people, tend to form "couples"? Do they have "affection" to each other? (In a metaphysical sense, of course). What are the prime gaps ("prime desert") – the strings of consecutive integer numbers without a single prime among them? How long these "prime gaps" can be (infinitely long)? What are the "tower exponents" and "*superfactorial*" and how fast they grow? (Fantastically fast).

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4 Primology awe

In the metaphysical depths of our perceptual realm, the infinite set of prime numbers (2, 3, 5, 7, 11, 13, 17, 19, 23 ... [to infinity]) plays a central role as it is well reflected in numerous books written from a variety of positions (Dickson, 1952, 1960; Ribenboim, 1989; Plichta, 1997; Du Sautoy, 2003; Giordano, 2011;). And all possible information, all books and messages, are coded somewhere in the trails of digits of prime numbers. Any specific number is finite, yet there is no limit to the length of prime numbers since they run to infinity. In this connection, we will talk later (Chapter 8) about the metaphor of the "library of babel" – "library of all possible books," as was devised by Jorge Luis Borges.

Of a particular significance for us are the pairs of close primes that, as explained in the previous chapter, also run to infinity. These "prime twins" pop up forever on the number line like some magic lovers dwelling in the depths of infinity. And in our "quantum mind" we can draw even more parallels between prime numbers and the physical reality. For me, a quantum physicist, it is especially tempting to outline such parallels.

4.1 Quantum nonlocalities and prime numbers

Everything we call real is made of things that cannot be regarded as real.
Niels Bohr (1885–1962)

The idea on nonlocality and instant connections between seemingly disjoint particles and objects in at core of quantum physics (e.g., Bohm, 1952, 1980; Bell, 1988; Bohm and Hiley, 1993; Deutsch, 1997; Penrose, 1998b; Grib and Rodrigues, 1999). In this way, the existence of infinitely many "prime couples" (or "prime twins" – see the previous chapter) can be seen as a metaphysical analogy to the "nonlocal connections: in the ideal platonic world."

In other words, the distribution of prime numbers (*primology*) and related areas of number theory (e.g., solutions of Diophantine equations) form the basis of unchangeable "platonic world" in a sense that "they are just out there." We just discover (for ourselves) the numerological patterns but in no way "invent" or "create" them. This is not quite so for "physical" laws of "our" universe, which are somewhat provisional and contextual. Among various mathematical (platonic) entities, prime numbers and their distribution are often seen as playing a special role (e.g., Plichta, 1997).

Likewise, human imagination, culture, and folklore – all demonstrate an ample significance of prime numbers. This is quite remarkable and persistent, for example, "2" is indicative to love/sex and duality, "3" to trinity (in Christian theology and outside of it), "7" is a traditional number for luck, "5" and "13" are used in occult, and "11" is the center of the recent lore of "Elevenology" (11:11) initiated by a new age "priestess" by the (pen) name "Solara" around 1990.

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What I venture to propose (original idea or not?) is that an infinite intricacy of prime number distribution forms the basis for the universal connectedness of (arbitrary) distant points and events. This seems resonating with the ideas of nonlocal quantum connectedness like quantum potentials and holomovement (David Bohm) or recent (theoretical and experimental) developments along Bell's theorem of quantum physics (in a nutshell this theorem states that quantum particles [electrons, photons, etc.] still maintain connection even when they are separated by huge distances).

To this, we can add the ideas of "cosmic size" of the wave function of the *quasistationary states* of radioactive isotopes (Berezin, 2015, 2016). Physical (and/or metaphysical) vacuum (in any imaginable model) is never "empty"; it inherently and unavoidably contains all platonic world and, correspondingly, an infinite capacity for informational unfolding and emergence. Different segments of prime number sequence may be "responsible" (like different segments of DNA in genetics) for different aspects of universal unfolding and concretization of particular "sets" of physical laws in individual "baby universes" of inflationary and/or Everett's cosmogenetic chains.

What "physics" really does in this picture is that it "labels" some specific patterns from the numerological and primological "platonic world field" to specify a set of particular objects and/or modes of existence out of entire platonic world. This "mechanism" of "specification" by "materialization" (or "embodiment") of platonic world is metaphorically similar to the reduction (collapse) of the wave function (Berezin, 2015, 2016). "Physically," the informational connection (platonic world decoding) through "space and time" can proceed by (any) mechanism of default labeling, for example, by pattern proliferation mechanisms in nonlinear dynamics (informational cloning) or by (any) kind of a pattern-cloning process, for example, "cosmic censorship," phase locking, morphic resonance, solitonic mode selection, and other effects (Berezin, 2015, 2016).

4.2 Isotopic prime number curiosities

All world as we see around is made up of some hundred chemical elements and their isotopes. Similarly, prime numbers show the presence in the game of chemical elements and their isotopes! If we look at the table of elements, we can notice a few curiosities involving prime numbers.

In the periodic table, the elements up to the atomic number $Z = 83$ are normally stable. This means that these elements have at least one stable isotope. After that (from number $Z = 84$) all elements are radioactive, and they have no stable isotopes. Yet, two elements in the middle of the periodic table (stable region) also have no stable isotopes! These elements are technetium ($Z = 43$) and promethium ($Z = 61$). They have no stable isotopes, and the curious fact is that they both have prime atomic numbers (43 and 61 are primes).

Now a few words about silver and gold. Both these elements are also "dedicated fans" of prime numbers – and, perhaps, for good reasons.

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To begin with silver, one can notice that its two stable isotopes, 107Ag and 109Ag, are both prime numbers, as well as the atomic number of silver itself ($Z = 47$) is also a prime number. One may wonder if this "love of prime numbers" has anything to do with the alleged mystical capacity of silver to fight dark forces, such as the folkloric "silver bullets" for slaying vampires. Not to mention a wide use of silver for the jewelry items, ear rings, silver vessels in religious ceremonies, and so on.

Moreover, we can go a step further and employ the ideas of quantum physics and digital informatics. We can notice that both isotopes of silver have almost same abundancies, 51.9% and 48.2%, respectively. The result of this is an enormous level of isotopic randomness in silver instruments such as daggers, crosses, and so on. This allows to "code" in them very long trails of information that can carry some spells to resist forces of darkness. I realize that it may sound a bit fantastic, but perhaps people with more experience in matters such as exorcism will have their own take on that.

And as for gold ($Z = 79$), it (unfortunately?) has only one stable isotope, 197Au. And yet, gold is also a "prime number" element, as both 79 and 197 are prime numbers. Ancient civilizations were laden with religious and mythical beliefs, and silver and gold were believed to be favored by the gods, who kept these metals shiny and rust-free.

In voicing these alleged connections between isotopes, prime numbers, and folkloric mysticism, I should make another comment. It is prudent for me to mention here that it is only in my present status of a "Professor Emeritus" (retired professor) who does not need any more "promotions" and "appointments" that I can put in print such "new age" comments, which almost certainly almost any "mainstream scientist" will instantaneously dump into a crazy box. But again, who can guaranty that there will be no takers of these ideas and possible connections, if not now, but than perhaps in 50 or 100 years hence? From here more of my "crazy comments" will keep following in this book.

Prime numbers form the foundation of the number system (any integer number can be presented as a product of prime numbers in a unique way, for example, $154 = 2\times7\times11$). This centrality of prime numbers for the structure and the dynamics of the universe was recognized since antiquity. Meditating on prime numbers as the building blocks of the world had invariably led to spiritual insights and enlightening contemplations. Thinking about the unchangeable and eternal platonic infinity of prime numbers puts us on the island of spiritual stability among the ephemeral happenings and problems of our day-to-day life and our transient existence on this planet where none of us is guaranteed neither the next day, nor even the next hour.

4.3 Numbers and love (Paul Erdos)

Probably no concept can be more simpler and universally understood as the concept of whole (integer) numbers. Even before we learn to read, we all can count: 1, 2, 3, 4, 5, 6, 7,... And the child is often asking, does it go on forever? From the kindergarten

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counting is our obsession. And for many people, this obsession persists for the whole life. Here is the story of a great mathematician Paul Erdos taken from the newspaper column that I wrote years ago (*The Hamilton Spectator*, April 9, 1999).

Number theory, a branch of mathematics, is usually considered to be the study of integers – positive and negative whole numbers plus zero. It deals with topics such as the relations of integers to each other and the distribution of prime numbers. Although it has some practical applications (e.g., security codes for bank transactions), it seems to bear almost no relevance to nonmathematicians.

And yet, it is a remarkable fact of human psychology that many of us have a strong affection for numbers. Thus, when Princeton University mathematics professor Andrew Wiles finally succeeded in 1993 in proving Fermat's last theorem, the event produced headlines worldwide.

What was the fuss all about? We all know that the sum of two squares can itself be a square. For example, 9 + 16 = 25 (three squared or multiplied by itself plus four squared equals five squared). At first glance, it may seem that it is equally easy with cubes – that is, to find two cubes that together make another cube. But, alas, 350 years ago, a French lawyer and mathematician Pierre de Fermat made a famous claim that such a trick is impossible for anything greater than squares. Thus, Fermat's theorem says that no two Nth powers can add up to make an Nth power of another integer, where N is any integer higher than two.

Fermat's proof (if he really found one) was lost, and for centuries numerous mathematicians tried in vain to prove (or disprove) Fermat's conjecture. Finally, Wiles succeeded. But why should other people care? Surprisingly, many of us do.

Trends in popular literature often reflect hidden aspirations of the reading public. Among the most interesting and accessible is a biography of a great number theorist Paul Erdos (1913–1996) by Paul Hoffman (*The Man Who Loved Only Numbers*). One of the most curious figures in the history of mathematics, Erdos literally lived in the world of numbers. He did not have a permanent residence or a permanent academic position. With all his lifetime belongings in a single suitcase, his life was a chain of short-stay visits at the houses of fellow mathematicians.

He did not have any interest in anything except mathematics. He never had a family or any known amorous relationship. Number theory was his only love affair. He was one of the most prolific mathematicians in the world (some 1,400 papers); much of his heritage is coauthored papers. His biographer reports that on one of his long train trips between two host universities, as luck would have it, he found himself sitting next to a beautiful young woman. The two started a conversation. By the time train arrived, they had finished writing a joint paper.

So, what fascinates us about integers? Perhaps, as some thinkers say, it is the combination of certainty, immutability, and inexhaustibility. For many people, this trio generates a mystical attraction.

Certainly, all questions about numbers should have an unambiguous answer: yes or no; true or false. This is ostensibly not so for almost all other aspects of our

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life. Even in “exact” sciences (except mathematics), we face uncertainties. Despite all their aesthetic appeal and physical plausibility, Big Bang theory and Black Holes remain speculative constructs. Future developments may revise them or replace them with other alternatives. This is not so for prime numbers. Any integer is either prime or not.

Second, this fact is unchangeable even by God (according to St. Thomas Aquinas). Such solid immutability is hardly attainable in our other ventures.

And finally, integers are a window to infinity. Infinity is usually explained with numbers: With any number you can imagine, you can always add one to get a bigger number – forever – that’s infinity. The main underlying fascination of Fermat’s theorem may just be this: there is an infinity of integers, yet not a single triplet matches a simple power equation for any power greater than 2.

“All is number,” said a Greek philosopher Pythagoras. Consciously and unconsciously, we are attracted to the charm of the immutable platonic reality of numbers whose language is universal among humans. Indeed, a quite substantial literature makes an even more universal claim, arguing that a “cosmic language” comprehensible to any intelligent life in the universe would be based on – you guessed it – integers.

And we love them, these intangible and elusive entities that are “pure numbers.” Love for numbers reflects basic human strivings, and that goes in so many ways (again, count the *number* of ways! – even word such as “many” implicates counting and counting *is* number). That is why so many people are fascinated by number theory and by things such as prime numbers (i.e., 2, 3, 5, 7, 11, 13, 17, 19, 23, etc. to infinity) – and certainly not only seasonal mathematicians (“experts in number theory”), but also millions of us in all strata of life and across all professions and occupations.

4.4 Numerology and prime number legends and fancies

Number system is not just infinite. It is absolute and unchangeable. Nothing else in the known universe can claim the same status of absoluteness. All the rest (except numbers) has some degree of relativity and conditionality. Laws of physics can be different in different parallel universes or even at various regions of “our” (“Big Bang”) universe. In “our” universe we have measured that the proton is 1,836 times heavier than electron. Somewhere else (in distant galaxies?) this ratio may be different.

However, this is not so for the prime numbers. Their “list” (infinite, of course) is *absolutely unchangeable* and ever the same. Not a single prime can be “removed” from the “list” or moved to another position. Removing even a single prime from the list would collapse the whole edifice of mathematics and the world would disappear. Not even God (or a devil?) can do that. So, *all* prime numbers are equally important and inevitable.

And yet, paraphrasing George Orwell (*Animal Farm*), “all Prime Numbers are equal, but some are more equal than the others.” This holds good, at least, as far as

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our human perception goes. We all have preferences, likes, and dislikes. And many of us like and practice various forms of numerology.

While it is not my intention to discuss extensively various aspects of numerology in this book (many other books do this), I would still like to mention a few things from this genre.

The first item I want to mention is the so-called lore of "Elevenology." That is a celebration of "11:11" introduced by the "new age priestess" with a pen name "Solara" in 1990s. There are various ritual activities going around the number 11 – the first member of the twin primes family (11 and 13 are twin primes). Many people (including myself) claim the observation that when we look at the clock, the combination 11:11 pops up more often than is required by the random statistics (e.g., Mary Jones and Larry Flaxman "11:11 Prompt Phenomenon: The meaning behind mysterious signs, sequences and synchronicities," *New Page Books*, Franklin Lakes, NJ, 2009). And many other objects and artifacts have number 11 in them. Canadian one-dollar coin ("looney") has 11 edges. A reader can look around to find more examples of number 11 in various items around.

In fact, 11 is also the first "twin prime" number; its "twin" is 13. One might think that 2, 3, 5, 7, which are all primes, also form two sets of twins, namely, 3–5 and 5–7; however, they are a kind of exception, the only case where three primes form a close triplet (or a quadruplet if we add two to their company), but 11–13 is the first "isolated" doublet of twin primes. As was just mentioned, the Canadian one-dollar coin (the "Loonie") curiously has 11 corners (it is a regular 11-gon). As for higher primes, quite often 17 and 37 are met in various fables and stories, while the prime number "137" (the inverse of the fine structure constant in atomic physics) has almost a cult or a mystical significance for some physicists.

However, the twin prime partner of 11, the number "13" is far less lucky. Actually, "13" has a pretty mixed reputation. On one hand, there is a well-known phenomenon of "Triskaidekaphobia" – the fear of number 13. It has many, very many, manifestations all around. There are no "13th floor" in many buildings, many people avoid being "number 13" in any listing, 13th day of the month (especially "Friday 13th") is often seen as a "bad luck day," and so on. In addition, some unlucky events seem to be centered on number 13 (also, some other primes seem to be "helping"). For example, Apollo 13 was launched on April 11, 1970 at 13:13:00 central standard time and suffered an oxygen tank explosion on April 13. It returned safely to the Earth on April 17. All prime numbers around!

For many, especially bad combination is when the 13th day on the month falls on Friday. This fear of "Friday the 13th" is known as *Paraskevidekatriaphobia* (from Greek). Very few people, if any, will schedule their wedding or any other major event on this day.

Yet, there are exceptions from that, some people and cultures like number 13 and feel no horror of it. This, so to say, "anti-Triskaidekaphobia" (also known as "Triskaidekaphilia") is also quite common. For example, in Italy the number 13 is held

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as lucky because it is associated with the "Great Goddess," who is responsible for fertility and lunar cycles. Many Italians believe the number 13 brings prosperity and life, and it is seen as especially lucky when gambling. In Wicca, most covens (circles of witches) have 13 members, although sometimes there can be fewer. In Judaism, 13 signifies the age at which a boy matures and becomes a Bar Mitzvah, that is, a full member of the Jewish faith. According to the Jewish law, when Jewish boys become 13 years old, they become accountable for their actions and become a Bar Mitzvah. As for myself, I, personally, do not have any fear of 13 and living now on the 17th floor of the apartment building I well realize that I, actually, live on the 16th floor, as after 12th floor follows 14th.

4.5 Prime number messages to cosmos

> *Two possibilities exist: either we are alone in the universe or we are not. Both are equally terrifying.*
> Arthur C. Clarke (1917–2008)

It is interesting to note here that due to the universality of prime numbers they are (were and most likely will be) used for interstellar communications. An example of this is the so-called Arecibo message. It is a radio message designed by Frank Drake and Carl Sagan that was broadcasted to cosmos in November 1974 from Arecibo Radio Telescope in Puerto Rico as part of the search for extraterrestrial intelligence experiments.

The message was binary coded in 1,679 pixels using the fact that 1,679 is a semi-prime (the product of two primes, 73 and 23). It is a graphical image that contained the key information about who we are, our planet, and our biology. The idea was (is) that if any intelligent civilization will intercept this message its inhabitants will figure out that the message is coded using prime numbers, will factor out 1,679 to core primes (1,679 = 73 × 23), and recover the message. Well, it may take many hundred (thousand?) years before we may get any reply, if ever... Yet, such attempts will (hopefully) continue with ever increasing power of radio transmitters. Of course, more complicated pictures and messages can be coded in a similar way using much bigger semi-primes (e.g., 36,928,907 = 4,219 × 8,753).

4.6 Prime numbers and safe communications

To wait for a radio-reply (in prime numbers, of course!) from extraterrestrials make us take a while. First, "they" ("extras") have to intercept our Arecibo message (and/or, perhaps, other similar messages if any similar were sent later), read it, and be

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interested to reply to us. On “our” side, “we” (or our robotic descendants?) have to detect it among all the radio noise, decode it, and interpret it the way our cosmic correspondents intended it to be interpreted. None of these many steps is anyway close to certainty and if even one of them fails, “we” (humans, robots, or whoever) are back to the square one.

But closer to home, prime numbers are *now* actively used in modern communication systems (Schroeder, 1986). For example, codes for bank transfers are based on long prime numbers. The trick here is that if we take two very long primes (e.g., each having 1,000 or 2,000 decimal digits) and multiply them, we will get a semiprime (semiprime is the product of two primes). To multiply two numbers with several hundred digits each is an easy task for modern computers; it can be done in milliseconds.

However, the *opposite* task – to *factor* a long, say 1,000 digits, semiprime is a formidable task for any existing computer. This means that to find the two primes whose multiplication makes the said semiprime. For small numbers it is rather easy: say, if I give you number 391 to factor, you can in a few minutes of test divisions on the pocket calculator to find that this number is the product of 17 and 23. But with the number of digits in semiprime increasing, the time that needs to factor it grows *exponentially* and the most powerful computer of today cannot make it for the semiprime with (say) 1,000 digits. And that fact (the unsurmountable difficulty to factor long numbers) is used for the secure bank transfers and other cases of confidential communications. There are special protocols developed for that purpose (interested reader may google “RSA protocol” for the technical details).

So, even if hackers will intercept the bank transfer message, they almost certainly will not be able to recover the prime factors and steal the coded information. To sum up, the security of confidential communication is based on the practical impossibility (for modern computers) to factor very long integer numbers. That may change with the (likely) development of practical quantum computers that, as physicists now predict, will be able to quickly factor integer numbers with almost any number of digits. If and when this will become a reality, the whole area of confidential communications will be in a need of some alternative options. I will not speculate here what such options may be; perhaps my younger readers will figure that out if and when such a need will arise!

As an example of some curiosity of history it is worth to mention the following. While the science of prime numbers was an object of intense fascination (and often a passion!) for many generations of mathematicians and lay people alike, many of them were utterly sceptical about the “usefulness” of prime numbers for anything practical. For example, a great mathematician and number theorist Godfrey Harold Hardy (1877–1947) remarked in his book *A Mathematician’s Apology* (Cambridge University Press, 2001) that in his view number theory has absolutely no practical use. That claim seemed true until the 1970s, when the theory of prime numbers became essential for the development of a highly secure encryption system that is now used to protect most of the confidential traffic over the Internet (Devlin, 2008, p. 68).

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4.7 Prime numbers in biology

Yes, we have five fingers and many flowers have five petals (pentagonal symmetry). But there is more to it. Some living species have figured out how to use prime numbers to improve their survival against the predators.

One example how Prime Numbers are finding their way to biology, is the annual peaks of some insects that are occurring in prime number cycles. It was noticed that some spices of cicadas emerge from their underground homes to mate every 13 or 17 years (Goles et al., 2001). Both these numbers are prime. You could just dismiss these numbers as random coincidence. But the curious fact is that there are no cicadas with 12-, 14-, 15-, 16-, or 18-year life cycles.

Why in this case the evolution has selected the prime cycles for the appearance of cicadas? The reason for that is easy to see: cicadas with prime cycles coincide with their predators and parasites less often. The philosophy is that if cicadas have 12-year cycles, all the predators with 2-, 3-, 4-, and 6-year cycles will eat them. However, the cicadas with 13- or 17-year cycles would have much better chance to survive.

Because 13 and 17 are both indivisible, this gives the cicadas an evolutionary advantage. Thus, prime cycles are helpful in avoiding other animals with periodic behavior. Suppose, for example, that a predator appears every 6 years in the forest. Then a cicada with an 8- or a 9-year life cycle will coincide with the predator much more often than a cicada with a 7-year prime life cycle.

These insects are tapping into the code of mathematics for their survival (Goles et al., 2001). The cicadas unwittingly discovered the prime numbers using evolutionary tactics, but humans have understood that these numbers are not just the key to survival but are the very building blocks of the code of mathematics.

While there may be over examples of prime numbers in biology, here is one more, relevant to all of us:

It is known that sex cells only contain one chromosome from each pair. When an egg cell and a sperm cell join together, the fertilized egg cell contains 23 pairs of chromosomes. One chromosome in each pair comes from the mother, and the other from the father. And 23 is the first "isolated" prime number that is not part of the twin; the previous primes that are 2, 3, 5, 7, 11, 13, 17, and 19 form two "twins," 11–13 and 17–19 and a "special set" 2, 3, 5, 7. I am unaware if biology has a clear explanation why it is "23" chromosomes and not any other number.

My only, tentative (and "metaphysical") guess here, is that nature does not do anything purposelessly (or, at least, many philosophers say so). Thus, the fact that it (nature) has chosen the first nontwin prime number (23) as the number of human chromosomes may have some deep significance. Perhaps, some younger readers of this book may find a convincing explanation for this amazing coincidence.

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4.8 Prime numbers and mobius strip

It is broadly accepted that many scientific discoveries, big and small, have been done "ahead of their time." Same is true for many scientific ideas. Enough to recall predictions of air flights and submarines by Leonardo da Vinci (1452–1519), or the mentioning of two small satellites of Mars by Jonathan Swift (1667–1745) in his *Gulliver Travels* (1726, amended in 1735). That was long before these satellites could be discovered by then-existing telescopes. Yet, Swift indicated their periods of revolution quite close to what was discovered 150 years later (in 1877) for the two actual satellites of Mars – Phobos and Deimos. Likewise, some other discoveries may be lost in the web of history, only to be rediscovered later (Teresi, 2002), or – who knows? – maybe not discovered at all if their time and need for them has gone... We can call them "premature discoveries," to indicate that such discoveries were made, incidentally or intentionally, before the historical context for them was "ready," socially and scientifically.

However, there are many (perhaps, even more numerous) cases of the *opposite kind*, when the discoveries and inventions were made much later than they could have been done. One can call them "delayed" or "postmature" discoveries. One can indicate three attributes of such delayed or postmature discovery:
(1) in retrospect, it must be judged to have been technically achievable at an earlier time with methods available at that time,
(2) it must be judged to have been understandable, capable of being expressed in terms comprehensible to the educated public of that era, and
(3) its implications must have been capable of having been appreciated at that time.

Both premature and delayed discoveries suggest a nonlinear and complex model of the advancement of knowledge. However, premature discoveries are either passively neglected or actively resisted at the time they are made. Discoveries can be premature because they are conceptually misconnected with the "canonical knowledge," are made by an obscure discoverer, published in an obscure place (if at all), or are incompatible with dominant religious and/or political doctrines of the time, and so on.

It is a far trickier task to find a good explanation for the delayed discovery. And the explanations here (if they are given at all) are usually not so obvious and far less convincing. Some of the delayed discoveries have been postponed not by just a "few years," but sometimes by many decades or even centuries. And here I am not talking of "why ancient Greeks did not have TV show talks," or "why Napoleon did not use motorcycles for his army invading Russia in 1812." Instead, I want to mention a few of such "undone advancements" that were reasonably warranted by the conditions existed long before they have been actually discovered and/or announced. Others probably can add a lot more to the following list of examples of such "late discoveries."

In my personal view, one of the most striking examples is the famous "Mobius strip" (Mobius band). Ask anyone if is it is possible to draw a continuous line on both

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sides of a paper without bending over the edge. Many people will, of course, answer affirmatively by referring to a famous Mobius strip. It is presently widely known well beyond the mathematical community. There are numerous examples of its use in visual arts; imaginative drawings of a Dutch artist Maurits C. Escher (1898–1972) are among the most popular.

So, this is – by now well known (almost anyone knows what it is) – construct of a one-sided surface that (at least, as far as common knowledge presently maintains) was first described by a German mathematician August Ferdinand Mobius (1790–1868) in 1858. Anyone can make it in a few minutes: just cut a rectangular paper strip of paper ABCD, bend it, connect in a cross-over manner B to D and A to C, and then glue or Scotch tape it. You got it. It is a glorious Mobius strip: in contrast to the usual paper sheet it has only *one* (and not two) surface. Its topological properties are very interesting and quite different from the regular two-side paper strip. There are numerous images of it on the Web now.

One can wonder that perhaps it was discovered before: maybe, just “may be.” Yet my (reasonably long) search on the subject has failed to turn up a single piece of a clear evidence that anyone prior to Mobius have noticed the existence of a one-sided surface, and made a clear publicly available record of it, either in words or in arts.

And this is despite that every time we wrongly fast waist belt upside down, we, in fact, create an authentic replica of the Mobius strip! Thousands of people undoubtedly did it many times over the centuries before Mobius. And yet, it seems to skip the attention of all the best minds from the antiquity through the Renaissance and to the modern times. How did it happen that such an obvious thing, which can easily be made, understood, and appreciated in a junior school, could come so spectacularly unnoticed until some elderly German professor has discovered it (most likely, by a mere chance) in the mid of nineteenth century, at the time when people already were building transcontinental railways and were at the verge of the commercial use of electricity?

Had not the mankind produced Euclid, Leonardo, Pascal, Newton, Leibnitz, Euler, Kant, and many, many more equally bright minds before? Why none of them (at least to our best knowledge) has devoted a single line of their writings to mention such conceptually interesting and simple (one may say, almost a trivial) construct as the Mobius strip certainly is?

To restate, a peculiar point that I am addressing here is the following: why this so simple construction was first discovered in the middle of the nineteenth century (1858) and not any time earlier (?!). Why nobody (*no*-body!) mentioned it in any known writings before? Perhaps, even a curious child can “discover” such a thing! (just twist and latch the belt at pants “the wrong way”).

Similar question can be asked about other things. For example, why the steam engine, telescope, microscope, and so on have not been invented in ancient Greece, Rome, or Byzantine, or dozens of other possible places? This is, indeed, odd. Really, why not? – these things are, after all, so simple and so obvious. In ancient Rome, they

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already had children toys that were set in motion by steam. So, why nobody went one step further and constructed some prototype of a steam engine? Why this had to wait for another 15 centuries or so?

Likewise, basic techniques needed for the construction of telescopes were long available too. Glass polishing and the art of making corrective glasses (we call them "spectacles" in English, "lunettes" in French, or "ochki" in Russian) were known for centuries (eyeglasses appeared around 1280 in Italy) before somebody was smart enough to put convex and concave lenses one by one to discover a telescopic effect. The first telescope was constructed in 1608 by Hans Lippershey in the Netherlands and the next year (1609) Galileo used it to discover satellites of Jupiter.

So, for the case of a telescope, we still can offer some (lame, perhaps) "excuse" that it requires not just a certain technology (e.g., glass polishing) but *also* some theory to make a telescope and these both may not be easily met in the same person. But, again, the *Mobius strip* (?!) – no "technology" and no "theory" are needed to "discover" it.

Yes, this little Mobius strip does not require any technology – any paper, papyrus, or even an elongated leaf will suffice(!). It could be discovered in ancient Egypt, Babylon, Greece, Rome, China, India, Byzantine, Renaissance Europe, and so on. Yet it was discovered only in the middle of the last century(!). Why none of the score of the brilliant scientists and philosophers devote (at least to our best knowledge) a single line of their writings to mention such an obvious and topologically interesting thing as this odd Mobius strip?

For many viewers Mobius strip produces almost a mesmerizing effect. This explains its frequent use in arts. Yet, the popularity of Mobius strip is not limited to arts and mathematics. Nowadays it is often used as a universal symbol of recycling. Its circular (yet nonlinear and "twisted") shape calls for a vision of the process of transforming waste materials into useful resources. On a personal level, the Mobius strip represents a willingness to move with the constantly changing cycles in our life process, transforming our challenges into useful solutions. The Mobius strip reveals planetary transformation, as well. Historically, there have always been Earth changes, that is, natural restructuring of land and ocean masses, continental drifts, tide changes, weather changes, seasonal changes, and so on. The shape of Mobius strip is symbolic of the eternal change within the stillness itself.

On a more philosophical and esoteric level, the Mobius strip can be seen as an expression of nonduality (or, to put it better – the transcendence of duality). It reveals the unity of all polarities, creating a state of oneness, joining the whole and the part, the masculine and the feminine, expansion and contraction, spirit and matter, and so on. Everything is one and nothing can be separated from anything else. Everything is completely intertwined, infinitely. The Mobius strip is a spiritually significant symbol of balance and union (yoga = union). The Buddhist philosophy of tantrism is also expressed by the Mobius strip shape. "Tantra" is continuity; the word derived from the root "tan," meaning to extend, extend continuously, to flow, to weave. The continuum

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is descriptive of the nature of reality, and in the words of the physicist David Bohm, "a single unbroken wholeness in flowing movement."

But what about prime numbers in the same context of "delayed discoveries"?

Yes, the Mobius strip is just one of many examples of these "delayed discoveries." Yet, there are many equally amazing "skips" in the history of science. Even in the most basic of all sciences, the arithmetic of integer numbers, there are quite remarkable examples. Take, for example, prime numbers, of which we discuss a lot in this book. Using Eratosthenes sieve (crossing out the multiples of 2, 3, 5, 7, 11, etc.), one can easily find "all" prime numbers one by one – theoretically, at least. Yes, the process is rather slow, but it appears almost self-evident that for integers between, say, 1 and 1,000 all the primes should have been known since the antiquity. Right?... *wrong*!

As Leonard Dickson (1952) tells us in his *History of the Theory of Numbers*, medieval mathematicians believed that the numbers in the form

$$N = 2^n - 1$$

are primes for every odd value (!) of n. It is so easy to check that it is *not* so, and yet such a check apparently has not been done till late Renaissance time. Indeed, the above equation "works" for $n = 3, 5$, and 7 (the values of N, respectively, 7, 31, and 127 are all primes), but, as anyone can easily check (no calculator needed!), it fails as early as at $n = 9$ ($2^9 - 1 = 511 = 7\times73$).

It is then truly amazing that the latter (truly trivial!) fact was first noticed by mathematician Regius "only" in 1536 (he also noticed that $2^{11} - 1 = 2{,}047 = 23\times89$). And here again, we are talking *not* about the "dark middle ages," but of a time when Europe has already built its most magnificent cathedrals, at a time when the book printing was a growth industry for already almost a whole century(!). And to discover the above "fact" (that $511 = 7\times73$) requires nothing but a piece of paper and less than an hour of test divisions (even Greeks knew how to do it).

Yes, it can be argued that the one-sided surfaces and prime numbers are relatively abstract esoterica. Again, depends on how one looks at it. But what about much more practical things? And here again, some amazing lapses can be found as well. Eye glasses were well known in Europe since the thirteenth century. Recall a churchman holding glasses painted by Jan Van Eyck in 1436. And yet, strange as it seems, it did not occur to anyone before 1608 to combine just two lenses (convex and concave) to produce a telescopic effect.

Even if we accept, as some sources claim, that the principle of telescope was known to Roger Bacon (1214–1294), this will be at best an example of a discovered-just-to-be-immediately-forgotten important instrument. The whole history could turn out, perhaps, quite differently if the moons of Jupiter were convincingly observed in early Renaissance. Say, in Dante time (before the ascend of inquisition), instead of some three centuries later by Galileo, who had a true misfortune to come up with his telescope discoveries during the crest of the antihumanistic reaction.

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Now take a microscope (!). Probably, it would be an even easier feat than the telescope. Just two convex lenses with a short focal distance (means, strongly curved), that is all it needs for a microscope. Rather primitive, of course, but still could reveal a lot of good (and bad) stuff such as blood cells, bacteria, and so on. Quality of glass polishing needed for such lenses was around for centuries before the two Dutchmen Zaccharias Janssen and his son Hans build a first microscope by placing two lenses in a tube. That was in 1590, three centuries after the Italian Salvino D'Armate made first wearable eye glasses (around 1284).

Steam engine (not just as a mere toy), hot air man-carrying balloons (Montgolfier brothers, 1783), quantitative scale for temperature, atmospheric pressure – all these things could be quite naturally expected to be discovered or constructed centuries earlier than they were actually delivered. For example, it was technically possible to build (and broadly use) hot air balloons for human flights for any major civilization since Pharaonic Egypt. On a more theoretic side, the law of pendulum (the fact that the squared period is a linear function of the pendulum's length) could have been easily established in ancient time.

All it takes that two people simultaneously count how many times two bobs hanging on the ropes of different length (one length is fixed and the second vary) swing during a given time interval. Several repeats and a simple data plotting could have revealed the pendulum law thousands of years before Christian Huygens (1629–1695) has found the law of pendulum (which is now in any physics textbook) "only" in the late seventeenth century.

But of course, it all happened long ago. Now we are not going to miss anything significant. But are we? Is the "fear of simplicity" an inherent part of our mentality and culture? Could it be one of our other hidden curses?

Let's imagine that by some miracle Mobius strip was not still discovered till today. Who will dare to dream that in the present peer review system a grant proposal to "search for one-sided connected surfaces in a three-dimensional space" had any chance to pass and get approval for a research funding by any granting "council" (?). The Mobius strip is too simple for a peer review to swallow and even less to digest. Most likely, the "experts" would right away dismiss the idea as an impossible rubbish.

These few random examples for whatever time tell us that it is often the *obvious* that is the most difficult to notice and appreciate as something special. That is probably *the* main explanation for the existence of numerous delayed discoveries. And some of them may likely still be on their way to us.

To wrap-up this discourse, it should be mentioned (again and again!) that it is rather general and deeply rooted phenomenon that a substantial segment of the scientific establishment is at best utterly unreceptive and at worst openly hostile to a profoundly new idea or approach. It happened not in the "dark Middle Ages" but around 1977 that Mitchell Feigenbaum could not publish his epochal ideas on the universality of chaos for a few years because of the repetitive rejects from several major physics journals.

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Likewise, it took me some 10 (ten!) rejects to publish an idea of *isotopic fiber optics* as an alternative to the conventional fiber optics (Berezin, 1989a). Perhaps still-existing lack of the genuine appreciation of a stable isotopic diversity and the technological potential of *isotopicity* (Berezin, 2015, 2016) falls into the same category of ideas that were spelled out before their "right" time has come.

But again, who is here to determine what is the "right time" for an idea or a discovery? Only the future can tell. Unless, of course, we believe that the trends discussed by John Horgan (1996) in his bestseller *The End of Science* do indeed reflect the actual vector of the modern science enterprise. This book still retains its popularity for over 20 years; apparently Horgan's arguments have merits in the eyes of many readers (I myself read and reread his book with great interest).

4.9 Cantor's set theory and prime numbers

> *In all chaos there is a Cosmos, in all disorder a Secret Order*.
> Carl Gustav Jung, *Archetypes and the Collective Unconscious*
> (1959, p. 32).

The idea of "nested infinities" ("Alephs") that was put forward by the great mathematician Georg Cantor (1845–1918) is certainly less known to the general public than such ideas as "prime numbers" or "π number" (any person with even a junior education knows what is "π").

In the next chapter, I go by the simplest route to explain infinite sets in a non-technical language with some historical tales on the controversies that Cantor's ideas have produced. Some top scientists (Leopold Kronecker and Henri Poincare) were strongly apprehensive and dismissive to these ideas, while others, equally great names (David Hilbert and Kurt Gödel), have embraced the ideas of "Alephs" with approval and enthusiasm (eventually, the latter side has won and now Cantor's ideas are a part of "Golden Fund" of mathematical science and philosophy).

Chapter summary

While to explain the basic facts about prime numbers does not take much more than the generally-known arithmetic, the philosophical dimension here is truly infinite. The eternal and unchangeable sequence of prime numbers exists (in a metaphysical sense) in the ideal platonic world and forms the digital code of the universe. As an essential part of the cultural dimension, prime numbers find their way to numerous traditions, beliefs, and practices of various civilizations over the course of history. Human fascination with prime numbers has many examples from serene

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contemplations to (sometime, almost paranoiac) life-time obsessions among mathematicians and people with all sorts of other backgrounds. Likewise, in the natural world from the atomic physics to biology, prime number "codes" are ubiquitous and responsible for numerous effects and phenomena. As a "genetic code" of the universe, the infinite sequence of prime numbers is the backbone of the self-organization and emergence phenomena at practically all levels of complexity.

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5 Platonic emergence

Be less curious about people and more curious about ideas.
Marie Sklodowska Curie (1867–1934, discoverer of radioactivity, two Nobel Prizes, 1903 and 1911).

In this chapter, I unfold the idea that can be spelled out as the "pressures from mathematical infinity to create nature". Can mathematics (pure numbers! abstraction!) "reincarnate" itself as physical reality? Or, perhaps, it is some kind of a reshuffling of a central idea of most religions – god (something "immaterial") creating the real world of matter and energy? "Mathematics as a god," to speak.

To begin with, I owe my readers the following disclaimer. Such ideas ("mathematics as god" and/or "god as mathematics") were (and are) common to many thinkers over the history. Thus, I abstain from any hard-core claims of originality. Yet, like in art, one and the same theme (say, Romanic love or what) was (is) reshuffled by many artists in many forms, so it is in philosophical and metaphysical quests. And every such quest brings its own colors to the discourse.

5.1 Cantor, Gödel, and "ultimate issues"

I am convinced of the afterlife, independent of theology. If the world is rationally constructed, there must be an afterlife.
Kurt Gödel (1906–1978)

In this chapter, beginning with the "countable" infinity of integer numbers (1, 2, 3, 4, 5...), I am going to discuss about the infinity of prime numbers (2, 3, 5, 7, 11, 13, 17, 19...) and explain how Cantor has demonstrated that these two infinities are of the "same size" – in spite that it "appears" that there are "more" integers than primes (all primes are integers, but not all integers are primes). There are several popular books explaining these issues (for example *The Mystery of the Aleph* by Amir Aczel), but my outline below is much shorter and more elementary.

As was just mentioned, the central idea I am talking about can be formulated as the "pressures from mathematical infinity *(!) to create nature*." Can the ideal Platonic world (IPW) that we call "mathematics" emanate from itself what we call the "physical reality"? Such an idea is, actually, synonymous (symbolically, perhaps) with the equating of IPW with a traditional idea of god as a universal creator. At least, such identification assigns IPW and "god" with the same powers.

And recalling the famous John 1:1 "In the beginning was the word, and the word was with god, and the word was god," (Word = Logos = Logic = Mathematics) such an imposition may not be that far-fetched. To repeat, this seems as just another take of the ideas of many religions – god (something "immaterial") creates the real (material)

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world of matter and energy. “mathematics *works* as god” (or mathematics *is* god), one may say (Livio, 2009).

Well, in our facing the “eternal” problems, some of us may come to search for what may be called “metaphysical invariants.” Probably, one of the best-known trails in this direction can be found in the area of pure mathematics. Here we are dealing with the issue of “metaphysical pressures,” the “desire” for “embodiment” from the ideal Platonic world (IPW) (Berezin, 1998b, 2015, 2016). Let me first explain the terminology and introduce the tools for the discussion. Two names seem particularly pertinent in this context.

Both are great mathematicians with strong philosophical inclinations. The first is Georg Cantor (1845–1918) and the second is Kurt Gödel (1906–1978). Cantor is mostly known for his ideas on the hierarchies of infinities (infinite sets), and Gödel for his incompleteness theorem. Both of these developments are broadly perceived as outstanding intellectual achievements …Is it not some kind of a “metaphysical miracle” that Gödel (Godel) has such a “divine” last name (God-el)?

Cantor’s theories of the “structure” of infinities were seen by some of his contemporaries as being on a verge of blasphemy. Leopold Kronecker (a great mathematician on his own) considered Cantor a “scientific charlatan,” a “renegade,” a “corrupter of youth.” Another great scientist, Henri Poincare (one of the founders of the modern chaos theory) thought that set theory and Cantor’s transfinite numbers represented a grave mathematical malady, a perverse pathological illness that one day can be cured (Dauben, 1979). Of course, not all have been that negative about Cantor’s ideas. Bertrand Russell described him as one of the greatest intellects of the nineteenth century (Russell, 1989). David Hilbert (“Hilbert space” in quantum physics) believed that Cantor had created a “new paradise” for mathematicians (Dauben, 1977, 1979) and kept highest regard for Cantor.

Furthermore, Cantor’s ideas have made a fundamental impact on the thinking about the “eternal issues,” the impact of which is probably still not fully appreciated. As Dauben says about Cantor’s views:

> … he summarized the position commonly encountered in the seventeenth century: that the number could only be predicated of the finite. The infinite, or Absolute, in this view belonged uniquely to God. Uniquely predicated, it was also beyond determination, since once determined, the Absolute could no longer be regarded as infinite, but was necessarily finite by definition. Cantor’s inquisitive ‘how infinite’ was an impossible question. To minds like Spinoza and Leibnitz, the infinite in this absolute sense was incomprehensible, as was God, and therefore any attempt to assign a basis for determining magnitudes other than merely potential ones was predestined to fail (Dauben 1979, p. 123)

Cantor’s major accomplishment was, perhaps, a clear introduction of the idea of cardinality of infinite sets. For example, set of all integers (1, 2, 3, 4, 5, 6, 7…) has the so-called *aleph-zero* cardinality (countable set). This is, so to say, the lowest level of (imaginable) infinity. Any (infinite) set that can be put in a one-to-one correspondence with the set of integers has exactly the same cardinality, *aleph-zero*.

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For example, no matter how counterintuitive it may appear at first glance, the "number" of all integer numbers and the "number" of squares is the "same"; there is not a bit "less" squares than all integers. It can be seen from the one-to-one correspondence between "all" integers and "just squares," the pairing of *all* integers and *their squares* (and such pairing can go to infinity) clearly demonstrates that both sets have the same "size" (same cardinality):1–1, 2–4, 3–9, 4–16, 5–25, 6–36, 7–49, 8–64, 9–81, 10–100, 11–121, 12–144, and so on (*ad infinitum*).

In other words, strings of all integers (1, 2, 3, 4, 5…) and the string of only squares (1, 4, 9, 16, 25…) have the same "length," (infinite, of course) and each square has a fixed "partner" – an integer of which is a square. Likewise, the number of primes (or their squares, or their millionth powers, etc.) is *exactly the same* (!) as the number of all integers, and so is the number of all rational numbers (ratio p/q of any two integers).

Because primes become progressively more and more rare among integers, "common sense" tells us that there are "infinitely fewer" primes than the composites (because, asymptotically, "almost all" integers are composites). If we were to choose any integer at random among the infinity of all integers, the probability of its being prime tends to be zero. This is indeed if we review all integers in the order of their natural appearance (1, 2, 3, 4, 5…).

However, David Lewis in his book *On the Plurality of Worlds* gives a simple example to illustrate the "paradox of infinity". Let us take the (infinite) set of integers and rearrange it in a form of two-dimensional array (Lewis 1986, p.119; see also Berezin, 2015, p. 43;, 2016, p. 3–11) in which the first column has *all* integer numbers (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11…) and to the right of it there are all *primes* arranged in a zigzag pattern. For each integer in the first column there are *infinitely many* primes in the corresponding line. There are no repetitions in this infinite table and every prime is listed in it.

4	(1)	2	11	13	43	. . .
6	3	7	17	41	53	. . .
8	5	19	37	59	97	. . .
9	23	31	61	89	127	. . .
10	29	67	83	131	173	. . .

……………………………………………………………

This zigzag table can be continued to infinity, both vertically and horizontally. In such a table, each horizontal line is infinite and has an infinite number of primes. *All* integers present in this table appear just once. For example, any composite integer will be eventually reached if we follow down the first column. And every prime will be found somewhere on one of the horizontal lines. Yet, we see that for each row, the primes "outnumber" composites by infinity to one (!).

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According to an image invoked by such a table, primes predominate among all integers, in spite of the fact that “we know” that the probability of “hitting” a prime number at random is zero (if we use all numbers with the same probability). Lewis uses the same logic to demonstrate that the “improbable” worlds whose (formal) probability is vanishingly small (such as worlds consisting of an intelligent life) not only can exist, but (in some sense) they can also predominate among all possible worlds.

However, the number of all real numbers (including such numbers as the square root of 2, or π, or e, etc.) has a *higher* “rank of infinity,” known as *aleph-one* cardinality. The number of all points on a line (an infinite line, or just a finite segment of it; this makes no difference), the points on a plane, and the points of three-dimensional (or any N-dimensional) space have the same power (“cardinality”) of *aleph-one*. Cantor showed that there “is” an infinite hierarchy of infinities themselves. He also constructed some examples (I put “is” into quotation marks to indicate that this refers to “existence” in the IPW of mathematics).

5.2 Platonic pressure effect

> *Science is above all about vision. Science begins with a vision. Scientific thought is led by the capacity to “see”things differently than they have previously been seen.*
> Carlo Rovelli, *Seven Brief Lesson on Physics*, p. 24 (Rovelli, 2016)

The “metaphysical pressure” of the IPW or the “embodiment” in a form of a “material world” (or what we perceive as such), or, in other words, “the desire” of the “numerological patterns” (such as pattern of prime numbers) for tangible manifestation (“embodiment”) is the crux of my argument. In my publications (Berezin, 1998b, 2015, 2016), I introduced the term “Platonic pressure effect (PPE)” to describe the above-mentioned (metaphysical) idea. This idea resonates to some degree with what John Archibald Wheeler called the “it from bit” concept (Wheeler, 1990; Wilczek, 1999).

According to Wheeler, *it from bit* symbolizes the idea that every item of the physical world has at its bottom – at a very deep bottom, in most instances, at least – an immaterial source and explanation. This is what we call “reality” and it arises in the last analysis from the posing of yes–no questions and the registering of equipment-evoked responses. In short, the message here is that all things that we call “physical” are, in fact, information-theoretic in origin and this is the meaning of the “participatory universe,” as Wheeler calls it.

To restate the above-mentioned argument using some anthropomorphic expressions, we can say that this metaphysical pressure results from the “urge” of (ideal) numerical patterns to find their manifestable existence at the level of individualization and their (self) isolation from other competing patterns. However, it should

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not be understood that such an embodiment in any way affects the metaphysical status of numbers (as if "promoting" them from the category of *potentialia* to that of *actualia*). On the contrary, the ever-the-same absolute nature of numbers implies their "metaphysical immunity" from all the activities that the numerical patterns can catalyze (e.g., cosmological emergence and self-organization).

This "Platonic pressure" arises by a sheer virtue of the fact that the entire infinite pattern of integer numbers and all algorithmically derivable sub-patterns (e.g., pattern of prime numbers) are instantaneously available as a "free lunch" at any instance/point of space-time (we mean here space-time of any dimensionality and hierarchical level, not just our ordinary four-dimensional Einsteinian space-time). This infinitely rich pattern of *aleph-one* (countable set) acts as an "independent" physical effect, which directly generates the physical world "out of nothing."

While I am unaware if the term "Platonic pressure" was used earlier, I shall refrain (as with all the other terms I use in this book) from claiming that I originated this idea. In fact, the entire Pythagorean–Platonic tradition can be to a large degree interpreted in this vein. Furthermore, the metaphysical primacy of integer numbers (as expressed in the PPE) is not necessarily remote from immediate experiences we can refer to. There are numerous examples of pattern formation governed by some simple iterative laws involving specific sets of integers. For example, the spirals of sunflowers follow the pattern of Fibonacci numbers. The peculiar lagoons of the Mandelbrot set are the result of the iteration of equations where all the seed numbers are truncated to rational numbers (all computer inputs are always rational numbers).

This certainly does not mean that the appeal to the PPE and the eternality of integer numbers immediately obliterates the most fundamental question of philosophy that was formulated by Martin Heidegger as "Why is there a universe"? (Hersh, 1995; Weatherall, 2016). Why is there something rather than nothing? Even a claim of absolute priority for integer numbers still leaves the following question unanswered: "Why there are integers in the first place"?. Here we have little recourse other than to take numbers for granted. However, making the minimal concession of admitting the existence of "numbers as such" appears to be a modest price to pay for all the constructive opportunities such a postulation brings in terms of deriving all the existential consequences of emergence, ascension, and physical structuralization. This, I believe, justifies the logical mismatches (and perhaps even some level of absurdity) that such treatment invokes.

To restate, in the brand of metaphysics adopted in the above-mentioned argument, the ultimate origin of everything lies in the infinite complexity of pure (integer) numbers. Integer numbers form the lowest level of infinite sets, the so-called *aleph-naught (aleph-zero)* of Georg Cantor (Dauben, 1977, 1979; Rucker, 1987, 1995; Tiles, 1989; Lavine, 1994; Pickover, 1995, 2001). Even this lowest level of infinity (integer numbers) contains in itself an inexhaustible source of complexity – such as the distribution of prime numbers (Dickson, 1952, 1960; Maier, 1981; Ribenboim, 1989;

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Casti, 1990; Casti and Karlqvist, 1991; Plichta, 1997; Derbyshire, 2004), or the digits of π (Wagon, 1985; Preston, 1992), or any iterative protocol deduced from it – and all these exert some kind of metaphysical pressure for the embodiment of any fragment of the "infinite resource" of ideal Platonic numerological patterns to transform (or "convert") these (absolute) patterns into a physical reality.

The ideas along the line of "mathematics as a god" was (and is) discussed by many authors in a great variety of the discourse modes (e.g., Dyson, 1979a, 1979b, 1988; Woo, 1981; Lewis, 1986; Tipler, 1989, 1994; Squires, 1990; Carloye, 1992; Zohar, 1990; Davies, 1993; Sharpe, 1993, 1997; Wolf, 1996; Plichta, 1997; North, 2000; Walker, 2000; Stannard, 1993; Zajonc, 2003; Foerst, 2004; Livio, 2009; Sams, 2009; Haught, 2010; Spitzer, 2000, 2001; Ward, 2010).

The notion of PPE (Berezin, 2015; 2016) opens another vista of this idea (God = Infinity) that is focused on the mathematical infinity, infinity of prime numbers, and the set theory of Georg Cantor (Dauben, 1977, 1979; Tiles, 1989; Aczel, 2000).

This immutable all-defining universal "vacuum" of pure (integer) numbers can perhaps be classified as "*aleph-zero* panpsychism" (to remind, *aleph-zero* is a countable set: 1, 2, 3, 4, 5...). Physical vacuum is relative and may be quite different in different baby universes of inflationary cosmology and/or the innumerous branches of the Everett's model of ever-breeding quantum universes, whereas the metaphysical *potentialia* of the Platonic numerological "vacuum" is absolute and always the same. It does not fluctuate (at any scale) and any of its specific features (e.g., some anomaly in the prime number distribution) are instantly available as a universal morphogenetic (pattern-generating) trigger in any of the innumerable branches of the inflationary cosmos and/or Everett's cosmological foam.

In other words, this metaphysical *potentialia* does not bother itself with the origin of the physical universe (Gott and Li, 1998), or with whether there can be time travel (Yourgrau, 1999; Gott, 2002). In Everett-type models, the creation of the universe automatically becomes a nonissue with unanswerable questions such as "*Who* created mathematics?" or "*Why* is 17 a prime number"? I am leaving the issue of whether "higher alephs" (uncountable sets) can add new insights into the metaphysical scenario above-described as an open quest for anyone who may be bothered to contemplate on the above-mentioned issues.

In summary, the principle thesis of the idea of Platonic Emergence (PPE) is the generation of all "reality" directly out of the infinite complexity of the IPW. This emergence is *a-temporal* ("outside of time"). This means, it is does not happen in any particular "time" in our meaning of this word (no special "time zero" point), but is an eternal emanation of the physical world out of the infinite substrate of the IPW.

Some analogy of the can perhaps be drawn from the traditional Trinitarian theology in which the Holy Ghost (the Holy Spirit, the third aspect of the Holy Trinity) "proceeds" from the Godfather and this "process" does not happen in any particular time, but is an eternal metaphysical emergence. Likewise, it can be said that the prime numbers (that are the subset of all integer numbers) "emanating" from the

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set of integer numbers are a kind of eternal a-temporal "process." Nature's "desire" for pattern generation at all levels of the physical world has its manifestation in the digital informational strings of isotopic combinations.

Another analogy can be the law of gravity. Although, the gravity is a physical effect (that is "explained" in the general relativity by the curvature of space), it is not really a "process," but rather a state of the permanent (a-temporal) attraction of masses through the gravitational field (gravitational interaction). A kind of an example of "dynamics frozen in time."

5.3 It from bit and the Leibnitz principle

> *It from Bit symbolizes the idea that every item of the physical world has at bottom an immaterial source and explanation (...) that all things physical are information-theoretic in origin and that this is a participatory universe.*
> John Archibald Wheeler (1911–2008)

The great philosopher Gottfried Wilhelm Leibnitz (1646–1716) said that in order to explain the origin of everything from nothing "there suffices a single principle" (Russell, 1989). Models of eternal cosmic inflation pretend to rescind this Leibnitz principle (LP), pointing out that the ultimate quest of "why there is something rather than nothing" becomes self-referential. This objection, however, can itself be objected to. Philosophical Platonism asserts the absolute (pre-) existence of an infinitely rich immutable world of numbers and mathematical structures. This IPW exists everywhere (but nowhere in particular) and logically precedes space, time, matter, or any "physics" in any conceivable universe.

How the IPW generates physical reality is the central point of the LP. The notions of the *PPE* (Berezin, 1998b, 2015, 2016) and/or "It from bit" (Wheeler, 1990), considered in the Section 5.2 may be efficient metaphorical tools in envisioning these ideas. One of the key structures of the IPW is an (infinite) hierarchy of Cantor's alephs and, specifically, the sameness of number of integers and rationals (a rational number is the fraction p/q with both p and q being integer numbers, e.g., 2/3, 17/11, and 317/137).

Illustrations such as "Cantor's carpet" construction demonstrate the zero Lebesgue measure of rationals on the *x*-axis. Any arbitrary small segment of the rational line (e.g., between 0.001 and 0.002), there are infinitely many rational points and yet, their total "weight" is always zero. Same is true to the rational points in any N-dimensional space. This is what we can call a "Paradox of infinity" (actually, there are many more "paradoxes of infinity").

At physical level, we can say that an infinite nested hierarchy of "alephs" (Cantor's infinite sets) resonates with what we often see as the fractal structure of the physical universe.

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Furthermore, we can recall that in *any*, however small, interval of the number line, there is a *continuum* (*aleph-one*) of "normal numbers" (Emile Borel theorem, 1909; see more in Section 8.3). And "each and every one" of such normal numbers carries (within its infinite trail of digits) every possible information. This means, every book, every (digitalized) N-dimensional image, every computer code (etc., etc., etc.) is contained somewhere in the digits of *any* (!) normal number. And, even more so, – every such message appears in *every* normal number *infinitely many times* (!). So, it is "infinity, upon infinity, upon infinity...).

Not a surprise then, that every code of emergence (evolution of galaxies, origin of life, our biological evolution, our social history, all our personal biographies, etc., etc., etc.) "sits" (infinitely many times!) in each and every normal number. And there is infinity (continuum) of normal numbers in the IPW (!). Thus, the (spelled above) idea of "mathematics as god" attains indeed a solid metaphysical foundation ("God = IPW," to express it shortly).

Asymptotically, at higher cosmic scales, the average density of matter seems to tend to zero (a visual analogy can be given by finite-volume zero-mass fractal construction such as the Menger sponge). Thus, in the spirit of the "inverse Zeno paradox," one can suggest the possibility of generating M = 0 (zero mass) states directly from IPW. In this regard, the (meta) physical Platonic pressure of the infinitude of numbers becomes an engine for the self-generation of the physical universe directly out of mathematics.

This, presumably, is the essence of the LP. While physics in other branches of the inflating universe can be (arbitrarily) different from ours, number theory (and the rest of the IPW) is not: it is unique and absolute. For example, π is expressible as (exactly) the sum of Leibnitz series. It involves only integers and has a very simple form; see formula (5.1) below. The Leibnitz series involves an infinitude of all (odd) integers, whereas in a classical Euclidean–Cartesian flat space geometry π has a clear geometrical meaning as the length of a circle with a unit diameter. This is one (of many) way how the number theory and the geometry of the "actual" space go "hand-in-hand."

Thus, paraphrasing Carl Sagan in his book *Contact* (Sagan, 1986), the "message of π" may be an eventual flatness and an infinity of (embedding) space-time. At the Planck scale the total number of quantum states of "our" (Big Bang) sub-universe is (well) below 10^1000, which, in terms of *aleph-naught (aleph-zero)*, is still an infinitely small fraction of all integers. This seems (but just "seems" – I give no guarantee for any of these models) to favor the steady-state universe (Fred Hoyle) and/or eternal inflation models.

Finally, in addressing the above-mentioned ultimate quest of "why there is something rather than nothing" (Leibnitz), concepts such as zero-point quantum fluctuations (ZPQF) of (whatever) vacuum are often used as alleged vital ingredients in some kind of primordial universal field ("void unfolding" in more explicitly metaphysical systems). However, even ZPQF still implies that some specific "physics" is involved in universal cosmological dynamics.

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Here, once again, we stress the eternal and unchangeable nature of the IPW of numbers and forms. While "physics" in other branches of inflating universe can be (arbitrary) different from ours, number theory (and rest of IPW) is not (it is unique, absolute, and same in any universe).

For example, "π is expressible as (exactly) the sum of Leibnitz series that involves only integers. More specifically, it involves infinitude of all (odd) integers:

$$\pi/4 = 1 - 1/3 + 1/5 - 1/7 + 1/9 - 1/11 + \ldots \ (\textit{ad infinitum}) \tag{5.1}$$

At the Planck scale the total number of quantum states of "our" (Big Bang) sub-universe is (well) below 10^1000 (10 to the power 1000), which, in terms of *aleph-naught*, is still an infinitely small fraction of all integers. This seems (but just "seems" – I give no guarantee for any of these models) to favor "steady-state" universe (Fred Hoyle) and/or eternal inflation models of modern cosmology.

To restate the above, "Why there is Something rather than Nothing"? we can make the following comments:

From Pythagoras ("everything is number") to Wheeler ("it from bit"), the theme of the "ultimate origin of everything" stresses primordiality of the IPW of mathematics. Even popular "quantum tunneling out of nothing" can specify "nothing" only as (essentially) IPW. As was just said, IPW exists everywhere (but nowhere in particular) and logically precedes space, time, matter, or any "physics" in any conceivable universe. This leads to propositional conjecture (axiom?) that (meta) physical "Platonic pressure" of infinitude of numbers acts as engine for self-generation of physical universe *directly* (!) out of mathematics: cosmogenesis is driven by the very fact of IPW inexhaustibility.

To repeat, while physics in other quantum branches of inflating universe (*Megaverse*) can be (arbitrary) different from ours, number theory (and rest of IPW) is not (it is unique, absolute, immutable, and infinitely resourceful). Let (infinite) totality of microstates (Wheeler's "its") of entire Megaverse form a countable set. Since countable sets are hierarchically inexhaustible (Cantor's "fractal branching"), each single "it" still has an infinite tail of nonoverlapping IPW-based "personal labels."

Thus, each "bit" ("it") is infinitely and uniquely resourceful. This opens a possible venue of elimination of "ergodicity basis" for the "eternal return" cosmological argument. Physics (in any "sub-universe") may be limited only by inherent impossibilities residing in IPW, for example, insolvability of continuum problem may be IPW foundation of quantum indeterminism.

In this context, it is worth to repeat, that in an eternal quest "Why there is Something rather than Nothing," concepts such as "zero-point quantum fluctuations" (ZPQF) of (whatever) "vacuum," are often used as alleged vital ingredients of some kind of primordial universal field ("void unfolding" in more explicitly metaphysical systems). Yet, even ZPQF still imply that some specific "physics" is involved in the universal cosmological dynamics.

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Along this line of thought, I propose that we go one step deeper (perhaps to *the* last step, indeed) and hypothesize that the ultimate origin of everything lies in the infinite complexity of pure (integer) numbers (the *aleph-zero* of Georg Cantor), so this inexhaustible source of complexity (e.g., prime number distribution, the digits of π, or any iterative protocol deduced from it) exerts some kind of "metaphysical pressure" for the embodiment of (any of the infinite resource of) ideal Platonic numerological patterns for the conversion of these (absolute) patterns into a physical reality. This immutable all-defining "universal vacuum of pure (integer) numbers" (UVPIN) can perhaps be classified as "ALEPH-ZERO panpsychism."

Likewise, the links between gravity and pure numerology may likely be tractable as well. For example, gravitational fluctuations at the Planck scale might be pertinent for the psi-reductions ("psi" means psi-function in the Schrodinger equation of quantum mechanics). The latter is otherwise known as the wave function "collapse" (Penrose, 1994, 1996), and it is often considered as the basis of self-organization dynamics at the quantum level. Here we can put together for comparing the issue of the "subtleness" of gravitational effects and (the alleged) "subtle" correlations in seemingly random (normal) digital strings.

This is the "distant Moon" analogy, described metaphorically by Richard Preston (Preston, 1992, p. 67) to account for the alleged long-scale fluctuations in the digits of π (as if a "weak gravity" of some "distant Moon" produces some fluctuations in the randomness of digits of π; this analogy can only be understood in some metaphorical or metaphysical sense).

Another conceptual umbrella-term analogy is the dichotomy between physical ZPQF and mathematical "primological" quasi-chaos. In this vista, opposing (or "contrasting") ZPQF (zero-point quantum fluctuations) to universal vacuum of pure integer numbers (UVPIN) resembles the dichotomy between "really random" physical noise and pseudo-noise in model systems and "deterministic chaos"; the latter is structured and reproducible.

Physical vacuum is relative (and it may be quite different in the different baby universes of inflationary cosmology and/or Everett's quantum branches), whereas the metaphysical *potentialia* of UVPIN is absolute and ever-the-same. It does not fluctuate (at any scale) and any of its specific features (e.g., some anomaly in the prime number distribution) are instantly available as a universal morphogenetic mold in any branch of the inflationary cosmos/Everett's foam of ever-breeding universes.

5.4 Emergence, cosmogenesis, and algorithmic compressibility

Emergence at various levels (from "void" unfolding of vacuum-to-matter cosmogenesis of Big Bang model and complexity emergence to bio/socio evolution

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and all forms of cultural creativity) may have a common underlying "mechanism" akin to algorithmic compressibility (AC). AC allows to "label" very long integer strings with (much) short code(s). Example: "first billion digits of π." Noncompressible strings are, by definition, random. Version of Gödel's theorem states that, in general, AC of any long (digital) string cannot be disproven. Hence, randomness of any such string is never "guaranteed"; chances are there that its AC is always positive nonzero). As almost all real numbers (that are transcendental) are "normal" (asymptotically equal density for all N-digit segments), there are all sorts of "messages" potentially available at any point of (any)-dimensional space-time.

The notorious "Babylonian library (BL)" of all possible books (Jorge Luis Borges) is an infinite resource of emergence (patterning) with AC playing a role of an amplifier: complex pattern (long string) can be transmitted (broadcasted) with a much shorter seed string. BL is a metaphor for a set of all books that ever can be written. Any normal infinite digital string (e.g., π) carries BL infinitely many times, same as *aleph-zero* of all integers. Metaphysical Platonic pressure (MPP) means that the virtual "existence" of full BL at any space-time point may lead to a direct cosmogenesis (e.g., Andrej's Linde model) from just pure numbers.

Infinititude of instantly available numerological patterns (e.g., patterns of all primes and factorizations of all composites) results in (meta) physical effect of the "desire" of patterns for physical "embodiment." This may form basis for ultimate transcendence of "Why there is Something rather than Nothing"? question posed by Leibnitz. The two distinct steps are as follows: (1) numerology of integer numbers (Cantorian *aleph-zero*) as a universal URAM-connector (Berezin 2014, 2015), and (2) "MPP" as a primordial cosmo-generating effect (void unfolding), of/or "potentialia-turning-realia" (symmetry breaking) effect.

Essentially, any intelligent life-form (even of a "continuous" [distributed] consciousness type) will likely to attain the stage of discovering integrilogical problems known to us, for example, "Fermat's great theorem," "twin primes." "Goldbach" or "Catalan" conjectures, and so on. Prime number distribution may contribute to physical effects (e.g., Barry Cipra, *Science*, 274, 20 December 1996, p. 2014).

So, another visualization of MPP stems from "Casimir effect analogy" (the latter is the physical pressure that arises from the disbalance of [virtual] vibrational modes of quantum electromagnetic field). In MPP, the selective pressure for the emergence of specific patterns may arise from dissymmetric engagement of primes and non-primes in the embodiment symmetry-breaking "phase transition." We can (symbolically) envision this as if primes and non-primes form the two wings of some "strange attractor" of the chaos theory (Gleick, 1988; Berezin, 1991b). In this view, one wing is acting as pattern *emanator* (*aleph-zero* of all composites that are all non-prime numbers), and the second, "less populated" (but "more exclusive") wing (*aleph-zero* of primes) acting as a pattern *selector* ("endorser" or "rejector" of particular patterns in the universal emergence dynamics).

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5.5 Pythagoras and Plato

One had to be a Newton to notice that the Moon is falling, when everyone sees that it does not.
Paul Valery (1871–1945)

Yes, the Moon, as the above-mentioned quote has, is falling and keep falling 24/7 since the formation of the solar system when our dear planet was assigned only one natural satellite (what an unfairness! even a small Mars has two satellites, not to mention Jupiter and Saturn with over a dozen satellite each! – but never mind, Mercury and Venus have none...).

So, why Moon does not crash on us? This is because every instance it "falls" on Earth, it moves on its orbit to exactly compensate for the "distance" it, to say, "passes" in its "fall." This is, of course, a continuous process and, theoretically at least, can go on forever. It may even seem trivial (any elementary physics text explains this well). Yet, Newton's contemplation on this "obvious fact" let him to formulate his law of gravity.

Something similar goes on in atoms, when (in a simplified classical picture) negatively charged electrons are moving around positively charged nucleus and do not fall on it (a quantum picture of this is a bit more fancy, as electron present there is represented by a standing delocalized wave).

Turning many centuries back, it was rather unlikely that in Ancient Greece or any other ancient civilization, people had some (or even any) knowledge of quantum nature of atoms or isotopes. But, again, how we can be certain in this? What if there was/is some "hidden knowledge" from "lost civilizations," or "extraterrestrial," or what? But let us first turn to Pythagoras and what came to us from him and his followers.

Pythagoras (about 570–495 bc) is mostly known for his Pythagorean theorem for rectangular triangles (Kirsch, 2001; Stewart, 2001). Literature on Pythagorean theorem is enormous. I will mention just two recent books: one by Arturo Sangalli (Sangalli, 2006) and the other by Alberto Martinez (Martinez, 2012). On the philosophical side, his main idea was on the prime role of numbers in the universe. In a core, he maintained that the ultimate reality of the universe is "number," a view that later flourished as a major philosophical steam. While Plato (427–347 bc) cannot be called a direct disciple of Pythagoras, many of his ideas fall into the same fold. And as such, Pythagorean tradition (Pythagorism) that posits that "everything is number," finds its uptake in the notion of the IPW of numbers and forms, which is an ongoing philosophical tradition up to the modern time.

Such modern Platonists as Georg Cantor, Kurt Gödel, or Roger Penrose (apologies to whom I am may not be mentioning) follow – in their writings – this Pythagorean–Platonic tradition and developed this line of thinking within the high standards of modern mathematics, physics, mathematical logic, and information theory. As an author of this book, I see myself within the same tradition, as should be obvious to anyone who will bother to read the pages that follow. And in visual arts, such

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directions and surrealism (e.g., Salvador Dali or Yves Tanguy) have much of a Pythagorean–Platonic spirit present in their pictures. For example, strange “animals” in the pictures of Yves Tanguy makes us to think about Leibniz’s “monadas” (separated worlds). Or, in a more modern fashion, imagine bubble-type “baby universes” that are constantly emerging in the infinite cosmic bubble.

Stressing “number” as the foundation of the universe, Pythagoras, as said, has some kind of a precognition of our digital age when almost all our information and communication technology rest on the using of digital strings. Digitization is everywhere nowadays. Nothing goes without digits. And quantum physics with its ideas of discreteness and quantum states (*Eigenstates*) is also pretty much on the side of digital world view. As Nobel Prize physicist Frank Wilczek mentions, “classical physics is profoundly anti-Pythagorean” (Wilczek, 1999). At the same time, quantum physics and general relativity (theory of gravitation) open the way to what Wilczek calls “Modern Pythagorism,” Combination of Newtonian constant of gravity (“G”), Planck’s constant (“h”), and the velocity of light (“c”) allows us to construct a fundamental unit of length, called Planck length:

$$L(\text{Planck}) = (Gh/c)^\wedge(1/2) \approx 10^\wedge(-35)\ \text{m} \tag{5.2}$$

Planck length is a fantastically small length, 35 orders of magnitude smaller than our human dimensions. The size of the (Big Bang) universe (and we, so far, do not know what may lie beyond it) is estimated as 10E26 m or, equivalently, 10E35 nm (if you put 3 or 4 atoms together then it is a nanometer). So, apart from a factor of 3 or 4, the Planck length is small in comparison with an atom, as an atom is in comparison with the universe (!). And yet, this length, Planck length, is among the fundamental units of physics and it is often used in quantum physics and cosmology.

Combining Planck length with other fundamental length in quantum physics, we obtain, the Bohr radius (which is 0.0529 nm, or 0.529 Å – a radius of a hydrogen atom), in the spirit of Pythagoras, a dimensionless number. The ratio of Bohr radius to Planck length is of the order of 10^26 (10E26), which is immensely a huge number. Yet, it is dimensionless (a pure number), even if it cannot be defined with such a precision, we can determine whether it is an integer number or not (most likely it is not).

Other similar dimensionless ratios can be obtained by using some other fundamental length in physics, for example, Compton length. Some units other than length (for example, time or energy) can also lead to a variety of dimensionless ratios, as the famous fine structure constant 1/137. All these appear well in the spirit of the Pythagorean idea of reducing everything to numbers (or rather explaining everything by numbers).

However, I have a somewhat cautious comment to make about this line of activity that Wilczek calls Pythagoras–Planck program. There is no real guarantee that the fundamental constants of physics do not change (albeit slowly) with time, or do

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not depend on the position of the observer in the (Big Bang) universe. Maybe so or maybe not, but anyone thinking about these issues will most likely run into such kind of cautions. Yet, for my own narrative that is focused along prime numbers and the paradigm of isotopicity, this objection does not appear to be of critical importance.

The cross-section between *isotopicity* (physical world is made of isotopes) and *Pythagorism* (IPW is made of numbers) lies, in my view, in the digital nature of isotopes, which can be counted individually by numbers. In particular, by prime numbers that form the infinite set of the same cardinality (*aleph-zero*) as the set of all integer (and rational) numbers. The string of DNA containing a chain of carbon atoms reads like a digital string of the type 1001010111001010, and so on (for simplicity, let us assume that we have 13C enriched carbon chain with half of all carbon atoms being 13C). In my publications (e.g., Berezin, 2015, 2016) and my present book, these ideas are advanced into other outlets of physics and/or metaphysics, whichever one may like to call it.

5.6 Nature's desire for patterns

In my publications (e.g., Berezin, 2015, 2016), I have indicated some possible implications of the phenomenon of *isotopicity* – the natural diversity of stable isotopes – for fundamental informationally related phenomena including spontaneous self-organization in nature, consciousness, and creativity. Isotopicity greatly diversifies most, otherwise almost identical, chemically defined systems (large molecules, crystals, etc.) and enables them to be highly individualized systems capable of an enormous number of inner states.

The first (actually, the key) idea here is the "nature's quest for patterns." Philosophical (or metaphysical – depending on how one puts it) reflections on isotopicity may lead to the following inferences. Isotopicity provides a route for nature to satisfy its alleged "quest for patterns" and gives an independent level of "freedom within the chemical structure." Isotopic freedom faces only rather minimal constrains imposed by other levels of organization (heterochemical, biodynamical, etc.). Dichotomy of complexity (trend to form rich, nonrepetitive, and multiscale patterns) and simplicity (nature's economy, along the Ockham's razor principle) can well be seen in the realm of isotopic freedom. Therefore, I suggest that *isotopicity*, which is currently a somewhat overlooked facet of nature's diversity, deserves a greater attention and further investigations.

In terms of how the nature creates its patterns one can draw useful analogies from the art of computer simulations. The realistic appearance of computer-generated landscapes is but one argument that complex natural systems can be efficiently coded by relatively short algorithms. The remarkable persistence of the "BL"

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idea of all possible books (including pattern-forming instructions) from the IPW of forms to the essays of Jorge Luis Borges (Borges, 1998; Bloch, 2008) illustrates our search for a unique principle to encompass cosmogenesis, emergence, and self-organization ("for deriving all from nothing there suffices a single principle" – G.W.Leibnitz).

In this regard, the often noticed "unreasonable effectiveness of mathematics" (E. Wigner) recasts the Pythagorean theorem "all things are made of numbers." At various physical levels, such a singular universal principle acquires numerous specific reincarnations. The general scenario proceeds from the delivery of specific "abstract" patterns to a specific level of their implementation. Take, for example, our carbon-based life-forms. How did it originate? Its origin, including its sentient level (consciousness), calls for some connecting agent positioned (in a metaphysical sense) between the BL of all patterns, and specific biochemical structures. A possible candidate is the isotopic diversity of chemical elements.

For example, flexibility in the positions of C12 and C13 atoms (different nuclear spins) in DNA renders the possibility of messages that are "overwritten above" (or independent of) the level of chemical diversity. Here, an analogy could be the so-called "subliminal messages" which, as claims go, can be overwritten on the music tapes. Isotopic diversity within chemically fixed crystalline structures admits "freedom within determinism" (Berezin, 1992c, 2015, 2016).

Furthermore, in spite that isotopic effects are generally subtle (energetically weak), they, in the spirit of the "butterfly effect" of the chaos theory, can informationally amplify themselves to the levels having profound consequences for the system. Because of the huge number of atoms involved, isotopic distributions may act as intermediaries between "BL of "eternal patterns" ("contained" in IPW) and physico-chemical level of biological functioning.

Isotopicity acts as a "detector" of universal BL patterns, connecting them to the atomic–molecular level. Once such connection is established (through isotopicity and/or other mechanisms), the entire "aleph-naught" of BL content (coded in the countable infinitude of all possible digital strings) becomes "available" to foster self-organizational dynamics.

Even "higher alephs" (of Cantor's sets) can also become "available" through integer truncations to finite digital strings (e.g., string of digits of "π" of any finite length). Likewise, patterns of (mega) universe at tower exponential scales (Dyson, 1979a, 1988) may also be engaged (the Platonist axiom says that there *is* an infinite Euclidean embedding space of any dimensionality and suggests that *some* kind of structures and objects are occurring at *any* scale of mega universe).

The potential convenience of isotopicity for the digitization of informational dynamics (isotopes are discrete entities, hence "integers") makes it possible for them to use Gödel-type numbering involving integer powers of primes. Informationally rich, super-long tower exponential integers (Knuth, 1976; Berezin, 1987g) can be "downloaded" from BL through quasi-fractal trees of tower exponents of primes

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[N(n) = p1^p2^...^pn]. Here p1, p2... pn mean consecutive prime numbers (2, 3, 5, 7, 11, etc.; "pn" is *nth* prime).

Every combination of primes defines a specific "integer empire." By this (peculiar, of course) symbolic term, I mean the set of all integers between N(n) and its next neighbor, which is N(n+1). Of course, because of the very mathematics of tower exponents, N(n+1) is immensely greater than N(n). Each so defined "integer empire" has a unique pattern of primes. These patterns may latter serve (in a metaphysical sense) as a "blueprint" for self-organizational dynamics. Isotopic clusters can implement such recording in a microscopically compact way (perhaps, at the nanoscale level). Supplementary to the brain and neural functioning, isotopicity may play some role in quasi-biological activity in solutions and contribute to memory transfer aspects of (the claimed) homeopathic effects.

5.7 Absoluteness of numbers

Leopold Kronecker, in spite of being a lifelong opponent to Cantor and his ideas of infinite sets, is credited with a motto, which somehow got a wide traction. He allegedly said, "God created only integer numbers, all the rest is the work of man."

What Kronecker apparently meant here is that the "laws" of integer numbers (e.g., the distribution of prime numbers) are the only genuinely immutable and ever-the-same foundation of the world – even our (more esoteric) mental constructs, such as the infinite hierarchy of sets introduced by Georg Cantor (Dauben, 1979) may bear the traces of contextual relativity. Even such monumental constructs as Gödel's incompleteness theorem (complete system of axioms always has statements unprovable in it) are subjected to logical challenges (Good, 1969).

Let us take the above-mentioned Kronecker's motto as a "minimal common denominator" of all-agreeable immutable truth(s). The laws of integer numbers are absolutely fixed and, as St. Thomas Aquinas asserts, not even god is capable to change them. Interestingly, as Bertrand Russell notes, St. Peter Damian (1007–1072) in a treatise *On Divine Omnipotence* maintained that god can do things contrary to the law of contradiction, and can undo the past. This view was rejected by St. Thomas Aquinas (1225–1274) and, since his time, this view was considered unorthodox (Russell, 1989, p. 407).

Furthermore, Kronecker's fundamental limitation is even more so applicable to the physical universe due to the fundamental interconnectedness of the physical world on all spatial and temporal scales. Yes, the fundamental physical constants (e.g., mass ratios of elementary particles, such as the above-mentioned M/m) are not "guaranteed" to remain fixed forever and may gradually change due to cosmological conditions. They are in no way can acquire the same status of permanency as the ratio of, say, two given prime numbers.

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5.8 The plurality of world's thesis (David Lewis)

> *There could be shadow galaxies, shadow stars, and even shadow people.*
> Stephen Hawking, physicist and cosmologist (1942– 2018)

In recent philosophical, physical, and metaphysical literature, the idea of the plurality or worlds and the coexistence of infinitely many parallel times have been picked up by several authors, among whom we mention David Lewis (Lewis, 1986). What makes his contribution especially interesting is that he discusses the physical thesis of the plurality of worlds in the context of the mathematical (Platonic) theory of infinite sets. Reviewing the models of time, Lewis discusses several alternatives. For example:

> Time might have the metric structure of the real line, as we normally suppose. And yet there might be infinitely many world-like epochs one after the other. Each might be of a finite duration; but their finitude might be hidden from their inhabitants because, as the end of an epoch approaches, everything speeds up. Suppose that one generation lives in and dies in twelve months, the next in six, the next in three, so that infinitely many generations fit into the last two years of their epoch (Lewis, 1986, p. 72).

The above-mentioned example is based on the well-known mathematical fact that sums of infinitely many terms can be finite. The simplest example of this (which Lewis actually uses in the above-mentioned passage) is the sum $1 + 1/2 + 1/4 + 1/8 + 1/16 + \ldots = 2$ (converging geometrical progression).

Applying this sum to progressively shortening time intervals (with progressively faster life), we see that infinitely many "full" lifetimes can be fitted into a finite total duration.

Another advantage of the theory of infinite sets is that it allows us to relax probabilistic restrictions. For example, the mathematical probability for anyone of us to exist is astonishingly small. We all have 2 parents, 4 grandparents, 8 great grandparents, and so on. Any small change in any one of the multitude of events in the past could have resulted in the possible scenario that some of our ancestors might never have met and that would be enough to break the chain of events that have produced us as specific and unique human beings.

Many authors have speculated how the history might have gone should this-or-that event never have taken place (for example, how history would go if Napoleon had been killed in his first battle of 1793 and had never fought all his later wars).

In the mid nineteenth century, Gustave Dore, famous for his illustrations of the Bible and of Dante's poetry, made a twin engraving showing his interpretation of alternative worlds (Gale, 1981, p. 162). In one scene, Judas is seen betraying Christ with a kiss. In the other, Christ is not betrayed and is free to go. One could only guess how human history would have evolved in the second scenario. Likewise, a recent collection of essays (Roberts, 2004) with titles such as *The Spanish Armada Lands in England*, *King Charles I Wins the English Civil War*, or *Japanese did not attack Pearl Harbor* discuss numerous versions of possible alternative histories.

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Yet, all alternative realities notwithstanding, and in spite of all the odds against our emergence, here we now are. How set theory helps us to visualize this probability paradox? The ambiguity here is based on the premise of the theory of infinite sets, namely on the fact that from any infinity one can construct an infinite subset in infinitely many different ways.

Lewis gives an example of the "prime number paradox." Consider all integer numbers, 1, 2, 3, 4, 5… We know that some of them are prime numbers that are divided only by 1 and by themselves. These are 2, 3, 5, 7, 11, 13, 17, 19, 23…. The rest of the integers are all composites; that is, they are products of at least two primes, or more (the unit, number 1, has a special status and is not counted as a prime or a composite). At the beginning of an integer set, primes pop-up quite often, but for larger and larger integers (N) their probability decreases as 1/log (N), inversely proportional to the natural logarithm of N. This relationship is known as the prime number theorem (Dickson, 1952, 1960; Plichta, 1997, p. 169; Du Sautoy, 2003, p. 54).

Because primes became progressively more and more rare among integers, common sense tells us that there are infinitely fewer primes than all integers (see Section 5.1). If we were to choose any integer at random among the infinity of all integers, the probability of its being prime tends to zero. This is indeed so if we review all integers in the order of their natural appearance (1, 2, 3, 4, 5…). However, because the set of integers is infinite, Lewis rearranges it in a form of two-dimensional array (Lewis, 1986, p.119; see also Berezin, 2015, p. 43, 2016, p. 3–11).

These zigzag figures (which, theoretically, can be extended to infinity; see Section 5.1) can be titled as "More primes than all integers?" It illustrates the "paradox of infinity." In it the consecutive prime numbers are arranged in the infinite zigzag table in which all the lines are numbered by consecutive integers (zigzag lines connecting consecutive primes are omitted from this diagram – it's easy to do it yourself – just go prime-by-by prime: 2, 3, 5, 7, 11, 13, 17…). This diagram creates the appearance that there are infinitely many more primes than integers! (All lines and columns are supposed to run to infinity due to the infinite number of primes available in the infinite Platonic world.)

Only the first column is composed of composites, the rest are exclusively primes arranged in an infinite two-dimensional pattern (to continue the infinity table indefinitely one needs to use the list of prime numbers and meander through it in a zigzag fashion). Each line is infinite and has an infinite number of primes. All integers occur in this table, each appears just once. For example, any composite integer will be reached if we follow down the first column.

Yet, we see that for each row, the primes outnumber composites by infinity to one. According to an image invoked by the above-mentioned table, primes predominate among all integers, in spite of the fact that "we know" that the probability of "hitting" a prime number at random is (asymptotically) zero (if we assign to all numbers the same probability). Lewis uses the same logic to demonstrate that the "improbable" worlds whose (formal) probability is vanishingly small (such as the worlds containing intelligent life) not only *can* exist, but (in some sense) they can predominate among all possible worlds (!).

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5.9 Infinite sets and anthropic principle

Follow your bliss and the universe will open doors where there were only walls.
Joseph Campbell (1904–1987)

The argumentation exposed in the above-mentioned sections that is based on the properties of infinite sets adds a new dimension to the discourse on the anthropic principle (Gale, 1981; Grandpierre, 2002; Hajduk, 2002). Anthropic principle is an extensive philosophical and metaphysical issue having several forms. In a nutshell, the central idea of it is the notion that, somehow, all the physical parameters of the universe are such that it allowed the emergence of life (and us). In other words, everything was happening "as if the universe knew that we are coming." Some versions of the anthropic principle boarder with the "scientific creationism," whereas some other forms disassociate themselves from the latter.

Within the presumed infinity of alternative realities in the infinite mega-verse (meaning by the latter the entire infinite tree of all branching bubbles of the inflationary cosmological models), all sorts of world situations occur with certainty (unit probability), infinitely many times. As Garriga and Vilenkin put it:

> Some readers will be pleased to know that there are infinitely many [mini-verses] where Al Gore is President and – yes – Elvis is still alive. (Garriga and Vilenkin, 2001, p. 4)

In our facing the ultimate reality and meaning (URAM) problems, some of us may come to a search of some metaphysical invariants. Probably, one of the best-known trails in this direction can be found in the area of pure mathematics. Here we are dealing with the issue of metaphysical pressures of "the desire" of the "embodiment" coming out from the IPW.

5.10 Atoms and isotopes in our life

Suppose you make a hole in an ordinary evacuated electric light bulb and allow the air molecules to pass in at the rate of 1,000,000 (one million) a second, the bulb will become full of air in approximately 100,000,000 (hundred million) years.
Francis William Aston (1877–1945, discoverer of isotopes, Nobel Prize 1922)

The issue of creativity has an inherent dichotomy in it. We often hear that there is "nothing new under the sun" (Eliade, 1971). On the other hand, the valuation of our experience as such implies its inherent axiological significance in non-relational terms ("axiology" is Greek for "value" or "worthness").

According to Sheldrake (1988), the issue of creativity may, actually, include both these aspects, that is, recalling, recycling, or updating the *past* and a non-zero addition of a *new* (ontologically untried) experience.

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The issue of virtual (quantum) reality suggests another slicing of this problem. It can be formulated as the following quest: *Does the manifold of all virtuality, all of which are imaginable or available* "somewhere" *in quantum superpositions, indeed include everything that has ever been actually created in whatever spaces, times, or the universes, whatever they could be?*

This might lead us to problems such as exhaustibility versus inexhaustibility of mathematics (Penrose, 1989a, 1994, 1996) and the dilemma of *potentialia* in an ideal world of Plato. Instead, let us turn this in the direction of emergence within our Earth's biology.

Biological evolution as we currently see it appears as a prolific natural creativity. It is a playground of forces of virtuality and spontaneity that are seeking an actualization and embodiment. Many hierarchical levels can be indicated within biological evolution. Here we discuss a specific facet related to the notion of isotopicity (Berezin, 2015, 2016).

As it was proposed earlier, the isotopic degree of freedom in chemical structures may play a significant role in mental dynamics and also could be important for the issue of creativity. Furthermore, one can look at isotopicity as a possible "missing dimension" in our present understanding of quantum foundations of human individuality, self-awareness, and the nature of personal identity (Berezin, 1990b, 1992a, 1994a, 2015, 2016; Pui and Berezin, 2001).

Some physical and philosophical aspects of these problems were recently discussed by Albert Shalom (1985) and Henri Margenau (1984). Another new and promising direction is the problem of the so-called quantum self (Zohar, 1990; Lloyd, 2002) that is provided by a recent paradigm of quantum computing.

Let us now look at the specific tools available to nature for its creativity at the level of the Earth's biology. Life on Earth, at least as we understand it now, is based on chemical diversity. All objects that surround us, including ourselves, are made of just a few dozens of (about 80) different chemical elements. An enormous variety of their possible combinations accounts for all the richness of minerals and other nonorganic structures found in nature.

Even more impressive is almost unlimited variety of biological structures and biochemical processes responsible for the existence and evolution of all living beings on this planet. Out of all chemical elements, only 4 are absolutely critical for all of (so far known) Earth's biology: these are hydrogen, carbon, oxygen, and nitrogen. A few more elements are also essential for the biology (e.g., phosphorus, Sulfur, and sodium) and another group of 30 or so elements is loosely labeled as "microelements." Microelements are usually related to some more specific biological functions, often with a varying degree of significance in different life-forms (e.g., elements such as magnesium, copper, iron, and calcium).

The biological role of a few other remaining elements (e.g., rare earth metals) remains still somewhat unclear, although they also could be responsible for some specialized or focused biological functions. So, it turns out that almost all chemical

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elements play some role in living organisms. Even rare "exotic" elements such as gold and uranium are known to accumulate in some specific organs and tissues in concentrations significantly exceeding their average chemical abundance in the Earth's crust. Therefore, one can conclude (at least as a statement of plausibility) that living nature ("Gaia") is "smart enough" to find some use for (almost) all members of the periodic table of elements.

But if so, a similar question can be asked about the *isotopic diversity* of chemical elements. About 3/4 of all chemical elements have at least two (and often three or more) stable isotopes. For example, 99 % of all atoms of natural carbon are 12C atoms. The nucleus of 12C atom consists of 6 protons and 6 neutrons. Yet, 1% (still a very large absolute number of atoms!) of all C-atoms is 13C isotopes. The latter has 6 protons and 7 neutrons in its nucleus and, consequently, it is about 8% heavier in mass than that of "ordinary" (12C) carbon atom.

Likewise, oxygen has 3 stable isotopes: 16O (99.8%), 17O (0.04%), and 18O (0.2%). Again, despite a seemingly small fraction of minority isotopes of oxygen, even such "negligible" concentration as 0.04% translates into a very impressive absolute concentration of 17O atoms. One out of 2,500 oxygen atoms is 17O isotope. A tiny living cell of, say, 1 mm size, has about 10^10 to 10^11 oxygen atoms (mostly, as water molecules).

Therefore, even such a small cell still contains several million 17O atoms. Incorporated among oxygen atoms, these "minority" atoms can form a tremendous number of combinations and arrangements. The latter fact can make a difference because 17O atoms have non-zero nuclear spin and, therefore, their magnetic properties differ from the magnetic properties of 16O and 18O isotopes that have zero nuclear spin.

Some chemical elements have two (or more) isotopes with comparable abundancies. For them, there may not be a clearly "designated" majority isotope. An example is silver that has 2 stable isotopes with almost equal abundancies, namely 107Ag (51.8%) and 109Ag (48.2%). A "champion" of poly-isotopicity, tin (Sn) has 10 stable isotopes. So, one can reword the earlier posed question in the following form: if nature makes such an impressive and skillful use of chemical diversity, why has it made no clear identifiable use of the isotopic diversity in biological structures known to us?

Stable isotopes of the same chemical element differ in their masses due to a different number of neutrons in their nuclei. This mass difference leads to detectable variations in the rates of some chemical reactions and atomic diffusivity. But the mass difference is not the only route through which isotopic diversity affects the kinematics and dynamics of physical and chemical processes.

Isotopes also differ in their nuclear magnetic moments (nuclear spins) and (due to a combination of mass, nuclear spin, and nuclear size variations) have slightly different position of corresponding atomic energy levels. Such differences (isotopic shifts), albeit small, are, nevertheless, important in various resonance-type phenomena, which can "amplify" these small differences. Isotopic shifts are well studied in atomic and molecular spectroscopy. Isotopic variations of physical and chemical properties are successfully exploited in several existing isotope separation technologies.

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However, the ideas of isotopic diversity (*isotopicity*), isotopic randomness, and isotopic informatics in biology and cognitive sciences are still in their initial stages (Berezin, 2015, 2016).

Chapter summary

The principle thesis of the idea of Platonic emergence (Platonic pressure effect [PPE]) is the generation of all "reality" directly out of the infinite complexity of the IPW – IPW. This emergence is *a-temporal* (happening "out of time"). This means, it is does not happening in any particular "time" in our sense of this word (no special "time zero" point), but is an *eternal emanation* of the physical world out of the infinite substrate of the IPW. Some analogy can perhaps be drawn from the traditional Trinitarian theology in which the Holy Ghost (the Holy Spirit, the third aspect of the Holy Trinity) "proceeds" from the God Father and this "process" does not happen in any particular time but is an eternal metaphysical emergence. Likewise, it can be said that the prime numbers (that are subset of all integer numbers) are "emanating" from the set of integer numbers in a kind of eternal a-temporal "process." Nature's "desire" for pattern generation at all levels of the physical world has its manifestation in the digital informational strings of isotopic combinations.

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6 Time labyrinths and melting watches

Impressive scientific developments in quantum physics, astrophysics, and relativistic cosmology provide a whole range of new ideas for scientific, philosophical, and literature discourse on topics such as multidimensional time, time travel, time loops, parallel universes, and the nature of infinity. The sustained tradition of speculating on these themes can be traced as far back as Giordano Bruno (1548–1600) and includes diverse representation in modern physical literature (e.g., David Deutsch, Richard Gott, and Julian Barbour) and scientific fiction (e.g., Jorge Luis Borges, Poul Anderson, Isaac Asimov, and Carl Sagan). In many of these offerings, the boundary between "hard science" and "metaphysical speculation" is rather fuzzy. While complete cataloguing of these developments is beyond the capacity of a single book, here I still suggest my short review of some of the major lines of this discourse in the context the ideas of platonic infinity, ultimacy, and eternity.

6.1 Time and eternity

Time is what keep the light from reaching us.
Meister Eckhart (1260–1328)

Regardless of any "definitions" of time ("what the time is," etc.), we all have some subjective perception of the flow of time. In terms of human perception, the concept of time presents an interesting dilemma. On one hand, we feel time as a uniform flow. In such a flow one moment can be distinguished from the other only through the events that "fill" the time in same way as physical objects "fill" an "empty" space. On the other hand, a personal experience of each and everyone of us gives us the distinct awareness of the reality of special points in time such as individual milestones of personal life (birth, aging, death) and of the humanity at large (e.g., major historical events).

However, in spite of these special points, the perceptual uniformity of temporal flow presents some conceptual difficulty to us. It is a challenge for humans to accommodate these "special points" on the time axis as something inherent to time itself. The events seem to be localized in time in what appears to be a somewhat random and erratic pattern. Our feeling about almost any specific event we are facing in our life is that it could have equally well happened earlier or later, or not happen at all. A powerful feeling of possible alternatives ("Why I did this?," "I'd better not be there") surrounds our everyday existence almost continuously.

Likewise, the interpretations of creation as a "beginning of time" (traditional theologies and Big Bang theories alike) still leave us wondering what was "before" the time-zero moment. At a more reflective and philosophical level, the dilemma of time

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uniformity and special points leads to what may seem as logically unsolvable paradoxes (dichotomies). Thus, B. Spinoza (1632–1677) argued that "the universe could not have a beginning because there could be no clock to tell it where to start" (Collins and Squires, 1993, p. 913).

On the other hand, developments in pure mathematics and logic have strengthened the intuitive metaphysical notions of infinity, unchangeability, and the ideal ("platonic") world of numbers and forms. The said "metaphysical set" has raised our awareness to the level of the realization of its extremely rich structure and their enormous potential for pattern generation. Such well-known constructs as Mandelbrot Set with its infinitely intricate structure that is generated by a simple mathematical procedure (Gleick, 1988, pp. 215–240) provide a vivid illustration of this pattern generation capacity.

How this ideal world converts itself into a time-based processual world is a key issue in all attempts to define time in terms of more fundamental realities (Spitzer, 2000). Such a task is possible only in a provisional sense because it is difficult to pinpoint any physical category that in a common human perception would appear "more fundamental" than time. Only notions such as "eternity," "numbers," or "infinity" might perhaps fit the bill. These are, however, notions of a metaphysical nature rather than truly physical concepts. In this regard "time" appears to be a category that lies at the border between the realms of physics and metaphysics.

Below I discuss the coexistence of some eternal and dynamic aspects of reality in the light of recent physicophilosophical ideas. One is the "time-frozen-within-eternity" (physicist Julian Barbour). The other is an issue of time-continuity versus time-discreteness, which can be approached on the basis of nested hierarchy of infinities (Cantor's set theory) and Gödel's undecidability theorem.

6.2 Time: Reality versus illusion

Time is surely the most obvious and most important of all concepts we use. Clocks and wrist watches are probably the most universal personal device across all geographical and economic boundaries. One can recall here the famous *Melting Watches* (*The Persistence of Memory*) by Salvador Dali, which we already mentioned in Section 1.4 (see also Section 10.12 on the art of Salvador Dali in the context of quantum physics and ideas of randomness).

Yet, all claims to the contrary notwithstanding, hardly anyone can claim that s/he really knows what "time is." Like the notion of a number, we simply do not have any simpler and conveniently perceived concepts with which we can "define" what time "really" is (Greene, 2004, p. 127). As we will elaborate further, we can no more "explain" what the time is than we can "explain" what the number 7 or the number 11 "are."

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The often-asked question is whether time is illusory or real. If it is real, in what sense can we verify its reality? Can we go back in time and undo what was done? Are there "time loops" (returns to earlier time), or is time always linear and directed from the past to the future? Are there "parallel times?" Is there two-dimensional time (or perhaps time with any number of dimensions)? Is time just an ultimate thing of its own, or is it "embedded" in some higher "timelessness," which we often call eternity? What is the nature of this eternity? Can we probe its nature with some technical or scientific means, or is the question "what is time?" forever bound to remain in the realm of metaphysical speculations?

All these questions, and many similar ones, have been discussed over and over since the beginning of civilization in various cultural, scientific, philosophical, and religious contexts. The literature addressing the phenomenon of time (and the very quest as to whether time can be seen as a "phenomenon") is so enormous that it is almost certainly beyond the realistic capacities of any single individual to review it exhaustively. Here I want to delineate several key aspects, with some indication of my personal preferences.

The natural starting point would be the dispute on the issue of whether "time is real" or "time is just an illusory." Historically and philosophically, we have strong arguments supporting either side of this dilemma. Could it be that both sides are, in a sense, right; or, rather, that the "illusiveness" and the "reality" of time form a complimentary dichotomic pair, of the same type we encounter in Bohr's complementarity principle in quantum physics? (The latter refers to the quantum mechanical dichotomy of the corpuscular and wave properties of elementary particles, such as electrons.)

Alternatively, could it be that "what-time-is" is an ultimately unknowable question, in the same sense as there are fundamentally undecidable questions in mathematics (i.e., Cantor's famous continuum problem)? While here I do not pretend to give final answers about the nature of time, I want to outline some ideas related to the aforementioned issues. Inevitably, there is some overlap, as well as some apparent contradictions between the ideas and quotes illustrating them. As an author, I believe that this is a reflection of the open-ended nature of this subject.

6.3 Infinity and time

Among all fundamental metaphysical concepts, two are perhaps the most often used and yet are the most enigmatic. These are the concepts of infinity and time. It appears to us that no matter what we hear about cosmology, Big Bang, and the origin of time, our most basic common-sense perception tells us that the time is infinite: it always was and it always will be.

Not surprisingly, the notion of time has established itself as one of the most important and universal ingredients of human existence. Practically, any discussion about the ultimate reality and meaning involves an explicit or implicit reference to time.

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Yet, there is hardly anything that resists any possible "explanations" more than the question about the nature of time (Ruhnau, 1994; Cramer, 1995; North, 2000; Landsberg, 2001). The paradox of time is that, on the one hand, it appears as utterly simple ("everybody knows what the time is") and, on the other hand, it defies any ultimate attempt to explain it.

Even among physicists there is little agreement about the nature of time. For example, a physicist Peter Landsberg quotes the result of an opinion poll conducted at an advanced workshop on theoretical physics in 1991 (Landsberg, 2001). Forty-two attending physicists were pooled on the question: "Do you believe time is a truly basic concept that must appear in the foundation of any theory of the world, or is it an effective concept that can be derived from more primitive notions in the same way that a notion of temperature can be recovered in statistical mechanics?"

Of the 42 questioned, 10 believed that time exists at the most basic level, while 20 denied this and 12 were undecided. Thus, in spite of the fact that time appears to be the most important concept in physics, it is also perhaps the one most difficult to explain. Furthermore, the very explanation of time seems truly impossible, if by explanation one means its reduction to some more elementary notions (what can be more elementary than time?!).

The idea of the infinite time axis that extends indefinitely to the past and to the future seems to be relatively simple and straightforward. While it is easy to say that "time always was and always will be," such a statement presents a logical vicious circle, in which "time" is defined through "always" while "always" needs time for its own definition. In fact, the assumption of either the beginning or end points (or both) on the time axis likely requires a more difficult discourse than the intellectual visualization of time axis (*t*-axis), which is infinite in both directions. As in a famous parable of an Earth resting on a turtle, the obvious next question (on what this turtle itself rests?) is answered by a proverbial pun, "there are turtles all the way down," which draws an image of an infinite tower of ever larger turtles (Rucker, 1995, p. 23).

Along with infinite and absolute space, the idea of infinite, absolute, and uniform time forms a basic (or rather, one of the prime pillars) of what is known as classical (or Newtonian) physics.

According to Isaac Newton (1642–1727):

> [there is an] absolute, true and mathematical time, of itself, and from its own nature, flows equably without regard to anything (any - thing) external, and by another name is called duration. (...) All motions can be accelerated or retarded, but the time, or equable, progress of absolute time is liable to no change. The duration or perseverance of the existence of things which exist remains the same, whether the motions are swift or slow, or none at all. (I. Newton, Mathematical Principles of Natural Philosophy, quoted in Novikov, 1998, p. 30)

The Einsteinian idea of curved space–time (four-dimensional space-time is curved according to the distribution of matter) has modified the aforementioned view.

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However, this modification is probably less radical than it is often supposed. Even if space–time is curved, the perception still remains with physicists that it is somehow embedded (immersed) in a real absolute Newtonian space and time, in the same way as we can imagine curved surfaces of ordinary objects (e.g., the spherical surface of the Earth) immersed in an Euclidian rectangular (uncurved) space.

At the same time, one may notice that the idea of the infinite *t*-axis leads us to another challenging paradox, which requires explanation: the problem of our existence (why we are "now" and not in any other time). Not surprisingly, there were numerous attempts to suggest some overcoming of this paradox and to envision alternative models of time. Eva Ruhnau (1994) discusses the following eight models of time in physics (graphical description given in *italics*).

(1) Absolute Newtonian time, discussed earlier (*infinite linear axis*).
(2) Time of Einstein's special relativity *(system of diverging lines to indicate relativity of simultaneity*).
(3) Time of general relativity (*system of converging lines to reflect slowing of time by the presence of mass*).
(4) Cosmological time arrow (*unidirected arrow with presumed zero point*).
(5) Thermodynamical arrow of time, driven by the law of entropy increase (*system of parallel unidirectional arrows to indicate independent entropy increase in various separate [sub] systems or subuniverses*).
(6) Time of emergence and spontaneous symmetry breaking and self-organization, emphasizing the absence of time in equilibrium and its presence in far-from-equilibrium states (*system of closed circles that represent closed time loops*).
(7) Quantum mechanical time emphasizing the irreversibility of measurement process (*system of wavy diverging-then-converging time lines*).
(8) Time as closed loop with space–time having no boundary and no initial singularity (*closed circle*).

We note that these models of time do not exhaust all the possibilities. On the contrary, many more can be offered. Circular time loops (models 6 and 8) resonate, to some extent, with the ideas of ergodicity and the eternal return (Berezin, 2002). This leaves us with the somewhat ambiguous question of whether models involving time loops imply a two-dimensional (or multidimensional) time (in ordinary geometry we need a two-dimensional paper to draw a closed loop). Actually, as was mentioned, "[models with more than one dimension of time] are not too weird to think about, since any observer's perception of time could remain one-dimensional" (Chown, 2001, p. 150).

Another key aspect of the nature of time is related to the issue of continuity over discreteness. The perception of infinity can go both ways – toward the infinitely large as well as toward the infinitely small. The former is generally related to the problem of the origin of time and its eternality, and the latter to the problem of the infinite

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divisibility of time. Is there a smallest time unit, or is time infinitely divisable? The traditional opening line for the divisibility issue is represented by the famous *Zeno paradoxes* (Zeno of Elea, 490 BCE), which have found a new interpretation in the context of modern physics (Grünbaum, 1967; Seife, 2000).

The importance of the Zeno paradoxes lies in the pairs of fundamental dichotomies such as discreteness versus continuity, progression versus regression (of time intervals), motion versus statism, and internality versus externality. In the words of Bertrand Russell "Zeno's arguments, in some form, have afforded grounds for almost all the theories of space and time and infinity which have been constructed from his day to our own" (Grünbaum, 1967, p. 3).

An interesting and visual example of a Zeno paradox is the so-called Gabriel's horn, which is a three-dimensional figure of revolution of the function $y = 1/x$ around x-axis in the interval from $x=1$ to infinity. This figure (Clegg, 2003, p. 240) looks like an extended conical surface that resembles a long trumpet (the name comes from an image that is often found in medieval iconic art showing the Archangel Gabriel blowing a long horn, e.g., *The Fall of the Rebel Angels*, by Pieter Bruegel [1562] in the Brussels Art Museum).

This theoretical construct is also known as "Torricelli's trumpet" by the name of the Italian physicist and mathematician Evangelista Torricelli (1608–1647). This genius scientist was the follower of Galileo's ideas on the solar system and in his (unfortunately short) life he has invented a barometer and gave the first known scientific explanation of the origin of wind (… "winds are produced by differences of air temperature, and hence density, between two regions of the earth"). The latter is one more illustration that great ideas can often be expressed in a single clear sentence. Another one-sentence great discovery from the same (seventeenth) century was a coded phrase by which Christiaan Huygens (1629–1695) described his discovery of the Saturn's rings ("surrounded by a flat, thin ring, nowhere touching [the planet] and tilted to the ecliptics"). Should Nobel Prizes be awarded in seventeenth century, Huygens almost certainly can get one for just this one phrase!

What is seemingly "paradoxical" about this conical surface is that it has a finite volume but an infinite surface area. Therefore, if we are to fill Gabriel's horn with liquid paint, we only need a finite amount of it. And yet if we want to use this paint to color the inner surface of the horn, we will never have enough paint because the area of the surface is infinite! Likewise, while an internal (mathematical) time can be continuous and infinite, the external (physical) time may manifest itself in finite and discontinuous (discrete) form. Yet another interpretation of such a figure may point to the possibility that times of different dimensionality need not necessarily be either finite or infinite. For example, it is conceivable that one-dimensional ("our") time is indeed infinite (time axis runs from minus to plus infinity), while the higher dimensional ("embedding") time may be "finite" and include "time loops."

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6.4 Certainty of infinity in mathematics (Platonic infinity)

> *The opposite of a correct statement is a false statement. But the opposite of a profound truth may well be another profound truth.*
> Niels Bohr (1885–1962)

Contrary to the category of time that we can provisionally perceive as a physical notion (we do have some physical sensual perception of running time), the idea of infinity is known to us mostly through its abstract mathematical meaning. For example, we say that the function $f = 1/x$ grows to infinity when x indefinitely approaches zero. Likewise, we talk about the infinity of integer numbers. Furthermore, we know that there is infinity of not just all integers, but there are infinitely many prime numbers: the latter follows from the famous proof by Euclid (third century BCE) that we reviewed earlier (Chapter 3).

Infinity has been discussed by many authors (e.g., Hofstadter, 1980; Maor, 1987; Dyson, 1988; Davies, 1993; Lavine, 1994; Pickover, 1995; Rucker, 1995; Aczel, 2000; Kaplan and Kaplan, 2003) as well as by many earlier authors. It is impractical to refer to all of them or to provide all the relevant quotes. Thus, the following selected quotes are inevitably only a sampling. For example, the physicist Paul Davies says:

> In our quest for ultimate answers it is hard not to be drawn, in one way or another, to the infinite. Whether it is an infinite "Tower of Turtles", an "Infinity of Parallel Worlds", an "Infinite Set of Mathematical Propositions", or an "Infinite Creator" – the physical existence surely cannot be rooted in anything finite. Western religions have a long tradition of identifying God with the Infinite, whereas Eastern philosophy seeks to eliminate the differences between the One and the Many, and to identify the Void and the Infinite – zero and infinity. (Davies, 1992, p. 229)

Furthermore, we know that mathematical infinity is an intricately structured notion (Maor, 1987, p. 54–60). One of the surprises of Georg Cantor's work is that there is not just one infinity but a multiplicity of them (Tiles, 1989, pp. 103–111; Davies, 1992, p. 230; Rucker, 1995, pp. 221–265). Thus, despite the direct nonobservability of infinity, the latter (infinity) acts as a source of patterns and serves as a driver of the dynamics of the emergence (origin) of structured objects out of chaos.

Thus, mathematical infinity acts as a "connector" of the physical world to an abstract mathematical (platonic) world of numbers and forms (Hersh, 1995; Pui and Berezin, 2001). Furthermore, at the final count, the [structured] mathematical infinity may point toward the resolution of the ultimate mystery, encapsulated in Leibniz's question of "why there is a universe at all?" (Greene, 2004, p. 310; Holt, 2012).

It is worth noticing that while the notions of physical infinity are inevitably speculative and remain in the realm of guesses and metaphysical glimpses (how can one be certain that space and time are indeed infinite?), in the realm of mathematical infinity, we do know with provable certainty many specific facts. We know that the number of primes is indeed infinite, and that the number π is irrational; this means that it is not equal to any rational fraction n/m where n and m are integer numbers. Furthermore, we

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know for certain (and not just speculate) that the fundamental constants of mathematics, "e" and "π" are indeed related to each other by a simple relationship discovered by Leonhard Euler (1707–1783) in the eighteenth century [e^(i×π) + 1 = 0], where "i" is the imaginary unit (a square root of –1), and many other similar commonly known facts.

However, even in mathematics, we should guard against unrestrained optimism. Contrary to what may appear, not everything can be reliably proven about mathematical ideas. Yes, we know something about mathematical infinities, but we will never know all. In principle, we cannot have a full knowledge of infinity. As Kurt Gödel has demonstrated in 1930s with his undecidability theorem, because of the infinite nature of mathematics and its inexhaustibility, there are always going to be mathematical statements that can never be resolved (Rucker, 1995, pp. 267–294; Barrow, 1998, p. 218). We may never know the "true" answer to them. One such conundrum is the celebrated continuum problem (Berezin, 2002, p. 263), which, as was recently proven, will remain forever undecidable (Kaplan and Kaplan, 2003, p. 262). Another recent and striking example to this undecidability is the so-called omega number, which was discovered by the mathematician Gregory Chaitin (Chaitin, 1999, 2000; Raatikainen, 2001). This is a number that is *proven* to exist in the interval (0,1) and about which it was also proven that it is in principle impossible to calculate its true value. Hence, it will always remain unknowable, regardless of how far our mathematical knowledge will ever go.

6.5 The trouble with certainties and infinities in physics

In physics, the situation with proven certainties and infinities is even more shaky than in pure mathematics. In mathematics, at least some facts about infinity can be proven beyond any doubt (like the fact that number π is an irrational number). This means that in mathematics we can achieve, at least for some statements, true certainty. As Max Tegmark puts (2003) it, "a mathematical structure is an abstract, immutable entity existing outside space and time."

This is not the case in physics. In physics, we do not have (and are not likely ever to have) similar provable certainties about the major facts. All that we know about the physical world amounts to plausible conjectures (see again an impressive list on "unknowns" in Section 1.5). We are never certain that what we call a physical fact is known to us to the very bottom of it, to a degree that it will never be subjected to a revision or an extension. A few examples are as follows:

(1) Conservation laws.
The so-called fundamental laws of physics, such as the law of energy conservation, conservation of the total electrical charge, or the second law of thermodynamics (law of the entropy increase) are, in fact, approximations that are experimentally verified to a very high degree. For example, the law of the charge conservation is confirmed to a precision of 1 part per 10^20 (100 billion of billions). It probably

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could be confirmed to even higher degree of precision. But that will not guarantee that this law will still hold to a precision of, say, 1 part per 10^1000. The latter level of precision is unlikely ever to be measurable. Similar conclusions can be drawn about all the other so-called conservation laws of physics.

(2) Fundamental physical constants.
This refers to the presumed constancy of the key physical constants (Barrow, 2002), such as the velocity of light (*c*), gravitational constant (*G*), Planck's constant (*h*), and so on.

However, these constants are not of the same kind as fundamental constants of mathematics, such as π, *e*, or square root of 2. The latter are true and immutable numbers that (at least, in principle) can be calculated with any arbitrary precision (e.g., mathematicians recently calculated over 50 billion digits of π). This is not the case for the constants of physics (*c*, *G*, *h*, etc.). Unlike mathematical constants, their constancy may not be absolute. It is confirmed only to a finite precision (only about 10 decimal digits), without any guarantee that they cannot slowly change. In fact, they well may be constants only in name. There is a sizable physical literature that challenges the assumption of unchangeability of *c*, *G*, *h*, and other physical constants and argues that their values slowly change during the evolution of the universe (Barrow, 2002, pp. 101–104, 227–230).

(3) Big Bang.
Speaking from the astrophysics point of view, the case for the Big Bang seems to be strong. Such key observations as the red shift in the spectra of distant galaxies and the presence of microwave cosmic background radiation ("3K radiation") are powerful arguments for it. Yet, the physical and philosophical literature exhibits a broad variety of interpretations (e.g., Sharpe, 1997; Nemesszeghy, 2001; Spitzer 2001; Grandpierre, 2002; Hajduk, 2002). The key questions almost anyone is tempted to ask about the Big Bang is "what was before it?," or "what caused it?" In spite of the fact that such questions are often dismissed (unduly, I believe) as naive, essentially all the answers offered to them so far are in the realm of metaphysical speculations.

6.6 Frozen time of Platonia

The physicist Julian Barbour (2000) uses the idea of *Platonia* to transcend the flow of time. In his view, time as such does not exist, at least as a process. He replaces the notion of time by the eternal *Platonia*:

> Nothing changes in Platonia. Its points are all the instants of time, all the Nows; they are simply there, given once and for all (...) The whole universe – Platonia and the wave function – is the closest we can get to a God (...) I am sure that there are locations [in Platonia] where the experience is much deeper and richer than here. Such experience may be perfectly timeless – consciousness

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> just sees what is. Perhaps we are somehow included in that awareness. Perhaps too, the world is redeemed, and its inner conflicts resolved and understood, somewhere in Platonia's distant reaches, farther from Alpha than we are. (Barbour, 2000, pp. 44, 327)

Likewise, the mathematician Ian Stewart talks about *Platonia* in terms of the *Mathiverse*, the immutable platonic world of mathematical objects:

> The Mathiverse transcends Time and Space (…) it transcends Intelligence and Extelligence … it transcends Thought; it transcends Transcendence itself. (…) The Mathiverse contains all numbers. The Mathiverse contains all shapes. The Mathiverse contains all geometries. The Mathiverse contains all vectors, matrices, permutations, combinations, integrations, separations, projections, injections, surjections, bijections, semigroups, transformations, relations, functions, functors, algebraic group schemes, supermanifolds, K-theories, M-theories, M-sets, power sets, subsets …. (Stewart, 2001, p. 28)

On a similar note, Albert Kirsch, commenting on an earlier article, writes about Pythagorean mathematics and its fundamental place in shaping (or perhaps even creating) the physical world:

> Perhaps, following Pythagoras, we should assign a perspective role to the mathematics: assume the equations are real and that matter is formless and comports itself in according to them. That is, the equations do not describe what matter does; rather, they tell it what to do." To which the original author (Max Tegmark) replies: "With such a viewpoint, which might also be termed Platonic, the mathematical structure encapsulated by the equations wouldn't merely describe the physical world. Instead this mathematical structure would be one and the same thing as the physical world, and the challenge of physics would be to predict how this structure is perceived by self-aware substructures such as ourselves." (Kirsch, 2001, p. 17)

It s worth noticing that in the aforementioned passage the self-aware structures ("we") are called substructures in relationship to (apparently) the entire "structure." The latter could be interpreted as the endorsement of mathematics-is-the-world (platonic) position (Berezin, 1998b; Pui and Berezin, 2001). On the other hand, the boundary between self-aware structures and the rest of the universe becomes less sharply defined, and can even effectively disappear, in theories appealing to a panpsychistic position. For example, Attila Grandpierre raises an intriguing question whether the Sun could be considered a living being (Grandpierre, 2002, p. 137) or whether atoms have some kind of anthropomorphic instincts (Ibid., p. 144). More on that in Chapter 7.

6.7 Frozen time in fine art

Striving for the "timelessness" and for the "transcendence of the flow of time" forms a powerful tradition in the pictorial arts. We can trace this trend in much traditional Christian iconography (both in the Western catholic and Eastern orthodox schools), as well as in some representative samples of the modern art. The latter largely (but not

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exclusively) related to those creators whose art falls under the broad umbrella of Surrealism. By necessity, only a few names can be mentioned here, and they, as any list of this kind are, to some degree, reflect the taste of the author. My choice would include Giorgio de Chirico (1888–1978), Salvador Dali (1904–1989), Rene Magritte (1898–1967), Paul Delvaux (1897–1994), Piet Mondrian (1872–1944), Paul Klee (1879–1940), Joan Miro (1893–1983), Yves Tanguy (1900–1955), and Vasily Kandinsky (1866–1944).

To that list one can add enigmatic creations of Maurits Escher (1898–1972) whose images of twisted space filled with topologically impossible objects, like his woodcuts showing closed, everywhere descending, staircases (Hofstadter, 1980, pp. 11–12; Maor, 1987, p. 165) are popular among physicists and other scientifically oriented intellectuals.

Despite the diverse and distinct personal styles of all these artists, one feature common to all of them is the implicit laboring toward the eternalization (transcendence) of time as a dynamical category, depicting an a-temporal ("out-of-time") world – a world of dreams and fictions. For Mondrian, the world is a frozen platonic realm of the geometry of lines and squares (for the analysis of Mondrian's art from the URAM prospective see Wilson, 2000); for Klee, Miro, and Tanguy it is the world resembling the eternal (Leibnizian) *monadas*, each living in its own time and space. Because the paintings are (usually) two-dimensional, the ideas of the the "flatland world" come to mind (Stewart, 2001). For Dali and Delvaux, the world is constituted of transcended human emotions and instincts that are presented as a-temporal Jungian archetypes.

6.8 Time-zero problem

The problem of the beginning of time, of its origin or creation (depending on what term one can prefer to use), or, alternatively, the "time-zero" problem, has produced an enormous literature (see, e.g., Spitzer, 2001 and references therein). This problem can be approached, though not resolved, from physical as well as metaphysical positions. North noted the following:

> In 1928 [astrophysicist] James Jeans, searching for an explanation of the spiral character of the nebulae, suggested that the centres of the spirals might be places at which matter is "poured into our universe from some other, and entirely extraneous, spatial dimension". He added that to us, therefore, they appeared to be "points at which matter is being constantly created". (North, 2000, p. 263)

North continues:

> As for a potential infinity of causes, an idea that has frightened off so many people, there are those who think that they can justify the notion of such an endless series. It does at least have the merit of allowing every physical effect to have a physical cause, so that no supranatural is needed. (Ibid., p. 264)

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This leads to the questioning of the idea of time cocreated with the universe. Saint Augustine (354–450 CE) is often mentioned in connection of this idea.

> (...) But what can be meant by "time coming into being"? Is "coming into being" not a temporal expression? Does the claim perhaps require at least two sorts of time? (Ibid.)

In modern physics, the aforementioned ideas are currently formulated in terms of the quantum origin of time, or quantum tunneling of the universe out of nothing (e.g., Gott and Li, 1998; Garriga and Vilenkin, 2001; Gott, 2002). Although exciting and mind-boggling, these theories are not (and most likely never will) be completely free from the closed-loop logical paradoxes such as the logical problem of infinite regression. Whatever "mechanism" we chose to explain quantum "tunneling from nothing," the next question immediately requires us to define the nature of this "nothing" in terms of something else. This presents a logically challenging (and perhaps ultimately unsolvable) problem. As mentioned earlier, and forever unknowable, *omega number* (Chaitin, 2000), what we may be facing here is impenetrable wall of Gödel's undecidability conundrum.

6.9 Elementary time units: time at the quantum foam level

One of the most persistent traditions in physics is the search for the elementary or ultimate building blocks of nature. This tradition can be traced from ancient atomism to the most recent theories of quantum cosmology. Thus, to find elementary units of time and space has always been a major task of the physics agenda. Finding such ultimate units that cannot be divided any further would mean that we had reached the "end" of our inquiry about the physical world, and as such it would certainly appeal to our quest for the knowledge of the ultimate reality.

At this point, the most fundamental physical units (Barrow, 2002) are those that were first introduced by Max Planck (1858–1947). They are known as Planck's units: Planck's length (L), Planck's time (T), and Planck's mass (M). All of them are combinations of fundamental physical constants (h, c, G). The latter are Planck's constant (h), the speed of light (c), and the Newtonian gravitational constant (G).

For example, Planck's time – a quantum of time – is

$$T(\text{Planck}) = \text{SQR}(hG/c\text{^}5) = 5.4{\times}10\text{^}(-44)\ \text{s} \tag{6.1}$$

This is an amazingly small value. It is worth noticing that according to the current Big Bang theory, the age of "our" universe ("Big Bang universe," BBU) is between 10 and 20 billion years. There are about 31 million seconds in a year; hence, the age of the BBU is about 10^18 s. And there are about 10^44 Planck's times in 1 s. This is still 26 orders more than the age of BBU expressed in seconds (!). Yet, this fantastically small

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unit of time enters numerous equations of quantum cosmology and can, in a sense, be considered as a measurable physical quantity.

Interestingly, Planck's time *T* is a combination that involves three major theories of physics. Indeed, "*h*" is Planck's famous constant of *quantum mechanics*, "*G*" is the gravitational constant (which is same for the Newtonian and Einsteinian *gravity theories*), and "*c*" is the velocity of light (*Maxwell's electromagnetism*).

Closely related to *T* is the fundamental unit of length, Planck's length (Wadlinger and Hunter, 1990; Zeilinger, 1990). It is the distance that light (photon) travels in one Planck's time. Planck's length is *L* = SQR(*hG*/*c*^3) = 1.6×10^(–35) m, a very small length. If we imagine a pinball blown up to the size of our universe (10^26 m), Planck's length *L* on this scale still be about the size of an atom!

6.10 Inflationary cosmology and megaverse

> *Two paradoxes are better than one; they may even suggest a solution.*
> Edward Teller (1908–2003, "father of hydrogen bomb")

The ideas of an ever-existing eternal universe are currently usually presented in the form of the so-called inflationary cosmology (Kaku, 1994, 2004; Garriga and Vilenkin, 2001; Tegmark, 2003, 2014; Greene, 2004). This world of inflationary cosmology, according to one of its authors, Andrej Linde, is a picture of the eternal creation of new universes, the picture of an exploding Eternity (Novikov, 1998, p. 200).

Like bubbles in a stormy water, in an eternal and infinite quantum foam, some zillion universes (or "miniverses") are constantly born from each other, grow up to their maturity, and then collapse to nothingness again. Some of them resemble our own miniverse (that is the [sub] universe that was formed in "our" Big Bang) and may contain life; others may be very dissimilar and lifeless (at least, in terms of our perception of what life is). Like bubbles in a never ceasing waterfall, there is no beginning and no end to such a picture. Despite its apparent dynamism, such a picture will, on a grand scale, appear to the "outside observer" (if we could imagine one), as a permanently frozen static state. This is because, eventually, there is nothing new that could ever emerge in it, on top of what "already" had happened zillions of times over.

Talking about the role of the Big Bang as a presumed starting point of the universe, one may notice that our common term "universe" (uni-verse) points to some kind of an absolute "verse" (ultimate principle) that encompasses the totality of existence. Perhaps, the root "verse" here is more than just a linguistic curiosity. A verse is an elementary unit of poetry expressing some concise idea. Human language, as an expression of the cumulative experience of many generations, can itself be a powerful catalyzer for metaphysical reflections, in this case referring to the universe as some

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grand idea. It is almost certainly the case that other languages and traditions provide ample sources for similar insights (see, e.g., Talwar, 2001).

In such a picture, the importance of the Big Bang as a presumed singularity that started the entire universe is somewhat lessened. The Big Bang we normally talk about in cosmology is now becoming just "our" Big Bang, the emergence of just our mini-universe. Like a population of fish that is locked in some small disconnected lake for whom their lake is "the whole universe," we are becoming helplessly locked into just our "personal bubble," our miniverse. Thus, (our) Big Bang is no longer seen as an absolute beginning, but just one of some zillion events in ever-bubbling cosmic foam, the totality of which forms a megaverse. This is our miniverse as, strictly speaking, we cannot legitimately use the prefix "uni" in the context of the inflationary cosmology. It ("uni") means "everything" (every-thing) and "our" ("Big Bang") "universe" may not be that "everything."

Despite the emotional chill and ultimate pessimism such a picture will likely invoke in many of us, this view is, in fact, attracting a growing acknowledgment among the public interested in ultimate issues. As a typical reaction, here is one quote from a letter of a reader of *Time Magazine* (July 16, 2001, Vol. 158, No. 2) written in connection with an article featuring the new (inflationary) cosmology:

> Scientists and theologians squabble about the beginning of time and the universe, but regardless of the fine points of their arguments, they are still singing from the same sheet of music: there was a beginning, and there will be an end. I believe that the universe is actually infinite in time and space. Our Big Bang was exactly that – ours. We will never discover the oldest body in the universe because we will never be able to sense its existence. It is safe to assume that there were other Big Bangs, and more will occur. (L.A. Girard, Depauville, N.Y.).

The picture of an eternally inflationary universe essentially implies the infinity of the universe at the grand scale (megaverse). That, in turn, opens question of infinite repetitions of all possible states of the universe as well as the issue of the eternal return (Eliade, 1971; Berezin, 2002). Recently a new version (or rather a modification) of the standard Big Bang theory was suggested. It pictures the cosmogenesis as a periodical generation (regeneration) of the universes through the collisions of branes (membranes) in the multidimensional space–time (Peierls, 1991; Greene, 2004, p. 408). Although, almost certainly, such models will be further amended in the future, their emphasis on some kind of cosmic cyclicity resembling the eternal return is likely to remain.

We can consider the following, somewhat refined, argument (Nevai, 1998; Garriga and Vilenkin, 2001). It starts from the estimate of possible quantum states of our [sub] universe (i.e., the bubble generated as a result of "our" Big Bang). Let us combine Heisenberg's uncertainty principle and the estimated number of elementary particles in "our" universe (about 10^80 particles). Then consider all possible permutations of these elementary particles over the (quantized) phase space to estimate the number of the so-called Planck's boxes.

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Using Planck's time and Planck's length as elementary units, we can "construct" an elementary "Planck box." The latter is a "cube" in a four-dimensional space, three sides of which are Planck's lengths and the fourth side is Planck's time. The size of "our" ("Big Bang") universe is about 10^64 Planck's units of length and its time duration (10–20 billion years) is about 10^64 Planck's units of time. Taking 64^4 (four-dimensional cube), we can estimate that there are some 10^256 elementary "Planck's boxes" in our Big Bang universe.

To be on a safe side with such (relatively crude) estimates, let us say that there are between 10^250 and 10^260 elementary Planck's boxes in our whole Big Bang universe (a few orders of magnitude "on" or "off" will not make much of a difference for our perception, anyway!).

Now, if we want to estimate the number of all possible *states* in such four-dimensional universe, we have to count the numbers of all possible *permutations* of these boxes. The number of permutations of *N* elements is (roughly) N! (N factorial), which, in turn, is (roughly) *N*^*N*.

Thus, for *N* = 10^260 we have (about) [10^260]^[10^260] possible permutations (the number of possible states of the universe).

This number is a three-story tower exponent that is (approximately, of course) about 10^10^263 (10 to the power 10^263). This is a fantastically huge number, yet it is finite. In fact, it can be easily beaten by any higher tower exponential number, for example, by the famous Skewes number that is is 10^10^10^34 (Pickover, 2001, p. 288).

Actually, in the realm of tower exponents (Knuth, 1976; Berezin, 1987g; Pickover, 2001), this number (10^10^263) does not look very impressive. It is "only" a three-story exponent (three levels) and it is even a lot less than *T*(4), which is the stack of four "10s."

In fact, no matter how big a number we can write (e.g., tower of 1,000 "tens"), it will always be infinitely smaller than infinity. Infinity cannot be reached in any finite number of steps, even if each next step is the extra story (extra level) in the tower of "10s" (Knuth, 1976; Berezin 1998b).

There is at least one possible escape route from the curse of the eternal return (Eliade, 1971). For this we can assume that there is an infinite regression to the quantum state of each particle, that is, that there are further levels of physical smallness below Planck's length, *ad infinitum* (cf. the "turtles all the way down" metaphor). In this way, it seems that we can never exhaust the individuality and diversity of possible "universes." In this view all possible combinations of things, events, and creatures are "happening" somewhere in this megaverse (Roberts, 2004; Berezin, 2004c).

This scenario presumes that each individual elementary particle (e.g., each electron) may contain within it an infinite and never-repeatable hierarchy of smaller and smaller units and states (analogy to an infinite Russian doll model). Under this assumption (i.e., that there is no smallest state), the total number of microstates is indeed infinite and cannot be represented by any tower exponent, no matter how

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high. This picture brings us again in close “metaphysical contact” with the ideal platonic world, Cantor’s set theory, and platonic pressure effect ideas discussed earlier.

6.11 Literary precursors of inflationary cosmology

Although ideas of the inflationary cosmology of the infinite tree of bubble universes appear to be firmly located in modern science (as they are based on quantum physics, theories of infinite sets, etc.), their origins can be traced to much earlier times.

Thus, Van Slooten (1997) mentions that the idea of parallel universes and the very term “multiverse” can be found in the work of the Italian philosopher Giordano Bruno (1548–1600). We, of course, remember that this martyr of science was burnt at stake for (among other things) proclaiming theories of multiple universes. Perhaps, some modern “anonymous peer reviewers” who are often intolerant to anything new and original may regret that such a practice is not (normally, at least) in vogue today (but, again, who knows?).

Similarly, the idea of parallel universes was explored by Edgar Allan Poe (1809–1849) in his essay *Eureka* (Poe, 1848):

> Let me declare that, as an individual, I myself feel impelled to fancy that there does exist a limitless succession of universes, more or less similar to that of which we have cognisance (…). Do such clusters [universes] of clusters exist, however they do – it is abundantly clear that, having no part in our origin, they have no portion in our laws. They neither attract us, nor we them. Their material – their spirit is not ours – is not that which obtains in any part of our Universe. They could not impress our senses or our souls. Among them and us – considering all for the moment, collectively – there are no influence in common. Each exists, apart and independently, in the bosom of its proper and particular God. (Quoted by Van Slooten, 1997)

In a similar vein, a physicist Michio Kaku quotes from the writings of St. Albertus Magnus (1193–1280):

> Do there exist many worlds, or is there but a single world? This is one of the most noble and exalted questions in the study of Nature. (Kaku, 1994, p. 263)

Likewise, Rudjer Josip Boscovich (1711–1787), one of the most versatile scientists of the eighteenth century, envisages similar ideas in his renowned *Theoria Philosophiae Naturalis* (1758):

> any number of universes, each of them being similar to the other, or dissimilar … and this too in such a way that no one of them has any communication with any other … and such that all the universes of smaller dimensions taken together would act merely as a single point compared with the next greater universe. (Quoted by Tee, 1997)

Ideas of the megaverse (under the slightly different name of multiverse) were recently presented by the Oxford physicist David Deutsch (1997; Chown, 2001). It is worth to point here an analogy with alternative universes ideas for which URAM itself may

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not necessarily be a singular concept. On the contrary, it may be seen as a multidimensional (probably, infinitely dimensional) idea that cannot be fully comprehended by us, but can only provide us with glimpses of reflections, as in the parable of the shadows on the walls of Plato's cave (Berezin, 2004c).

6.12 Pantemporalism

Philosophically, the antidote to the notion of "created time" is *pantemporalism*. Apart from some nuances, it can be seen as another version of the "frozen time" theme. John Jungerman explains:

> According to some physicists, the Big Bang did not just explode in previously existing space and time – it created them. In this view, science has no answer to the question that immediately comes to mind: What was there before the Big Bang? (...) The idea that space-time has always existed, because there have always been spatiotemporal events, is admittedly an assumption, but no more so than the idea that space-time as such was created only about thirteen billion years ago (in a Big Bang). (Jungerman, 2000, p. 164)

Similar ideas are expressed by David Ray Griffin, a professor of the philosophy of religion and theology at Claremont University in Oregon, and a prolific scholar in the area of pantemporalism (Griffin, 1986, pp. 21–26).

He suggests that:

> [A]ny position that denies pantemporalism, the view that time has always existed, inevitably runs into paradoxes, some of which are so strong that they must be called self-contradictions. We can avoid these self-contradictions, if we carry out the logical implications of our premises, only by affirming pantemporalism. (Quoted in Jungerman, 2000, p. 165)

It should be noted, however, that many of these paradoxes can be translated into their mathematical equivalents such as Zeno paradoxes, the paradox of the Gabriel's horn, or logical paradoxes stemming from set theory and Gödel's theorem. In fact, the whole idea of the beginning of time (traditional religions) and pan-temporality (eternal existence of time and its possible multi-dimensionality) may not be that irreconcilable. Their coexistence may be envisioned as a Hegelian dialectical synthesis of alternative ends (opposite interpretations) of these paradoxes.

6.13 Multidimensional time and time loops

The idea of multidimensional space is well placed in mathematics and physics. Normally, we have no conceptual (or even visualization) difficulty to use $6N$-dimensional phase space to describe the instantaneous microscopic state of a system of N particles

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(each particle has three coordinates and three components of the velocity). For typical (macroscopic) systems, the number of particles is some 10^23 (the Avogadro number). The number of atoms in a human body is about 10^28. Thus, (10^24 – 10^28)-dimensional phase spaces are common useful mathematical models that were extensively used by the founder of statistical physics, Ludwig Boltzmann (1844–1906).

While such higher-dimensional spaces can be useful tools to assist our comprehension of a complex physical situation (such as a motion of many molecules in a gas), their alleged perception by our immediate senses is somewhat less obvious. For example, some interesting observations appear in a review of Stewart's (2001) book on two-dimensional Flatland:

> In 1884, a Victorian headmaster named Edwin A. Abbott released his now-famous tale of the inhabitants of Flatland. Although these two-dimensional creatures mostly lived their lives contentedly within the Euclidian plane, they were at times both titillated and frightened by rumours of a third dimension (...) Just as the Flatlanders' conception of their world was inadequate for an understanding of what space is actually like, so too, our view of space as three "flat" dimensions and a single temporal one is only the tip of the iceberg. (Lehrer and Andrew, 2001)

The ideas of time travel, time loops, and the possibility of changing ("redoing") the past served as inspirational and fertile ground for numerous writers of which I mention only a few. The century old *Time Machine* by H. G. Wells (1905) most certainly was not the first piece of literature taking this direction. Celebrated modern science fiction writers such as Poul Anderson (1926–2001), Isaac Asimov (1920–1992), and Ray Bradbury (1920–2012) have extensively contributed to the topic of time travel and alternative realities. Only a few of their numerous books and stories on these topics are mentioned here.

In *Guardians of Time*, Poul Anderson makes us travel to a branch of time in which the Carthaginians (and not Romans) won the Punic Wars and, hence, all subsequent civilization developed on the basis of the Carthaginian culture (Anderson, 1976). In *The End of Eternity*, Isaac Asimov (Asimov, 1955) describes a community of humans who live outside time and who have developed the technology to revise the past in order to eliminate their past evil deeds. Although such an activity may seem to be based on good intentions, some may find in it sinister parallels with George Orwell's "1984," in which the ministry of truth worked hard to change past records and eliminate all "nonpersons" from the annals of history.

In a chilling story *A Sound of Thunder*, Ray Bradbury describes Time Safari Inc. that operates a commercial time machine. During a time-tour to the age of dinosaurs, a time-traveler accidentally kills a little butterfly. Upon his return, back to our time he finds that the United States has just elected a vicious fascist as its president (Bradbury, 1966, pp. 110–123). A similar idea that even a minute change in the past can later amplify to catastrophic changes at the global level is known in the modern theory of chaos as the "butterfly effect" ("A swing of a butterfly's wings in Brazil today can result in tornado in Texas a few days later," Gleick, 1988, p. 8). It is noteworthy that similar discussions have gone on in theology for a long time. As one commentator points out:

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> [to the question as to whether God's powers include the capacity to undo and remake past events]: Ever since the time of Thomas Aquinas, it has been the standard church line to negate this possibility; the argument is that "God's power cannot reverse His eternal decrees, for this implies change of intention or new knowledge, both of which are impossible in a perfect God". But a celebrated eleventh-century churchman named Pietro Damiani (St. Peter Damian in English), known mostly for his monastic reforms, did toy this notion in his minor treatise "De omnipotentia". (Bell-Villada, 1981, p. 197)

An Argentinian poet and essayist Jorge Luis Borges (1899–1986) wrote several influential pieces discussing time, timelessness, and eternity. In a short story *The Garden of Forking Paths*, written in 1941, he played with the idea of forking (branching) time (Borges, 1998). In an analogy with branching trails in the park, Borges offered:

> the image of a forking in time, rather than in space, [such that] all the outcomes in fact occur; each is the starting point for further bifurcations (…) Unlike Newton and Schopenhauer, [Borger's protagonist] does not believe in a uniform and absolute time; he believes in an infinite series of times, a growing, dizzying web of divergent, convergent and parallel times. That fabric of times that approach one another, fork, are snipped off, or are simply unknown for centuries, contain all possibilities. In most of those times, we do not exist; in some, you exist but I do not; in others, I do and you do not; in others still, we both do. (Borges, 1998, pp. 119–128)

In another philosophical essay with the strange title *Tlön, Uqbar, Orbis Tertius*, Borges discusses timelessness and eternity:

> One of the schools of philosophy (…) goes so far as to deny the existence of time; it argues that the present is undefined and indefinite, the future has no reality except as present hope, and the past has no reality except as present recollection. Another school posits that all time has already passed, so that our life is but crepuscular memory, or crepuscular reflection, doubtlessly distorted and mutilated, of an irrecoverable process. Yet another claim that the history of the universe – and in it, our lives and every faintest detail of our lives – is the handwriting of a subordinate god trying to communicate with a demon. Another, that the universe might be compared to those cryptograms in which not all the symbols count, and only what happens every three hundred nights is actually real. Another, that while we sleep here, we are awake somewhere else, so every man is in fact two men. Bertrand Russell posits that [it could be] that the world was created only moments ago, filled with human beings who "remember" an illusory past. (Ibid., p. 74)

The notion of time loops can be connected closely with the issue of time creation and the origin of the universe. In an article titled "Can the Universe create itself?," the physicists Gott and Li posit that in their version of the theory:

> The Universe did not arise out of nothing, but rather created itself. [In their model of the time loop] every event would have events to its past. And yet the Universe not have existed eternally in the past. (Gott and Li, 1998, p. 39)

To argue by analogy, the aforementioned authors say that while we can indefinitely travel east along the Earth's equator going around over and over again, we will never reach the "east-most" point on the Earth because there is no such point. Thus, the appeal to time loops achieves, in certain way, the circumvention of the time creation

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problem by eliminating a need for a "time-zero" point. Time, in principle at least, can be finite without having any definite point of beginning.

On the surface, the very admission of time travel and closed time loops seems to invite logical paradoxes (Kaku, 1994, pp. 235–251). However, from the standpoint of physics, the situation with time travel is not as hopeless as it may appear (Davies, 2002). In the 1940s Kurt Gödel proved that the existence of the closed time loops was consistent with Einstein's general relativity theory (Yourgrau, 1999). As Michio Kaku has put it, "Gödel showed that the river of time could be smoothly bent backward into a circle" (Kaku, 1994, p. 243) and "the river of time itself may fork into two rivers; that is, a parallel universe may open up" (Kaku, 2004, p. 223).

To question some physical aspects of time travel, Richard Gott (2002, pp. 20–22) retells the story from the popular 1980 sentimental movie *Somewhere in Time*. In it a young playwright receives the gift of a golden watch from an enigmatic old lady attending his play. After some romantic developments and studies of physics, the playwright manages to travel back in time to meet this lady as a young woman. As a gift of love, he presents her the watch he took with him on his time travel. This is the same watch that she will "later" give back to him as her gift. She kept it all her life until it is time to return it to him.

So, the hitting point here is that the old lady gives the watch to the writer and he, by travelling back in time, returns the same (!) watch to this lady when she was a young woman. That sounds a great romance indeed, but do you see an obvious paradox here? Where this watch actually came from?

Thus, the obvious question here is who made the watch in the first place? The answer is no one (!). The watch never went anywhere near a watch factory. Its time line forms a circular path, a loop. It looks like such a thing can never happen. Yet, in Gott's interpretation, such a watch can indeed appear as a "jinni" – an object with a complex structure that was never deliberately made. It did not have its own "time zero" (the moment of its creation); rather, it just exists in a closed time loop. The very possibility of closed time loops seems to be at odds with common sense, but, amazingly, we do not know of any laws of physics or physical principles that would prohibit their existence.

Thus, strange as it may sound, the existence of closed time loops (and hence, the existence of various "jinnis") is not completely excluded by either physics or logic. According to Gott, what it takes to have a "closed time loop jinni" is that the entropy of the universe should spontaneously be reduced through some macroscopic fluctuation. The probability of such a fluctuation is exponentially small (say, about 1 divided by the Skewes number), yet it is finite (not zero) and hence such events would occur *with certainty* (!) somewhere in the (infinite!) megaverse. Thus, along the *jinnies* popping up from the sealed bottles in oriental fairy tales, our *jinni* may be less fantastic than it seems.

It may appear that such weird ideas as time loops or multidimensional times, which (so far, at least) have no experimental versifications, should be relegated to

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the area of pure fantasy. However, such a position of dismissing them out of hand as “unrealistic” may be too categorical. In fact, these ideas are not much more inexplicable than some of our more ordinary conjectures about the nature of time and the origin of the universe. As Davis Lewis puts it:

> Almost everyone agrees that God, or the Big Bang, or the entire infinite past of the universe, or the [particular moment of a] decay of a tritium atom, is uncaused and inexplicable. Then if these are possible, why not also the inexplicable causal loops that arise in time travel? (Lewis, 1976, p. 149)

Similar thoughts are articulated by Robert Lawrence Kuhn – an international corporate strategist, investment banker, and public intellectual. He is trained as a scientist, with a PhD in brain research. He created and hosts the public television series *Closer to Truth*, where he interviews the world’s greatest thinkers on fundamental issues of existence – particularly cosmos, consciousness, and philosophy of religion.

Kuhn, who grew up as a theist, is now noncommittal on the big questions (quote from one of his talk shows):

> What do I think? Does God make sense? To me, honestly, nothing makes sense! God? No God? Both hit circularities, regresses, dead-ends. Arguments? I love them all, but in the end, they all falter. Theistic arguments, atheistic arguments - none are dispositive. I’ve (half) joked that if I had to choose, I’d have to say that I find the atheistic arguments more palatable to swallow but the theistic conclusion more satisfying to digest. That doesn’t make sense, of course. And I guess that is my point. It’s not scientifically becoming to admit belief without reason. But to me, honesty trumps image. Throughout this multiyear adventure of producing and hosting Closer To Truth, perhaps I’ve progressed. I now see a richer, more textured picture of what a Supreme Being, if such a being exists, might be like. Many people seem certain of their beliefs. I wish I were certain. I may continue lurching and lapsing in my beliefs, but I will never cease wondering, striving, searching. As for me, for now, passionate uncertainty is closer to truth.

Chapter summary

In this chapter, I did not pretend to give any final view on the nature of time, least of all to “explain” what time is. To anyone with even some awareness of the enormous literature on the topic and all the diverse ideas about time, creation, infinity, and eternity, such a task would most certainly appear insurmountable. Very likely it is. The only common trait of many writings about the nature of time is that they are almost invariably thought provoking and stimulate further reflection. Here I have collected together some recent ideas about these issues that are scattered in various sources, ranging from rather popular books and articles to some more academic studies. One of the key points I have tried to emphasize is the existence of a deep connection between the problem of time and the mathematical idea of infinity.

Specifically, the discovery (largely by Georg Cantor in the late nineteenth century) that the mathematical notion of infinity is a highly structured concept sheds a new

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light on the problem of parallel times, multiple universes, and the issue of the eternal return. Is the total number of possible states of all possible universes finite (no matter, how huge this may be), or, on the contrary, does it form an infinite set? The latter option can, in principle, be opened through infinite regression to smaller and smaller scales beyond Planck's length. If so, each particle that appears elementary in our universe (e.g., each electron) hides, in fact, within itself an infinite depth of individual structures. According to recent speculations, "quantum particles can be viewed as tiny black holes" (Kaku, 2004, p. 175) – opening tunnels (wormholes) to the parallel universes.

In particular, I see the need for more extensive discussion of the hypothesis of infinite oscillations within the context of cosmological inflationary models. If (as proponents of this model propose) "our" universe is just one bubble in the infinite foam of universes, such that "our" Big Bang is just a microquantum tunneling event in some "parent" universe, then the oscillation scenario is due, I think, for a radical reinterpretation. Some go so far as to say that, with proper (Planck's) energies, new "universes" can be even created in the laboratory! In short, I think, it is an open question, whether we could talk of a "one-time-creation" and "continuous (infinite) creation" not as mutually exclusive possibilities, but as some kind of a complimentary pair (in the sense of Bohr's complementarity). Such a view (a synthesis of opposites) may eventually emerge along the lines of this cosmological discourse.

As has been argued earlier, recent developments suggest that the notions of time travel, time loops, and multiple universes are not merely wild speculations or the stuff of science fiction. While, of course, we do not have working time machines (and no certainty that we will ever have them), the aforementioned topics are now treated as serious and profound problems for the mainstream physics. Consequently, it is fair to suggest that these developments could have some noticeable effect on human ideas about ultimate reality and meaning (Berezin, 2004c). For example, the long-standing theological problem with the idea that the past is changeable can now be amended by the notion that travel into the past can, in fact, bring time travelers into an alternative universe with a different set of events. This potentially allows one to circumvent (if not totally eliminate) severe logical paradoxes that the ideas of time travel invariably face within the framework of classical Newtonian physics and the Newtonian notion of time.

However, we must always remain aware of the fundamental limitations of science in addressing ultimate issues. To quote Max Planck (Kaku, 2004, p. 205): "Science cannot solve the ultimate mystery of Nature. And it is because in the last analysis we ourselves are part of the mystery we are trying to solve."

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7 Consciousness unlimited

In this chapter, we talk of consciousness from the position of infinity, eternality, oneness, and ideal Platonic world of numbers and forms.

7.1 Consciousness: Door to infinity

> *Why do you insist that the Universe is not a conscious intelligence, when it gives birth to conscious intelligences?*
> (Cicero, c. 44 BCE)

The standard mainstream materialistic doctrine posits that the consciousness is a kind of epiphenomenon that is somehow produced entirely as a play of molecules, neurons, and other structures in our brains. Needless to say, in spite of truckloads of books and mountains of PhD dissertations written on this topic, nobody has ever truly and satisfactory explained how it actually comes along (that is, how mind and consciousness is emerging from “dead matter”). And now we are pondering if and how an artificial intelligence (AI) can do the same trick (tons of fiction and nonfiction on this).

However, my goal is to navigate the reader to another course. This is to embrace the nature and metaphysics of consciousness in the context of the ideas of (digital) infinity and eternality. To begin, we can discuss the notion of consciousness from the vistas of the ideas of universality: “oneness” and infinity. While the long-standing traditions of panpsychism are common to many cultures and civilizations, they are currently transcended by some authors offering pancosmic views of consciousness, in particular with a relationship with quantum physics and the so-called anthropic principle (Gale, 1981).

In the following lines, I will try to sketch a conceptual framework for the ongoing key ideas on the extended views on consciousness with the aim to facilitate further discussions of numerous issues arising in this broad discourse. A deeper probing of the nature of consciousness will connect this approach to the informational aspects of consciousness and establish a linkage between separate events in consciousness, such as synchronicities.

In spite that the word “consciousness” and its derivate appear to be universally recognized as “self-obvious,” it is one of the most difficult concepts to define within the framework of the mainstream science. In this sense, it falls into the same fold as fundamental and “self-obvious” concepts such as time, space, energy, numbers, infinity, or eternity, to name only a few the most important. Superficially, everyone “knows” what each of them means and yet, in reality, hardly anyone does, at least in any self-consistent way.

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For example, if you are to ask anybody "do you know what the time is?" a person may even be offended by such a "stupid" question ("Are you takings me for a fool?"). However, upon further quests, it is highly unlikely that anybody can come up with anything better than some verbal equilibristic. At best, "time" can be (superficially) "defined" through some other terms (e.g., "time is a duration"), but, at the bottom, these are just linguistic games of a mere tautology and semantics. They do not actually move us much closer to the "understanding" what "time" (or other terms mentioned above), *really* mean.

And yet, never mind academic discourses and dictionary definitions, we all have a rather broad intuitive grasp of these fundamental concepts. Starting from our non-verbal comprehension of these notions, we can move on to developing extended conceptual links between them. The links that can substantially enhance our intuitive (and even rational) take on these concepts. The aim of this chapter is to focus on the concepts of consciousness and a variety of its interpretations and speculative offerings that have been in circulation over the years.

There is a deluge of books in recent years discussing links between consciousness, mysticism, and quantum physics (or, properly to say, quantum side of the reality). Partial (and by all means, incomplete and rather random) list could include books such as Capra (1976), Zukav (1980), Rucker (1987, 1995), Penrose (1989a, 1994), Kafatos and Nadeau (1990), Squires (1990), Siler (1990), Zohar (1990), Talbot (1992, 2011), Goswami (1993), Wolf (1996), Walker (2000), McTaggart (2003, 2007), Laszlo (2007), Caudill (2012), Koch (2012), Radin (2013), and many others; it is impossible to mention them all here. The plethora of such books (and numerous magazine articles) on these topics show a strong (and perhaps, growing) public interests on the issues of consciousness and its place in the general order of things.

At the face of the things, human consciousness and mind (which are strongly overlapping, yet not totally identical terms) is, or at least should be, a vast subject of study by many branches of science from brain research, psychiatry, and neurology to computer simulations (e.g., studies on AI, artificial neural networks, and applications of chaos theory to psychiatry) to fundamental logic and philosophy. All these areas have a huge volume of research activity and generate Amazon-scale nonstop output of literature.

And yet, anyone who will look at all these from an open-mind (no pun intended) position, will unlikely fail to notice the fundamental limitation that is common to all (or almost all) of these studies. An absolute majority of people involved in the mainstream science (of all brands) are almost automatically (and probably, subconsciously [again, no pun intended]) subscribe to list of "dogmas" that for them appear self-obvious (see Section 1.5). So it is "self-obvious" and unquestionable that any departure or doubts about them will immediately brand people who voice any alternative views and ideas as "fringe scientists," or "heretics," or "loons" (not to mention some harsher terms that are often used for such people). And, apart from the name-calling, such people are often jeopardizing their jobs and reputations in pretty real terms.

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For example, philosopher Paul Churchland recognizes that "consciousness and intelligence come in different grades, spread over a broad spectrum. Certainly, intelligence is not unique to humans: millions of other species display it in some degree… even the humble potato displays a certain low cunning. No metaphysical discontinuities emerge here" … [Churchland further emphasizes creative and learning aspects of intelligence]…" A system has intelligence just in case it exploits the information it already contains, and the energy flux through it (this includes the energy flux through its sense organs), in such a way as to increase the information it contains. Such a system can learn, and that seems to be the central element of intelligence" (Churchland, 1987, p. 153).

Studying for a number of years the effects of isotopic randomness (isotopicity), I was particularly interested in the informational aspects of isotopic diversity. These are some of the quests that I have discussed (Berezin, 2015, 2016). Can isotopicity be used, for example, to build a new type of random number generators, or a new type of isotopic optical fibers, or can it be used to make microchips for quantum computers? And what about compact information storage? And do isotopes affect brain functioning? Or, perhaps, can isotopes be an essential aspect of the very mechanism of consciousness (Berezin, 1990b, 1992a, 2015, 2016; Pui and Berezin, 2001)? Can there be an "isotopic life" out there in cosmos, as an alternative to the "regular" chemistry-based biology (Berezin, 1984h, 1987f, 1990b)? Can life be based on a single chemical element? (Berezin, 1984e). In summary, many key quests in science of consciousness can be molded in the context of isotopic randomness and isotopic informatics.

7.2 Localized versus distributed consciousness

We are like islands in the sea, separate on the surface but connected in the deep.
William James (1842–1910)

The above-mentioned comments by Churchland, well pointed and relevant, still leave a sense of mainstream limitations formulated in Sheldrake's "dogmas" (Section 1.5). In spite all the "taboos" of the mainstream science listed earlier, the feeling that our consciousness (mind) has some extension beyond our head is pretty common among people and across cultures. References and claims of telepathy, "past lives," precognitions, remote viewing, as well as amazing (and often truly improbable) "synchronicities," and other purported phenomena of this kind are numerous and persistent.

On a more philosophical and reflective level the interpretation of such claims opens the issues of localized versus distributed (delocalized) consciousness. Can "consciousness" (or, whatever, we intuitively feel it is) be interpreted as some kind of all-penetrating "field," the field for which our individualized "consciousnesses" (elementary consciousnesses) is like a quanta of this global field of a universal

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consciousness? As Jack Carloye puts it, “consciousness is not a mental state (...). It is a field within which mental states might be related” (Carloye, 1992, p. 178).

There are numerous thoughts along this line that were developing by many authors (e.g., Eliade, 1971; Dyson, 1979a; Eccles, 1986; Squires, 1990; Zohar, 1990; Kaku, 1994, 2004, 2006; Deutsch, 1997; Haught, 2010; Tegmark, 2014; Berezin, 2015, 2016). This is, of course, just a partial and inevitably incomplete (and somewhat subjective) list.

Various metaphors and mental constructs are used to describe such a distributed all-encompassing cosmic consciousness. Such, for example, is an ancient notion of the “akashic field” (Laszlo, 2007). It also often goes under the name “akashic record” that implies a universal and omnipresent field acting as a depository of all information about all the events and processes happening in the universe in the past, present (and, according to some versions of it), and also in the future.

This notion falls along the same idea as *Holographic Universe* meaning that in every smallest particle or a peck of space–time realm, the whole universe is reflected with all its content (Talbot, 2011). Furthermore, the concepts similar to the *Holographic Universe* have found their prominent place in the theosophical and anthroposophical movements related to such names as Helena Blavatsky (1831–1891) or Rudolf Steiner (1861–1925). Another analogy is the idea of “Babylonian library” (Library of Babel [LB] of “all possible books”) from the known essay of Jorge Luis Borges (Bell-Villada, 1981; Borges, 1998; Bloch, 2008; Berezin 2004c, 2015, 2016).

Electrical engineer and inventor Nikola Tesla (1856–1943), a person of the extraordinary and original insights, used the ideas of the akashic field as pointing to the embedded intelligence of the matrix of space–time across the entire universe. More recent ideas such as fractals, order-within-chaos, or infinitely deep and intricate patterns of iterative sets (e.g., famous Mandelbrot set), or other mathematical (“Platonic”) constructs, are seen by many thinkers as footprints of god and infinity that can serve for us as providing some glimpses of the eternal reality.

More recently, the ideas akin to akashic field came from the side of quantum physics as a hypothesis of the *zero-point-field* (ZPF) and the actual discovery (not a “hypothesis”!) of the *Bose–Einstein condensation* (BEC). The first, ZPF, presumes that the universe (whole space) hides in itself an enormous resource of density (yes, the “pure space” that we call “vacuum” is full of energy!). For example, the energy that is contained in 1 m^3 of space is enough to boil all the oceans on the Earth (!). There have been (and still going) research projects attempting to extract this energy for a good use.

So far, at the time of this writing (April 2018), and to the best knowledge of this author, there are no publicly known positive results regarding this new, presumably unlimited, and energy generation source. Thus fore, we (humankind) still forced to rely on the conventional sources of energy, mostly nonrenewable resources, primarily petroleum. Although, to be fair, it should be mentioned that there are some theories circulating around that the petroleum [oil] is not, actually, a non-renewable fossil

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fuel but is constantly regenerated by the hot biosphere deep inside the Earth's crust (Kudryavtsev, 1973; Gold, 1999).

Contrary to ZPF (which, within the realm of a hard-core science at least, still remains a hypothesis), the BEC is a well-known physical effect that has numerous experimental confirmations. In a nutshell, BEC is a formation (under certain conditions) of a highly coherent (collective) state of a large number of particles or photons. Such collective states behave as single entities when the individual particles become a part of the symphonic whole. An example of such a quantum-coherent state is a laser pointer known to everyone (atoms in a laser emit radiation in symphony, like musicians in a large orchestra).

Thus, we have a physical illustration of the oneness principle when the individual properties of the particles yield to the behavior of the whole. Main examples of BEC are the superconductivity and the superfluidity of some "quantum liquids" (such as isotope of helium, He4) and photons in the coherent emission of lasers. Since lasers are ubiquitous in the modern society (from CD players to optical communications, etc., etc.), not a single day passes when we do not use BEC in one way or another.

In the area of modern physics, a relevant analogy here could be a wave–corpuscular dualism of quantum physics with particles of light (photons) being quanta of electromagnetic field. In quantum physics, such a duality is usually interpreted within the ideas of the complementarity principle proposed by Niels Bohr. For those familiar with quantum physics, the complementarity principle is mostly known through the Heisenberg uncertainty relationships for the "complimentary" variables, such as position velocity or time energy. Uncertainty relationship, in a certain logical sense, reconciles the simultaneous existence (coexistence) of seemingly contradictory notions (like particles versus waves).

And in a resonance with quantum complementarity principle, the said dilemma of individuality and universality of consciousness may likely call for a similar complimentary interpretation. There are numerous other observations and interpretations related to the ideas on delocalized consciousness of which only a few can be mentioned here (e.g., Woo, 1981; Kafatos and Nadeau, 1990; Berezin, 1990b; Walker, 2000). All these authors (and many others), in one way or another, emphasize inherent links between consciousness (mind) and quantum physics.

This notion of "complementarity" points to the fundamental inadequacy of our words (and the concepts formulated by words) for the grasping of the "meaning" of the (physical) reality. As Michael Talbot notices,

> Heisenberg proposed that the physicist should simply accept the complementarity of paradoxical aspect of subatomic entities (...) By doing so Heisenberg was making a statement that belonged as much to mysticism as it did to the new physics. That is, the ultimate nature of reality is beyond verbal description. The greatest commonality in both mysticism and new physics is that both point to the inadequacy of language (Talbot, 1992, p. 51).

Even apart from the linguistic area, "complementarity principle" finds its place way in a realm of a direct perceptional dynamics of consciousness. For example,

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there are numerous well-known "gestalt images," such as in "old–young women", two faces or a vase, Necker cube, and other ambiguous images. Such images are well known in an old, as well is in the modern art (Foerst, 2004; Honeycutt and Stickels, 2012).

As Anne Foerst puts it, [in such images] "we only can see either, never simultaneously. Our perception apparatus oscillates quickly between the two [mental] interpretations of the image" (Foerst, 2004, p. 19). In such images at any given instant, we only see either an old or a young woman (a well-known iconic image) but never both simultaneously, in an analogy with the quantum uncertainty principle and wave–particle duality.

Thus, the limitations of our language and inevitable relativity of our words and concepts define the limits of our understanding of the universe. Only the nonphysical transcendental realms that are not confined to any physical and linguistic limitations can provide some escape route to circumvent this ontological dilemma. Perhaps, only the absoluteness, eternality, and unchangeability of the infinite, and unexhaustible ideal Platonic world of mathematics (say, the distribution of prime numbers, or digits of "π") can, to a certain degree, offset the said fundamental inadequacy of our words and concepts.

It should be noted that, however, mathematics (no matter how efficient it is for the description of the dynamics of the physical world) is *per se* no more a part of the physical reality that our image in the mirror is a "real" human being on its own. Yet, mental constructs of mathematical "objects" (such as numbers, functions, or infinite sets of Georg Cantor) can give us some graspable images of transcendental and immutable infinities lying outside any physical world(s).

7.3 Panpsychistic traditions from antiquity to "new age"

> *My religion encompasses all religions. I believe in God, I believe in the universe. I believe you are god, I believe I am god; I believe the earth is god and the universe is god. We're all god.*
> Ray Bradbury (1920–2012)

There is hardly any human society from the Stone Age to the flourishing ancient civilizations that are totally void of any spiritual attitudes to inanimate objects. On the contrary, almost all pre-monotheistic religions, as well as modern pantheistic and neo-pagan New Age movements such as "Wicca" – all profess worship of natural artifacts (mountains, rocks, rivers, trees, etc.) as "gods" and "goddesses."

The main chemical for our life – water had (and has) a special significance in this regard. It plays important, and often central, role in many forms of art, folklore, mythological, and philosophical reflections, religious rituals, and other symbolic actions. In many mythological systems, water is assigned with properties of some quasi-alive substances (e.g., "dead" and "life" water in Russian folklore). At the beginning of

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ancient Greek philosophy, Thales of Miletus (ca 624–547 BC) considered water as the foundational and primordial substance of the universe.

And in view of the fact that hydrogen is the first element of the periodical table (and hence all other elements, in a sense, are built from hydrogen), such a view is, actually, not far from the modern science. Water is the only substance on this planet that exists naturally as solid, liquid, and gas. It is very special, and hence it has long been invested with spirit, and was accorded a great respect and importance by early cultures.

An author Christof Koch, who calls himself a “romantic reductionist,” summarizes that “panpsychism has an ancient and storied pedigree, not only within Buddhism, but also within Western philosophy: from Thales of Miletus, a pre-socratic thinker, to Plato and Epicurus in the Hellenic period, Spinoza and Leibniz in the Enlightenment, Schopenhauer and Goethe in the Romanticism era, and on into the twentieth century.” (Koch, 2012, p. 133)

Koch then quotes the Jesuit priest and paleontologist Pierre Teilhard de Chardin (1881–1955), who has his own tilt on panpsychism when he says that “we are logically forced to assume the existence in rudimentary form…of some sort of psyche in every corpuscle, even in those (the mega-molecules and below) whose complexity is of such a low or modest order as to render it (the psyche) imperceptible” (Koch, 2012, p. 133).

Thus, according to Teilhard, complexity breeds consciousness and that goes up as an ascent of the spirit. As Koch comments, [for Teilhard] “there is no reason why complexification should cease at the boundary of our blue planet with interplanetary space. Theilhard de Chardain believed that the entire cosmos evolves toward what he terms the Omega Point, when the universe becomes aware of itself, by maximizing its complexity, its synergy” (Koch, 2012, p. 134).

Even many (perhaps, most) people who see themselves as nonreligious (or almost nonreligious) still maintain numerous “superstitions” claiming special links to inanimate objects such as crystals, specific images, and alike. In other words, it is a strong propensity in many of us to extend the attributes of spirituality and consciousness well beyond our own formal minds (which, according to “common sense science” reside exclusively inside our brains). And majority of claims of a paranormal and parapsychological nature (telepathy, extrasensory vision, “auras”, “channeling”, etc.) also come along these lines (McTaggart, 2003, 2007; Sams, 2009; Sheldrake, 2012; Radin, 2013).

To repeat from Chapter 4 on the special role of prime numbers, we recall such broadly and persistently held beliefs as astrology, fortune telling (e.g., tarot cards and other means of New Age “divination”), or assigning specific powers to numbers (numerology). Of this, specifically, a human fascination with prime numbers can be mentioned. The trend here is quite remarkable and persistent, for example, “2” is indicative to love/sex and duality, “3” to Trinity (in Christian theology and outside of it), “7” is a traditional number for luck, “5” and “13” are used in occult, and “11” is the center of the recent lore of “elevenology” (11:11) initiated by a New Age “priestess” by

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the (pen) name “Solara” around 1990 (Berezin, 1998b). In fact, number “11” is also the first “twin prime” number, its “twin” is number “13”. One may think that 2, 3, 5, and 7, which are all primes, also form two sets of “twins”, namely 3–5 and 5–7, however this is a kind of exception, the only case when three primes form a close triplet (or a quadruplet if we add number “2” to this tight company). That argument makes the pair “11–13” to be the first isolated doublet of twin primes. Curiously, Canadian One Dollar coin (“Loonie”) has 11 corners (regular 11-gon). As for higher primes, quite often 17 and 37 are met in various fables and stories, whereas the prime number “137” (inverse of the thin structure constant in atomic physics) has almost a cult or a mystical significance for some physicists.

7.4 Global and cosmic consciousness

> *The most beautiful system of the Sun, Planets, and Comets,could only proceed from the counsel and dominion of anIntelligent and Powerful Being.*
> Isaac Newton (1726 – quoted in Dennett, 1995)

The extension of consciousness to objects (animate and inanimate) of “our” human scale does not stop here. There is an equally (if not a stronger) important tradition to assign consciousness (mind) to cosmic objects, first of to our Sun. The idea of “living Sun” is persistent throughout history. Egyptian Pharaoh Akhenaton (1353–1335 BC) has introduced the Sun as the sole deity, which some historians see as one of the first attempts to establish monotheism (it did not work at that time since subsequent pharaohs reversed to polytheism and Akhenaton was proclaimed heretic).

Nonetheless, in some sense, it was a good guess since an idea of a living Sun mesh well with the “modern” fact that the prime chemical elements of Earth’s biology (hydrogen, oxygen, carbon, and nitrogen) are the same elements whose chain of nuclear transformations (Bethe-Weizsacker cycle) are (partially) responsible for the Sun’s energy production. One can wonder is this a mere coincidence or evidence of some fundamental biological communality?

Over the course of history, a number of thinkers entertained the notions of cosmic consciousness and similar ideas. One can mention, for example, a German philosopher and experimental psychologist Gustav Theodor Fechner (1801–1887) mostly known as an author of the logarithmic relationship between the sensation and the strength of the stimulus. On a philosophical side, his world view was animistic (panpsychistic) along the line of the ideas of universal cosmic consciousness. He felt the thrill of life everywhere: in plants, Earth, stars, and the entire cosmos. His ideas influenced philosophers such as Ernst Mach (1838–1916) and William James (1842–1910).

Recently, a philosopher and author Gregory Sams (b. 1948) discussed the idea of a living Sun in his book *Sun of God* (Sams, 2009). In the title of his book, he

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deliberately made the middle letter in the second word as a capital "O" (actually, it is a large circle on the cover of the book). This is to symbolize the disk of the Sun the way we see it. Sams further notices in one of his postings that "as we explore the history of these cultures, we all too easily overlook the one underlying principle common to Egyptians, Maya, Celts and Greeks, not to mention the Sumerians, the Chaldeans, the Assyrians, the Gnostics, the Khmer, the Norse, the Inca, the Aztec, the natives of South and North America and countless other cultures through the world, including today's Hindu and Shinto religions. This is recognition that our local star is a conscious entity – a celestial being. It remains one of the most unspoken taboos of the Western world and one which even modern researchers of the above cultures are often reluctant to breach. While not a new concept to me at all, reading that just now was a major slap in the face: how many of us here have really reflected on the possibility that the Sun is literally a conscious being, beyond just giving the idea some form of token acknowledgement every once in a while?" (Gregory Sams, "Bring back the Sun!" Internet article).

Once again, it should be stressed that these views posit that Sun (and other stars, and galaxies) is alive and conscious not in just some symbolic or metaphoric sense, but that they are literally both alive and conscious; furthermore, they are quite possibly much, much smarter (by many orders of magnitude) than we, humans, are. "The Sun is smarter than we think," as Sams says on the cover of his book.

As Graham Hancock writes in his foreword to Sams's book "It is important to emphasize that Gregory [Sams] is not merely suggesting that Sun is a large complex system with some form of self-governing intelligence to it, but also that it is a living being, aware of itself and its place in Universe, that its power of consciousness is so far beyond what we enjoy, that it should be accorded deity status of a high order" (Sams, 2009, p. XI).

And if collective human perception means anything, children's pictures of smiling Sun (which are plenty in every kindergarten!), as well as similar images of Sun with eyes in zillions of advertisements and logos, this can be seen as an almost ubiquitous endorsement of the feeling (perhaps, unspoken) that, yes, our Sun is indeed alive and conscious!

Sams further goes to speculate that our Sun and other stars are aware of each other that there are intricate communication networks between them and that the whole galaxy is alive and conscious as some gigantic super organisms. While presently modern astrophysics introduces concepts such as "dark matter" and "dark energy" to explain the stability of galaxies ("normal" gravity appears insufficient for this), Sams sees no need for such farfetched hypotheses (nobody so far has convincingly explained what the "dark matter" is). On the question why galaxies are stable, his answer is far more straight and simple, "galaxies are stable because they are smart". Like we, living organisms, do not fall apart because we have some inner self-organization and survival strive, so do the galaxies and, by extension, perhaps even clusters of galaxies.

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The ideas of planetary, stellar, and cosmic consciousness are often the topics of science fiction stories. Polish author Stanislaw Lem in his novel *Solaris* (Lem, 1981) describes a planetary-sized brain (thinking ocean) that is capable to probe human minds (scientists on the research satellite orbiting this planet) and create phantom personalities extracted from the memories of these people.

In the same breath, one can wonder whether we can be the “emanations” of Sun’s (super) mind. What if the Earth, the Moon, and even humans are direct thought projections of the Sun itself? Every atom in our body apparently originated in the interior of a star (heavy elements and isotopes are thought to be generated at the explosions of supernova across the universe).

The above-mentioned idea could also be extended to all other stars as well, of course. This puts an interesting quest on the stories of various gods ascending and “becoming” particular stars at the end of their earthly lives. Maybe they originated in the minds of those stars to begin with, travelled to Earth in starlight and radiation, and when the thoughts or intentions of those stars were exhausted or complete, the beings simply returned back to their original homes and essences in the minds of higher celestial beings. As Gregory Sams puts it, “perhaps light, the major component of the electromagnetic force saturating our Universe, is itself the Universal Mind, and the Universe we know is but its physical body and organ of re-generation” (Sams, 2009, p. 130).

A view that Sun somehow watches us (and, perhaps, can be judgmental), are likewise pretty common. As Sams comments, “a conscious and divine Sun, looking at this planet, might be disappointed at the obstacles that our gifted species has placed in the way of enjoying the gift of life on Earth. It might despair at the sheer destruction we wreak upon each other, and our thoughtless damage to the planet. There could even be such disappointment that another new start is called for. It is a shame for all concerned, but what’s a few thousand years to put a new garden on Earth? Compared to an 80-year-old human’s life, a million years for Sun would be about 3 days” (Sams, 2009, p. 220).

As for the alleged capacity of Sun to see, Sams also provides an interesting argument:

> perhaps Sun is also a giant eye in the sky, reading the returning photons by some means. Perhaps those fine red spicules in its chromosphere have something to do with it. Our vision gets all its information from the light coming through the pupil, that small black circle in the middle of the eye. By capturing more photons through the bigger circle of a telescope lens we see the moons of distant planets and mountain ranges on Mars. If Sun does have a faculty of sight than it’s not going to be through a little lens like our eye, or even through something as awesome as the Hubble telescope, which can spot star being born in distant galaxies. We can only guess that if the Sun could see, then its lens would probably be the size of…the Sun. The resolution would be some hundreds of billions of times higher than Hubble. The Sun could have an absolutely wonderful view of its planets and of other stars and distant galaxies. It is receiving light from all directions at all times and its lens is simply gargantuan. Together with the visual information coming into Sun are the electromagnetic signals of all other wavelengths sent out by its neighbors in this galaxy, and the unified signals sent out by other distant galaxies. Regardless

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> of the mechanics, physics and optics that might explain how our local star could be operating with the faculty of sight, it appears reasonable that by some means the very source and creator of light itself – that which illuminates our world – it itself equipped to see what is going on in its solar system. This isn't exactly a novel concept either – Sun as an all-seeing gOd (Sams, 2009, pp. 126–127)

While Gregory Sams looks like more bold and explicit in his views on the conscious Sun, numerous other authors and commentators are sympathetic and favorable to such ideas. Internet postings by Sams attract many favorable and agreeable comments. In another book, the author Todd Siler talks about the analogies between brain and galactic structures and discusses the idea of "neurocosmology" (apparently, his own term) that points in the same direction of global consciousness (Siler, 1990). Undoubtedly, there is a keen interest in such ideas among growing public audience.

7.5 Dual dynamics of consciousness emergence

> *You and I are all as much continuous with the physical universe as a wave is continuous with the ocean.*
> Alan Watts (1915–1973)

The notions of the universal presence of consciousness in the universe are inherently entangled with the issues of the universal emergence of the world. Depending on cultural and metaphysical premises of such discussions, "consciousness," as well as "emergence," can have a range of contextual interpretations and go under a variety of terms. In religious connotations, "universal consciousness," or "consciousness as a source of Grand Design" is (almost) synonymous to the notion of God or Creator, whereas less religion-pointed interpretations often use more fuzzy (less precise) terminology, ranging from such scientifically sounding "universal quantum field" to the notion of "oneness," the latter is popular is a variety of "New Age" movements.

While it seems unlikely that there can be a singular "good-for-all" definition of "emergence" or "creativity," we can, nonetheless, offer some functional definition befitting the context of this discourse. In a human realm, creativity is generally understood as a generation of new patterns from the existing "building material." All books (and as a corollary – all ideas) can be written down by using letters of the alphabets that normally (with the exception of Chinese and other hieroglyphic scripts) employ pretty small sets of characters (some 30 to 50 in most cases). Furthermore, since everything can be digitized, any information (pattern, picture, etc.) can be converted to a binary string consisting of only two characters (e.g., 0 and 1).Thus, any massive information (no matter how rich and complicated) can be coded by a long integer number.

Furthermore, there is a mathematical theorem (a *proven* statement!) that there are *infinitely many* prime numbers that begin *or* end with any given integer number. Hence, *any* possible message, any pattern, or a picture (even N-dimensional image)

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can be coded by a prime number (actually, by infinitely many prime numbers!). Such is the majestic power of primes in the universe!

Following this information-based argument, we can within the context of emergence invoke two possible, seemingly opposite, scenarios. Conditionally, we call them top-down (descending) emergence (TDDE) and down-top (ascending) emergence (DTAE). The first kind, TDDE, traditionally fits the creation scenarios of major religions and folklore traditions; the second one (DTAE) is more in-line with scientific evolutionary theories and physical scenarios of order-out-of-chaos emergence (complexity emergence).

At first glance, TDDE and DTAE scenarios appear contradictory to each other. However, at a more subtle level, there may be some complementarity between them, akin to quantum complementarity principle (Niels Bohr, Werner Heisenberg, David Bohm, and others). In fact, within Pythagorean–Platonic tradition of all-encompassing ideal (Platonic) world of numbers and forms (IPW), either of these scenarios become a synthetic unity.

According to the known Pythagorean motto ("all is number"), which, in essence, identifies an infinite and eternal world of numbers with God, an *infinitude* of numbers and patterns serves as inexhaustible template (library of patterns) for any complexity emergence and evolution (Berezin, 1998b, 2004c, 2015, 2016). In this way, TDDE and DTAE scenarios are becoming two sides of the same coin.

Such a dichotomy, or perhaps a synergy, of TDDE and DTAE vectors (which, at the surface, appear to be directed oppositely to each other) can be traced (and, in a sense, reconciled) in the creation stories of mystical religious traditions, both eastern and western. Quoting Jack Carloye, "these view creation as an emanation of finite spirits from the One, or Godhead. Illusion is introduced in that act, which must be removed in order to restore the One" (Carloye, 1992, p. 185).

This Pythagorean–Platonic tradition has numerous reflections in the ideas of other thinkers. As mathematician Martin Gardner explains,

> Thomas Aquinas contemplated a spiritual substance called materia prima (primal matter) as formless, utterly unknowable, and incapable of existing apart from the mind of God. When God created the universe He gave form to primal matter and it become materia secunda (secondary matter). Following Aristotle, secondary matter divides into earth, air, fire, and water. Aristotle's heavenly matter and Aquinas's primal matter are not far from what some modern cosmologists call the primal field, a structure of pure mathematics that somehow gave birth to all the fields and particles of the world we know. However, because such a mother field would have form (mathematical structure), Aquinas probably would not have considered it primal (Gardner, 1990, p. 310).

Discussing consciousness and emergence within the metaphor of the *Holographic Universe*, the author Michael Talbot (1953–1992) says:

> we cannot ask if the part is creating the whole, or the whole is creating the part because the part is the whole. So, whether we call the collective consciousness of all things God, or simply the

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> consciousness of all things, it does not change the situation. The universe is sustained by an act of such stupendous and ineffable creativity that it simply cannot be reduced to such terms. Again, it is a self-reference cosmology (…) The dream is dreaming itself (Talbot, 2011, p. 285).

7.6 Dichotomy of individuality and oneness

> *All theory is against the freedom of the will; all experience is for it.*
> Samuel Johnson (1709–1784)

Human individuality at a personal level versus the unity of the human race is a dichotomy that can be discussed at many levels. Individual responsibility that in monotheistic religions is aligned with the concept of personal salvation is, in a certain way, blurred in the idea of oneness that (in several versions) presents in many old and modern world views. The seeming opposition of these two ideas (individuality and oneness) is, again, a source of a new dichotomy, which is prone to a number of ramifications.

The ideas of oneness are presently a strong component of the so-called New Age visions. Modern urbanized "western" society is rich in a variety of groups falling into the fold of the New Age movements. The degree of popularity of such movements is subjected to geographical and demographical variations and everchanging fads and fashions, yet their overall volume and visibility are quite significant both in their cultural and economic aspects.

Some of the New Age groups practice various forms of meditations, group healings, and alike activities that (in view of their adepts, at least) stress the ideas of oneness and universal consciousness ("we are in unity with the universe"). Ideas such as virtual realities, simulated realities (Bostrom, 2003, 2016; Berezin, 2006), and various forms of "matrix" scenarios that are actively discussed in recent decades, all have a touch of the metaphors and philosophy of oneness.

7.7 Universal consciousness in infinite and eternal multiverse

> *Spiritual science thinks of Galaxies as Conscious Beings who inhabit and structure the Universe, just as we do on Earth.*
> Barbara Hand Clow (2004, p. 70)

Presently, an almost universally accepted (in the mainstream science) scenario for the origin of the universe is the so-called Big Bang theory. It posits that some 14 billion years ago full (visible) universe suddenly appeared from the microscopic-scale super-explosion. From that original "bang," the universe later evolved to its present stage with all the stars, galaxies, planets, and life-forms (if indeed there are any other life-forms apart from what we know on our planet).

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In this scenario, all the matter and energy of the universe originally contained within the volume that is much smaller than the size of an atom. Yet, somehow, this ultra-tiny volume has managed to blow itself up to the size of "our" (Big Bang) universe (BBU), the "size" of which is presently estimated at some 14 billion light years across.

Nobody (at least, to the best knowledge of the present author) has come up with a convincing (or even a plausibly sounding) explanation from where (and how) this proto-atom came about in the first place. However, some physicists were (are) smart enough to circumvent this embarrassment by proposing scenarios in which this proto-atom appears from the Black Hole in some prior universe.

This above-mentioned hypothetical "prior universe" was, in turn, generated "earlier" (whatever "earlier" can mean in such a case) by a similar process, and so on, and so on, *ad infinitum*. This is a model of the so-called *inflationary universe* in which the total universe (mega-verse) is an infinite chain of separate BB universes (mini-verses) that, in totality, has neither beginning, nor the end (Berezin, 2004c; Haught, 2010; Holt, 2012).

The notion of a multiverse (or mega-verse) is, in a variety of scientific, mythological, folkloristic, and metaphorical forms, is one of the persistent lines of discourse over the centuries. Diverse thinkers and writers such as Giordano Bruno (1548–1600), Rudjer Josip Boscovich (1711–1787), or Edgar Allan Poe (1809–1849), have expressed similar ideas (Poe, 1848; Cowles, 1959; Lewis, 1976; Lem, 1981; Egan, 1994, 1997; Tee, 1997; Van Slooten, 1997; Borges, 1998; Kaplan and Kaplan, 2003; Roberts, 2004; Berezin 2004c, Caudill, 2012; to name a few). Such ideas are presently widely discussed by many popular and science fiction authors (e.g., Capra, 1976; Zukav, 1980).

There are numerous scenarios of parallel universes that may differ in detail but, in essence, focus on the same idea. This is a mental picture of a huge number (or an infinite number) of parallel universes (mini-verses) that somehow "coexist" in an infinite multidimensional (infinitely dimensional?) space–time continuum. The universe (mini-verse) that we inhibit ("our", or "Big Bang", universe) is just one tiny droplet in this infinite continuum.

The model of inflationary universe (mega-verse), as well as its "sister-idea" – the (quantum) model of the parallel universes (Everett model based on quantum parallelism) – while they both eliminate the problem of the beginning – still leave open the issue of existence (and origin) of consciousness, whether the latter be at individual or cosmic level (i.e., the individual [e.g., human] consciousness, or some form of a universal [cosmic] consciousness).

Yet, the situation here is not that hopeless, since the references to immutable and infinite "Platonic reality" of numbers and patterns (and dynamical algorithms coded by them) seemingly may solve the emergence problem (Berezin, 1990b, 1992b, 1994b, 1994d, 1996, 2004c, 2015, 2016). Any emergence (ascending) algorithms eternally exist as templates (blueprints) within the abstract that are countable and continuum infinities (Cantor's "Alephs"). As such, they (the said "templates") are "instantly available" in any point of emergence in any infinitude of branching universes. This is what the present author calls "Platonic pressure effect," as was discussed earlier in Chapter 5.

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Likewise, the Russian philosopher and mathematician Vasily Nalimov (1910–1997) took a similar, "digital" view of the evolving world as a variety of "texts" (messages). In his view, "all possible meanings of the world are primordially related to Cantor's linear continuum, the numerical axis on which all real numbers are plotted in increasing order [. . .] Meanings of the world are compressed in the way the numbers on the real axis are" (Drogalina-Nalimov, 1990, p. 22).

Since almost all real numbers are "normal" (contain all possible combinations of digits infinitely many times and hence everything can be "coded" or "infolded" in them), this brings us again to the Pythagorean "all is number" and the holographic vistas of the ultimate reality (Sharpe, 1993; Talbot, 2011). As a somewhat simpler and more transparent offering of this idea, the metaphor of the "Babylonian library" (*The Library of Babel*) by Jorge Luis Borges (Berezin, 2004c, pp. 309–310) can serve as a good illustration.

As a quantum remark (which may be relevant to inexhaustibility and infinite depth of consciousness), one should note the following. Do the quantum states in any "Big Bang" (mini)-verse form a countable ("Aleph-Zero"), or an uncountable (continuum, or "Aleph-One") infinity? A possible (but in no way guaranteed) answer to this conundrum is that if any specific BB mini-verse is of a finite size (in space and time), then all its quantum states are discrete and form a countable set. Furthermore, if the total energy of the said BB mini-verse is finite [has an upper limit], then the total number of quantum states is finite as well, possible estimate for it is about T(4) = 10^10^10^10 or, at most T(5), where T(5) means a tower exponent of 5 "tens" (Berezin, 1998b).

To repeat: The notation T(N) designates the extremely fast growing "tower exponential" function. For example, T(2) is "just" 10^10 (10 billion – about the same order as the current Earth's population), whereas T(3) is 10^10^10, that is 10 in the power 10 billion – the number well beyond the capacity of human imagination. And T(4) is 10 in the power T(3), and so forth. Mathematicians sometime use tower exponents in various "esoteric" proofs, for example, in the theory of "Turing machine," which is a code name for the universal computer (Casti, 1990, p. 346).

However, if there is an infinite regression to smaller and smaller scales beyond the Planck length (10^{-35} m), then the total number of quantum states may indeed be infinite and form a true continuum (uncountable continuum in the terminology of Georg Cantor). Or, perhaps, even higher "Alephs" can be involved – according to Cantor's set theory, there is infinite hierarchy of higher and higher Alephs (Aczel, 2000).

The idea of a primordial consciousness that is tantamount to the infinitely resourceful information field ("library of possible patterns") opens another vista on the issue of the universal emergence. Such primordial consciousness is ontologically prior to all physical realities and contains in itself a coded information for constructing any possible universe. In this way, it is theologically equivalent to the idea of god as an ultimate principle (Ward, 2010).

Yet, in its dynamics such an "information engine" of emergence (whatever term can be used for it) operates on a narrow boundary between order and chaos. As John Haught puts it, "our ordinary experience tells us that information must walk the

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narrow ridge between too much order and too much chaos. If the universe is in any way something like an information system, it too would allow its content to manifest itself between the two extremes. Any information processed by the universe could easily be eclipsed by excessive chaos or deadened by too much order" (Haught, 2010, p. 317)

In view of the centrality of information in the present "digital" stage of the human civilization (Shannon, 1951), the above-mentioned informationally loaded and holographic metaphors serve as efficient accessory tools in the ongoing discourse on these issues of fundamental importance.

And here again the universal coding by prime numbers takes the central seat. In 1951, the Polish mathematician Waclaw Sierpinski (1882–1969) proved an interesting theorem. It says that if we take any (*any*!) digital string of numbers of *any* length (sting like 3571290372432...56791967 [just an example]), then there is an *infinite* number of prime numbers that start with this string (Ribenboim, 1989, p. 280). This means that *any* digital message of *any* length can be "carried" by the infinity of prime numbers. We mean, "carried eternally" in the realm of the ideal Platonic world (IPW).

Suppose, we take a huge digital string that will code the *entire* LB. Call it "LB string." It can be in decimal coding, or binary coding, or in any other digital coding. The length of such a sting is tower exponential numbers, say, T(5) or T(6), in notations that were explained earlier. And yet, there will be *infinity* of (much longer) prime numbers that will start with the said "LB string." And the tower exponent that codes the entire LB is still far, far smaller than the tower exponents such as T(1000) that we discussed in Chapter 3 in connection with the idea of *superfactorial* (Berezin, 1987g). And never mind, no matter how far we will keep running by jumping on the prime numbers, there will be still infinity of them ahead! There is never an end to the IPW that is infinite in infinitely many ways!

7.8 Occam's razor principle revisited and inverted

At first glance, the idea of a "multi-verse where everything happens" seems as an ultimate violation of the *Occam's razor principle* (ORP). The latter is a philosophical principle that "entities must not be multiplied beyond necessity," or, in other words, in order to explain something, we should make as few assumptions as possible. However, as somebody else pointed out, ORP in its application to the idea of multi-verse (omni-verse) can be inverted to its opposite and hence serves as an argument *in favor* of the multi-verse ideas. This argument goes the following way:

(1) As was just said, ORP in its standard (classical) interpretation posits that the "entities must not be multiplied beyond necessity." At first glance, the multi-verse (infinity of mini-verses) appears a much more complicated entity than just one mini-verse ("our" Big Bang [Hubble] universe, BBU). Hence (if ORP is followed in its face value), the idea of the multi-verse should be ruled out as unnecessary

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complex and physically highly unlikely. Often ORP is formulated in even more common-sense form – "the simplest hypotheses most likely is the correct one." In other words, in case there are several competing hypotheses, the preferable choice should go to the simplest one. The question then boils down to what is simpler: "our" single BB-mini-verse or the truly infinite mega-verse.

(2) The contentious point in the above-mentioned argument is the proposition that multi-verse is far (actually, infinitely far) more complex that one-verse ("our" mini-verse). Yet, strange as it may appear, it is possible to argue precisely the opposite. Take, for example, set of all integer numbers, 1, 2, 3, 4, 5, 6, 7… (*ad infinitum*). This set is, of course, infinite (countable infinity, or "aleph-naught" in terminology of Cantor's set theory). Then take some specific very big integer, for example, some integer that contains trillion decimal digits [or, say, T(5) = 10^10^10^10^10 decimal digits – the latter is far greater than the number of atoms in "our" mini-verse, which is "only" about 10^80]. Then what is "simpler" – the whole (infinite) set of integers of just *one* (specific) integer? The answer is given in terms of the notion of algorithmic complexity. A computer program that can print out (in principle, of course) the whole set of consecutive integers is very simple – just a few lines of computer code. On the contrary, a program to type a specific long integer (excluding trivial cases such as 777777…777, etc.) is normally very long. In fact, for most integers, such a program will be the size of this integer itself.

(3) Therefore, *omni*-verse, and infinite multi-verse in which every physically possible mini-verse occurs infinitely many times (!), is (algorithmically, at least) a *much simpler* (!) idea than just one particular ("our") universe (BB mini-verse). Yes, in such multi-verse, there are infinitely many *exact* copies of our planet, ourselves, and even our whole Hubble volumes, as well as zillions (infinitely many!) copies that differ from "our" world in all possible details. Yes, there are universes in which I am Napoleon and there are infinitely many such universes (!). And, yes, there is a universe in which *everything* is exactly the same as in "our", except that you have a different color of eyes, or you had three cocktails instead of two at tonight's party reception for nonorthodox scientists (!).

Furthermore, in terms of tower exponential numbers, we even need not go that far to find an *exact* copy of our Hubble world, perhaps at a distance of some 10^10^10^10 = T(4), or T(5) km (kilometers) from us, we will find it (exact copy of our mini-verse). Furthermore, at a distance of (say) T(6) or T(7) km away, there will be zillions of our *exact* (!) copies (tower exponents grow enormously fast with every next level).

Note: For distances expressed by tower exponential numbers such as T(4), or T(5), the particular unit of distance (would it be kilometer, or millimeter, or Planck length [1/10E35 m], or a light year [which is about 10E13 km]) is totally irrelevant. Even T(3) = 10^10^10 km is stupendously greater distance than the size of "our" BBU (which is about "only" 10^24 km).

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7.9 Quantum consciousness and paranormal claims

From its inception some hundred years ago, quantum physics was used to support and backup a variety of paranormal and parapsychological claims. The reason for this is that, on one hand, parapsychological effects (such as telepathy, precognition, synchronistic coincidences, etc.) appeal to the ideas of nonlocal (distributed) nature of consciousness, and, on the other hand, quantum physics as such is a theoretical construct that makes a strong emphasis on nonlocality (Grib and Rodrigues, 1999). Specifically, quantum entanglement effects (Selleri, 1990) have recently come into the focus in a variety of areas from quantum informatics to nanotechnology and biomedical sciences.

Note: In essence, quantum entanglement (which, due to Albert Einstein, is also known as "spooky action at a distance," *Spukhafte Fernwirkung*) refers to the physical effect (now confirmed experimentally) that quantum particles (such as two electrons ejected from the atoms) remain connected even if they are separated by macroscopic distances. Paradoxically as it may sound, these quantum nonlocal connections between distant objects remain active even if the objects (electrons, atoms, as well as macroscopic objects like ourselves) are separated by astronomical distances (e.g., if they are in different galaxies). In numerous philosophical and metaphysical discourses, this notion of quantum entanglement is interpreted as an indication of the universal inter-connectedness of all objects in the universe (in particular, in claims of the "oneness" of consciousness, as explained later).

It is not my purpose to present in this book any more-or-less detailed analysis of a broad range of paranormal and parapsychological claims. Yet, only one startling example can be mentioned as perhaps pointing to a direct control of physical effects by human consciousness. This is an often-mentioned phenomenon (ritual) of "fire walking." As Michael Talbot mentions,

> The phenomenon of fire walking remains one of the most documented and enigmatic examples of how consciousness affects reality. All attempts to explain it in the framework of classical physics have so far proved unsuccessful, and only undermine the phenomenon as incongruity, a glistering unreality in the maya of our classical conception of space-time and causality. (Talbot, 1992, p. 48)

Yes, within the standard areas of classical physics such as thermodynamics, heat conduction, thermal properties of materials, and so on to give a convincing explanation of fire walking is a pretty hard task, to say the least. And yet, an explanation can perhaps be sought if we include the direct interaction of human consciousness and physical reality at the microscopic level as just another legitimate physical effect. Not everyone can do a fire walk right away. According to numerous observations and the accounts of this phenomenon, it requires a special spiritual preparation, meditative practices, and similar procedures. But once the person is ready for a fire walk, the direct interaction of the mind of the walker (by some bio-gravitational field, or what)

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can affect atomic and molecular structures of the body parts in contact with hot coal to block the heat flux and thus avoid being burnt during the walk (sometime, many meters long).

Numerous books and articles with "quantum" titles dealing with issues of consciousness (e.g., Zohar, 1990; Wolf, 1996) contribute to the popularity of discussing quantum (nonlocal) aspects of consciousness and, by extension, issues related to interhuman, global, and cosmic consciousness. In several research establishments, such as Institute of Noetic Sciences (IONS), or Princeton Engineering Anomalies Research (PEAR) laboratory, and so on, there is an ongoing work on human interconnectedness, effects of consciousness on the random number generator (PEAR group claims nontrivial correlations in these effects), collective effects (cooperative resonance) in group consciousness, and so on (Radin, 2013; Nelson and Bancel, 2011).

On a more philosophical level, these inferences lead to metaphysical reflections of an all-encompassing cosmic consciousness for which a metaphor of "oneness" serves as a convenient umbrella term.

As was already discussed in Section 1.10, the ideas of oneness, universal, and cosmic consciousness and alike do not have much sympathy within the mainstream scientific community. The physicist Alan Sokal who is mostly known for his notorious 1996 paper in the journal *Social Text* wrote in the introduction to his paper, "There are many natural scientists, and especially physicists, who (...) cling to the dogma imposed by the long post-Enlightenment hegemony over the Western intellectual outlook, which can be summarized briefly as follows: that there exists an external world, whose properties are independent of any individual human being and indeed of humanity as a whole; that these properties are encoded in "eternal" physical laws; and that human beings can obtain reliable, albeit imperfect and tentative, knowledge of these laws by hewing to the "objective" procedures and epistemological strictures prescribed by the (so-called) scientific method" (Sokal, 1996a, 1996b).

The above-mentioned quote seems to fall in the same line as the dogmas of the mainstream science. Thus, at first glance, it may appear that Sokal intends to advance arguments criticizing these dogmas in favor of a more wholistic vision of the reality, inherent limitations of words, and concepts or ideas of the participatory universe. And, in fact, this is what Sokal does in the bulk of his paper. However, after this paper was published, Sokal revealed that he wrote the whole paper as a spoof to ridicule the ideas of "postmodernist" approach to science, relativity of concepts, and alike. This paper produced an extensive follow-up literature (by Sokal himself and others) as well as innumerous Internet comments. In essence, Sokal (as well as the majority, though not all, commentators) demonstrate their concurrence with the above-mentioned mainstream dogmas as if any departure from them will be a road to the New Age "mumbo-jumbo" and alike. And it pretty much remains the state of affairs today. It is highly unlikely that any university department of astrophysics will seriously entertain a lecture proposing that Sun is alive and conscious.

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And yet, in spite of Sokal's attempt to make a mockery of "New Age science" (to which he bulks numerous controversial topics and claims), his article is far less a parody than he himself apparently believed. In spite of numerous (deliberately put) absurdities, the article turns out to be an interesting, thought provoking, and bibliographically resourceful text. If so, Alan Sokal should be credited for his effort to stir a debate, even if his original intentions were different, if not the opposite.

Thus, even when writers such as Sokal start from the intention to dismiss and ridicule ideas such as "quantum consciousness" and the whole list of paranormal claims, they, nonetheless, and against their own wishes (!), end up by providing ammunition for the opposite side. Unquestionably, within the whole range of paranormal activities, there are many overly excessive claims and perhaps even direct fabrications and falsifications. And yet, to flatly discard the entire body of *all* accumulated observations on the side of paranormal effects as "hoaxes," "frauds," "mistakes," "delusions," or "hallucinations" without any in-depth critical analysis is to subscribe to the position of naive simplicity if not a deliberate and arrogant ignorance.

No matter how rarely and truly paranormal and parapsychological effects can occur, even very few of them are enough to prove that they may have place in the real world. The same way as in known parable of the *Black Swan*, the existence of just one black swan would be sufficient to disprove the statement that "all swans are white". The writer Maureen Caudill (Caudill, 2012) discusses such "Black Swans" of parapsychology; among them are psychokinesis (e.g., "spoon bending"), remote viewing, energy healing, telepathy, precognition, survival after death, and reincarnations. Although the degree of acceptance of all these phenomena may vary in a broad range of people, each one of these claims has a massive body of accumulated observations, even if the quality and reliability of many of them can often be questioned.

Furthermore, the informational ("digital") foundations of the (universal) consciousness and emergence that are discussed previously can render some indirect support to the plausibility of paranormal and parapsychological claims. The inexhaustibility of mathematics and hence the potential infinite diversity of possible patterns and dynamical scenarios can open room even for extremely rare (in a common sense) effects that we classify as "paranormal" or "supernatural".

For example, a popular "New Age" author Barbara Hand Clow who writes on connections between quantum physics, consciousness, and spirituality, mentions: "According to QM, photons split into pairs and travel independently in the universe, yet they are still able to communicate no matter how far apart they move. *Photons are conscious in some way*." (Hand Clow, 2004, p. 69)

As James Stein mentions,

> mathematics is not only infinite, it is more infinite than you or I can possibly imagine. This level of infinity is more than enough for supernatural phenomena to exist…if there is room for the infinite… there should be plenty of room for the supernatural or paranormal phenomena (Stein, 2013, p. 197)

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In this regard, Dean Radin quotes Saint Augustine as saying, “a miracle does not happen in contradiction to nature, but in contradiction to what is known to us of nature” (Radin, 2013, p. 46).

On a slightly entertaining note, it seems appropriate to summarize this discourse on “orthodox” versus “wholistic” and “paranormal” science with a short anecdotal story about Niels Bohr (repeat from the Introduction).

During a visit of reporters to Bohr’s cottage, one of them tried to tease him by asking about the horseshoe nailed over the door of the cottage: “Surely, Professor Bohr, you don’t believe such nonsense as a horseshoe bringing luck to its owner?” To this, Bohr replied: “Of course I don’t. But they say it works even if you don’t believe it”.

7.10 Consciousness and physical measurements

> *Pick a flower on Earth and you move the farthest star.*
> Paul Dirac (1902–1984)

The above-mentioned quote by Paul Dirac (Dirac equation, prediction of anti-particles, Nobel Prize in 1933 at the age of 31) is not just a nice metaphor.

It is a real physical fact that can be supported by direct calculations. All objects, from elementary particles to galaxies, have a mass and exert (“emanate”) gravitational forces. Hence, each particle is attracting every other particle of the universe. By the above-mentioned saying, Dirac speaks of the long-range effects of the fields of gravity. Everything around us have gravity fields emanating outward from every atom in our bodies, extending to far reaches, and crossing and intermingling with other gravity fields from other bodies, not only here on Earth but to the farthest star.

Everything in the universe is related in some way. The gravitational force has an infinite range, although it goes off as the inverse square. In principle, moving the flower could affect anything in the universe. Therefore, you cannot pick a flower without the ripples from the effects of that picking finally reaching the farthest star (see example by Emil Borel in the end of this section).

As for the alleged (and real) effects of consciousness, there are quite a lot of controversies on these issues between the (so-called) “mainstream” and “nonorthodox” (or “fringe”) science.

The boundaries between “mainstream” and “fringe” are to some degree arbitrary. Or at least “fuzzy.” Traditionally, the notion of the “mainstream science” includes the main content of major natural sciences such as physics, chemistry, biology, geology, and most engineering-related disciplines.

This definition, however, backfires with the effect that almost anything can be exempt. For example, (pure) mathematics is not seen by some people as “science” in a proper sense. There is no “mainstream” or “fringe” mathematics, as there are no “experiments” in poor mathematics. Thus, mathematics is rather a philosophy of the

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eternal and immutable ("Platonic") world (Dauben, 1977, 1979; Penrose, 1989a, 1994; Lavine, 1994). Likewise, many other areas that are traditionally counted as "sciences" cannot be fully "objective" by almost opposite reasons – they often carry too heavy ethical, social (and sometime, political) load, for example, such areas as psychology or some aspects of medical sciences.

Hence, almost any commonly held perception about the notion of what is the "mainstream science," requires some "individual" specification. For the purpose of this discourse, let us adopt the following working definition of the "mainstream science." We can define the "mainstream science" as a body of knowledge that is built on the question "how?" (e.g., how "it" works, how "it" evolved or evolves), or "what it is?" (e.g., "what is isotope?" – an atom with particular number of protons and neutrons in its nucleus).

Within this framework, the question "why?" is meaningless or, at least, has no convenient placement except in a cause-and-effect chain. In spite that the question "why?" is, probably, the most often asked question, in science such as physics it can only be properly asked in a structural or a dynamical sense. We can ask "What is temperature?" (average kinetic energy of molecules), but it is (almost) impossible to answer the question "Why there is the temperature?" In mathematics, it is even far more acute dilemma. We can ask all we want about the pattern of prime numbers (Ribenboim, 1989; Plichta, 1997; Giordano, 2011), but the question "*Why* 17 is prime number?" is meaningless (as if it calls for some "explanation"), and the only valid answer to it "because it is" (17 is a prime number because *it is* a prime number).

If defined as above: (mainstream) science can easily exist without any metaphysics-related traits. Same as commerce, manufacturing, construction, or other numerous mass occupations. The alleged difference though, is that the clientele and profession of science is to a large extent (though not exclusively) stuffed by people with some genuine interest about the foundation of this world. Therefore, metaphysical connotations are not that rare even in mainstream scientific texts (though for the most part, it is a game of escapism, akin to fishing, gardening, or knitting). Here we come to another slice of it, another angle to look at this whole phenomenon (of escapism), something which can be provisionally labeled as a "power of a ritual and/or the notion of a service" metaphor.

In developing the above-mentioned theme, it is useful to study the effect of the "ritualization emergence". In many connotations, the emergence of a ritual can be traced to mythological and metaphysical aspects of the situation. In what way? The ritual implies the imbedded repetition of some kind of a protocol (mantra, prayer, and liturgy) for the purpose of transcending the limits and restrictions of a given moment of time/space, or, in other words, to eternalize "the present".

We can observe that (almost) entire realm of scientific activity can be considered under this angle. Let us again begin with (likely the most convenient) the example of a "pure" mathematics. Even a superficial exposure to the philosophical foundations of mathematics (e.g., Rucker, 1987; Russell, 1989; Lavine, 1994) is likely to yield a

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conclusion that is a confidently robust message at the level of a common sense. The message is simply this: What mathematics "discovers" (literally: *dis*-covers) is "in reality" some "eternal" Platonic truths. Probably the best (and perhaps easiest to follow) example is provided by the number theory (theory of integer numbers). The "best" here means something that can reliably (robustly) appeal to a common sense. For instance, the intricacies of the distribution of the prime numbers are all and forever fixed and unchangeable.

Whatever we can "dis-cover" about prime numbers (Dickson, 1960; Ribenboim, 1989; Arnold, 1992; Plichta, 1997; Giordano, 2011), is, of course, already "known" to god (or to a universal mind, or whatever metaphor is used by a particular metaphysical belief system). And as such it has been "already" discovered and rediscovered in the uncountable many "worlds" and "baby universes" that are, so to say, are "parallel worlds" to "our universe" (for some cosmological models the time sequentially is unimportant, that is, "it does not matter" if our world is "before" or "after" some other worlds [which are similar or not] to ours).

Take, for example, a known (anonymous) quote: "Science is the game we play with God to find out what His rules are." So, in this context, the issue of a ritual, or "eternalized service," opens up as a kind of a naturally inviting development of the topic. In the so-called natural sciences (physics), dealing with the specifics of "our" form of reincarnation (or "embodiment") of the laws of physics and material universe, the situation with ritualization at first glance seems to be less immediate. I suggest, however, that it is largely an illusion and ritualization element in physics that is often as strong as in "much purer" world of mathematics.

The clashes in physics are, on occasion, run about what are essentially pseudo issues. Sometime, such clashes can be resolved (or at least, mediated) by admission of the "multiplicity of truths" types of philosophies (e.g., multivalued logic).

An example of this is the controversy over the reproducibility of the physical measurements. From the point of view of the mainstream physics, the reproducibility is an absolute must. No result in "true physics" should bear any trace of the individuality of the discoverer. To admit such a possibility, according to the mainstream thinking, is to betray the very foundation of the whole edifice of science. To hold the view that such "objective physical parameter" as, say, the mass ratio of a proton and an electron (M/m = 1836), can depend (even in the 20th decimal digit) on the individuality of the experimentalist (or even more startling, on his or her "intensions"), will be normally perceived as a sheer lunacy. Such an assumption simply has no place within the framework of the mainstream physical thinking.

One press-documented illustration of a controversy on the above-mentioned issue is presented by the polemics between two physicists working at the same university. One is Philip Anderson, professor of physics at Princeton University and a Nobel Prize winner for the discovery, among other things, of the quantum effect now known as "Anderson localization" (Anderson, 1958). The other person is his colleague, Professor Robert Jahn, head of the Princeton Engineering Anomaly Research Laboratory.

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Jahn's group has been studying the alleged effects of the conscientious intentions on the performance of electronic random number generators. The major claim made as a result of this work was that some operators do indeed have a statistically verified ability to "bias" random number generators by mental effort (Jahn and Dunne, 1988). The possibility of such "spooky action" is an anathema for mainstream thinking. And Anderson explains why in his opinion it is so (Anderson, 1990, 1991):

> If the "observer effect", as he [R.Jahn] calls it – or "magic", as one might equally well characterize it – is correct, precise measurement is not possible. His ideas are as incompatible with the intellectual basis of – physics as "creation science" is with that of cosmology or biology. (Anderson, 1990, 1991)

Leaving aside the highly contentious issue if one should add an extra weight to the authoritativeness when the pronouncement is made by the Nobel Prize holder, I can indicate at least the following two open ends from the above-mentioned (seemingly sensible) Anderson's quote.

(1) Suppose the "precise measurement" is indeed not possible and the (very small) observer effect does exist – Why this should augur "the end of physics," as Anderson apparently fears?
(2) "Intellectual basis of science," as all historical record clearly indicates, is a rather fuzzy, controversial, and everchanging arena, rather than something we can agree upon "once and for all."

Yet, what many philosophers and metaphysicians are searching for in all these feeble and ephemeral stuff, is some kind of a permanency, a solid foundation of our experience and its eternal validation. Physical science, despite its appearance of utter objectivity, has an irreducible contextual factor (Jahn and Dunne, 1988; Arnold, 1992). Perhaps, we should indeed take a more serious note of a famous quote assigned to a German mathematician Leopold Kronecker (1823–1891), "God created only the integer numbers, all the others being the work of a man."

What Kronecker apparently meant here is that the "laws" of integer numbers (e.g., the distribution of prime numbers) are the only genuinely immutable and ever-the-same foundation of the world – even our (more esoteric) mental constructs, such as the infinite hierarchy of sets introduced by Georg Cantor (Dauben, 1979) may bear the traces of contextual relativity. This may, perhaps, explain the animosity that Kronecker felt toward Cantor and his theories of infinite sets. Even such monumental constructs as Gödel's incompleteness theorem (which posits that the complete system of axioms always has statements unprovable in it) are subjected to a challenge (Good, 1969).

Let us take at least for the sake on an argument the above-mentioned Kronecker's motto as a "minimal common denominator" of all-agreeable immutable truth(s). The laws of integer numbers are absolutely fixed and, as St. Thomas Aquinas asserts, not even god is capable to change them. As Bertrand Russell notes, St. Peter Damian in a

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treatise *On Divine Omnipotence* maintained that god can do things contrary to the law of contradiction, and can undo the past. This view was rejected by St. Thomas and has, since his time, been unorthodox (Russell, 1989, p. 407).

Furthermore, Kronecker's fundamental limitation is even more so applicable to the physical universe due to the fundamental and all-encompassing interconnectedness of the physical world on all spatial and temporal scales. Yes, the fundamental physical constants (e.g., mass ratios of elementary particles like the above-mentioned M/m) are not "guaranteed" to remain fixed forever and may gradually change due to cosmological conditions. They are in no way can acquire the same status of permanency as the ratio of, say, two given prime numbers.

The mental "locking" can go on in "discrete portions", for example, in the following way. Suppose we have "matched" the M/m ratio to a ratio of two large prime integers (it is always possible to do it with any degree of precision). Change in the 100th decimal digit "induced by the mental effort" will "violate" this numerical locking and the M/m ratio should now be "better" approximated by the ratio of another pair of primes. This is an irreducible (though subtle) effect that Anderson wants to deny in *any* approximation. Note that for the philosophically oriented observer, it is immaterial if the effect "starts" at 20th decimal digit or 100th or 1,000th digit.

Owing to the chaotic (exponential) divergence (*butterfly effect*), an arbitrarily small effect can relatively quickly accumulate to an observable level. So, the apparently "insignificant" difference between very small effect (Jahn) and no effect at all (Anderson) turn into an acute dilemma of "either-or" category. Another opening for the above-mentioned argument can be related with the introduction of the concepts of "fuzzy" set theory (theory of Fuzzy sets). The unavoidable fuzziness of the space–time metric may put fundamental limitation on the precision of measurements (due to the effects such as relativistic metric fluctuations). Small "intentional" perturbations may provide an additional component to this inherent fuzziness.

Besides, even within a strict materialistic paradigm, the direct effect on consciousness on the physical processes cannot be ranked as an absolute impossibility. Indeed, even if we look at the consciousness as a result of some dynamical activity that is occurring in brain structures (neuron firings, etc.), these processes can affect (by, say, electromagnetic and/or gravitational interactions) the processes in surrounding objects. While these effects are presumably quite weak in energetic terms, the extreme sensitivity of physical processes to the minute variations of the initial conditions (the so-called butterfly effect of the chaos theory) can well result in the observable consequences (Popper and Eccles, 1977; Eccles, 1986).

For instance, decimal truncation of (inverse) fine structure constant (= 137.03...) may indeed be affected (and "changed") in some next digit by experimentalist's intension (!). It may even happen much earlier than (about) the 30th digit implied by metric fluctuations at Planckian scale (Berezin, 2015, 2016).

The idea of the so-called butterfly effect is that very small (energetically weak) actions can produce drastic consequences in larger systems. As a popular illustration

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of it has this, “a single flap of the butterfly wing on one side of the Earth today can result in a tornado on the opposite side of the Earth tomorrow.”

As early as 1913, a French mathematician Emil Borel (1871–1956) gave even more impressive example of the same effect. Suppose, we consider a single atom at a distant galaxy some few million light years away. Let this atom shift its position by just 1 cm. Then, the *change* of the gravitational interaction from this said shift will be sufficient to totally randomize the positions of gas atoms in our room here on Earth within a fraction of a second (Kautz, 2011).

Thus, even leaving aside such questionable claims as “mental spoon bending,” the direct effects on mental activity on the physical processes in random number generators cannot be denied as an upfront impossibility. Thus, quite likely, more studies are desirable in this area.

7.11 Conscious sun and the “dark matter” puzzle

> *If the Sun is 1 cm in diameter (size of a blueberry), the closest star (4.3 light years away) will be 240 km (150 miles) from the Sun.*
> Trivia (anybody can calculate this)

The above-mentioned trivia quote illustrates how enormously large even the “near universe” is. On the same scale (Sun is a blueberry), our Earth will be 0.1 mm (one tenth of a pinhead). And any interested reader can estimate how far on this scale will be Andromeda Galaxy (ca. 3 million light years away). And, mind you, Andromeda galaxy is still the nearest galaxy to our Milky Way; some galaxies are billions light years away!

Now back to our charming solar system.

Restating what was said earlier in Section 7.4, in his book “Sun of god, Discover the Self-Organizing Consciousness that Underlies Everything,” the philosopher and the author Gregory Sams unfolds (quite convincingly, in my view) the idea that our Sun, as well as other stars are not “dead balls of hot gas,” but are, actually, *living beings* that possess *consciousness* (Sams, 2009). No matter how farfetched and even “crazy” such idea may appear at first glance, it is well argued on the basis of quantum physics and the theory of chaos (or closely related to it the theory of self-organization).

Yes, for the modern “mainstream” and “academic” mind the ideas of a living and conscious (!), Sun almost certainly sounds like a “crap science” of the first rank (what a “serious” and “peer-reviewed” science journal would publish an article on this?).

However, these views were in fact common for centuries and millennia in many human cultures and civilizations. The Sun has been an object of veneration in many cultures throughout human history. In many prehistoric and ancient cultures, the Sun was thought to be a solar deity. Worshipping the Sun was central to civilizations of the ancient Egyptians, the Inca of South America, and the Aztecs of Central

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America. In some religions (e.g., Hinduism), the Sun is still having a divine status. To this, we can add numerous “Sun worshippers” and solstice fests of the modern “New Age” culture.

Also, it is worth noticing a common observation that children when drawing pictures of the Sun often draw it as smiling. And children, as they say, “cannot be wrong.” This is the way they feel. Also, quite often car stickers and various bizhuteria items (clips, pins, necklaces, etc.) show the image of a smiling Sun. All these demonstrate our innate comfort with the idea of a “friendly and conscious Sun.” (I would love to see the reaction of seasoned “peer-review academics” from some “learned journal” to such thoughts!)

Now, out next “target” is the now-popular in physics and cosmology the idea of “dark matter” (DM). The existence of DM was postulated by many scientists since 1920s to explain the stability and the dynamics of our galaxy (and other galaxies as well). This problem originates in the movement of stars within the galaxy. If the stars are just balls of matter being moved around by the gravitational force of a big black hole in the middle of the galaxy, then the stars at the edge of the galaxy should be moving much slower than the ones near the middle. But they are not. They are, actually, moving faster to maintain the spiral structure of the galaxy.

This apparent inconsistency is the core of the problem. We need far more gravity than the visible stars can provide to account for the stability of galaxies. But so far, there is no clear idea what the DM can be, or it is just some out-of-blue hypotheses. As a recent comment goes, “Today DM has grown into a cult-like religion within supposedly “rational” science, supported by faith alone and having less evidence than that ascribed to many Biblical miracles.” (Gregory Sams, “The Dark Matter Delusion,” published in *International Times*, June 2015). In fact, for many mainstream scientists the chaise of the DM (likely nonexisting DM) came to the level of paranoiac obsession, with some “big names” involved in the quest.

So, where do we go from here? Assuming that the Sun and Stars are conscious beings, it is just one step to suggest that they *deliberately* direct and focus their electromagnetic fields and fluxes of the emitted particles to each other to maintain the stability of the galaxy – their living community. As Sams says, “galaxies do not form apart because they are smart.”

Galaxies maintain their stability in a similar way as a multicellular organism. The latter remains stable through the interactions of their cell. Or, we may say, that stars, like people, form partnerships (couples and/or “extended families”) that converse with each other on various issues, and that make galaxies vibrant living communities (do they have “presidents” or other “administrations”?).

Furthermore, we can perhaps talk on the next hierarchical level and presume that the galaxies in the universe communicate with each other. Perhaps, these communications go in a similar way as they go between various nations on our planet. The latter (nations) communicate with each other, diplomatically, economically, and so on. Can we talk then of a kind of “United Nation of Galaxies?”

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In fact, some similar thoughts were presented by me in 1988 in a short paper "Bubble distribution of galaxies: evidence for bio-evolution?" (Berezin, 1988g). Although I have to admit that at that time I did not go as far as to suggest that that stars and the whole galaxy (and perhaps, the entire cosmos) may be conscious. These thoughts came to me later, in particular, after I became aware of Sam's books and YouTubes.

Therefore, let us conclude with Gregory Sams: "We do not need dark matter. We need only recognize that stars, our Universe's most populous residents, are not dead dumb balls of plasma randomly reacting to physical laws" (Sams, *op cit*).

7.12 Miracle of light in physics and metaphysics

For the rest of my life I want to reflect on what light is.
Albert Einstein, APS (American Physical Society) News, vol. 8(4), April 1979.

Among all miracles of the world, light is probably the number one. Nothing is more simple than light and nothing is more enigmatic. Physics tell us that "light" is an electromagnetic wave, a vibration. But vibration of what? They used to talk about "luminiferous aether" as a medium in which light propagates. But all attempts to find hard evidence for such an all-penetrating medium have failed, and now the hypotheses of aether as a physical substance is more-or-less abandoned (with some few exceptions among nonorthodox scientists).

Here I will not discuss all "pros" and "cons" for the aether as a possible "physical" substance, but rather put on my "metaphysical hat" to make some comments about light along the narrative of this book. Light is full of paradoxes. We see everything with light, yet light itself is invisible. We cannot see light "as such." Look at the night sky, preferably far away from city light, say, at some remote southern beach.

Beautiful dark sky with thousands of shiny stars and the majestic milky way across. Yet the space around is flooded by Sun's light, but we do not see it! Only if there are some objects such as the Moon or occasional passing satellites and space stations (many of them are in cosmos nowadays), we see them reflecting the sunlight.

Other important "paradox" of light (and that is where the "quantum metaphysics" really enters the game) is that light is *simultaneously* a wave and a particle. A particle called "photon." Photon, quant of light, is an elementary portion of light. And as a quantum particle, the photon has the "ability" to be in two (actually, in many) places at the same time. Like passing through two different slits as wave (waves can do that) and then, miraculously, be "reassembled" into a particle (photon) to be registered by the detector (this is the famous "double-slit" experiment that is discussed in any popular book on quantum physics).

Furthermore, there are more fan when we start talking about light and time connection. Even more, "metaphysics" here! You see, as the relativity theory asserts,

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when we are moving faster and faster, the passage of time slows down. The famous "paradox of twin brothers" is often used as an example. One brother goes to some nearby stars in a rocket moving close to the speed of light. The other brother remains on Earth. When the traveler returns, he finds that his twin brother is much older than himself. In fact, this not just a farfetched idea, the effect of slowing down of time was experimentally demonstrated with clocks on satellites and decays of the radioactive particles (mesons) moving at velocities close to the velocity of light.

Thus, if you move with a velocity of light, the time stays still for you. You cannot do this; of course, no material object can do this. But light (photons) can. They move, by definition, with the speed of light. And they experience no time at all! Photons that arrive to us as a light from a distant galaxy many millions, even billions, light years away, have traveled (by *our* time) millions of years. *Yet*, in its own time frame, its flight was instant, the moment "he" ("she"? "it"?) was emitted by the star at that galaxy and the moment "he" arrived to us to be caught by our eye or a photo-plate, is the *same* for this little guy (photon). In other words, "he" (photon) "did not know" that "he" has traveled that long!

Thus, photons, like the numbers in the infinite Platonic world do not age. Photons, like prime numbers "exist" outside of time, so to say. Then, is there any surprise that conscious stars communicate primarily by light?

7.13 Consciousness in the context of ultimate reality

Ultimate reality and meaning (URAM) discourse (Berezin, 1994b, 1996, 1998b, 2002, 2004c, 2006) is a convenient platform to dwell on the issues of infinity, ultimacy, and eternity. The range of URAM-related aspects in modern science is quite diverse. Such are the problems as the eternalization of time, backward causation (the future affects the past), time loops, and so on. All these can be discussed in various contexts (quantum physics, cosmology, philosophy, theology, etc.).

Here we can indicate such a quest as the multidimensionality of time. For example, is it possible to introduce a kind of quantum "Hilbert space" for time itself, if one introduces time as a variable with infinite dimensionality? All these aspects, and many others, are awaiting further elaboration by philosophers, metaphysicians, and spiritual workers.

What, then, could be a practically suitable "operational model" that could be used as an everyday tool in this search? It is well known in specific sciences that the very fact of the existence of operational model(s) for the alleged effect might be a stimulating factor for more focused experimental studies. What can the new quantum physics contribute to the sharpening of the URAM problem? The following provisional (and, of course, utterly simplified) "list of options" could be suggested in terms of our potential ability to have a "final" solution for the URAM problem.

(1) There is no URAM in the world. The latter is random and meaningless.

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(2) The existence and nature of URAM are not accessible to us. We have no means to find out if URAM exists or not. The best we can do is to take some sort of a “personal guess” on the issue and stick to it.
(3) While URAM may be hidden (obscured) from us, but, in principle, it exists and is available for the discovery by scientific, metaphysical, or spiritual efforts. Its accessibility to us may also depend on our deeds and earned merits (this is common to most philosophies putting the prime value on spiritual growth).

The latter option can be “mapped” on the infinite set of prime numbers as this book attempted to present. As any message is “eternally coded” infinitely many times in the (infinite) set of prime numbers that provide an eternal unshakable foundation to our perceptions and reflection on what we call URAM.

Quantum physics with its concept of virtual reality makes these options somewhat dependable on our “observational efforts.” Virtual reality can, in a way, deliver anything we want (within some imposed guidelines of unfolding). In a sense, all three of the above-mentioned options for URAM, can even be thought of as coexisting in some kind of “quantum superposition.” A quote ascribed to the Nobel Prize physicist Murray Gell-Mann says: “Anything which is not prohibited, is compulsory” (cited by Comorosan, 1974, p. 74).

This implies that under proper circumstances, it is very likely that nature will find a way to utilize almost any conceivable physical scenario. This well may go in us and through us. Numerous claims of successful attainment of highly cohesive URAM states by many individuals do indeed provide a viable exemplification of the above-mentioned quoted Gell-Mann’s dictum.

Summarizing on consciousness

In the above-mentioned discourse on consciousness (which in no ways claims to be exhaustive on the views discussed), I tried to bring attention to a variety of ongoing speculations of the extended nature of consciousness in the context of physical and metaphysical discourses. The scope of these topics ranges from ideas such as a “living and conscious Sun” to the Pythagorean–Platonic ideal world as an ultimate substrate of consciousness and cosmological emergence. In some, perhaps symbolic, a sense of quest can be posited as to whether numbers themselves can be seen as “alive” and having some form of “consciousness.” Do numbers (for example, prime numbers) “play games?” (in spite of remaining eternally frozen and immutable in the infinite Platonic reality). Do numbers have “feelings” similar to ours? Or entirely different? Do numbers have sense of humor? Whether such quests are too far-fetched, or they still can be up-taken for further discourses, remains to be seen.

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Many of us often wonder about enormous complexity and diversity of our world. Yet, all the stars and galaxies, crystals and minerals, and living creatures of all sizes and types, including ourselves, are made of "just" several dozen chemical elements (and their isotopes, of course). Nature appears to us as "something" that (or "Who"?) is unbelievably creative, self-propelled, and self-motivated enterprise. Furthermore, this "enterprise" seems to be working on a very limited resource base (just atoms and physical fields and not much else). And yet, it never falls into a pessimism or recession. It tirelessly devises all its new and new structures and living beings with an enormous pace, but also with a (seemingly) tremendous wastefulness.

A common feature for a number of versions of quantum theory of consciousness is that they assume a two-way linkage between consciousness and the physical world. In other words, consciousness as a quantum phenomenon and the surrounding physical reality are jointly locked into an interactive loop. Some recent experiments seem to confirm the direct action of consciousness on physical systems, such as electronic random number generators. Tentative conclusion from these experiments is that there is some kind of "cooperation" (resonance) between the physical system and the consciousness of an observer.

Furthermore, there seems to be no truly impenetrable barriers between the "natural" creativity and the creativity of us, human beings, would the latter be at the individual level or at a level of a collective social activity. There are several major (and many more less common) ways and traditions of how people, more or less systematically, express their connectedness to the whole universe and claim their own place and role in it. Such ideas as *supreme god* in all major monotheistic religions, or *God-in-Nature* (Albert Einstein), or various polytheistic gods and goddesses, or concepts such as *Gaia* (James Lovelock), or *Participatory Universe* (John Archibald Wheeler), and so on, are all examples of our indestructible strive to be inherently related to the whole and eternal. Even within the most extreme materialistic doctrines of a purely physicalist random universe ("only-matter-and-no-spirit"), one can usually also indicate some remnants of this search for the universalities. This can take a form of, say, appeals to concepts such as universal physical symmetries, primordial quantum vacuum, models of intrinsically interwoven network of "baby universes" in recent cosmological theories and many other similar constructions.

When thinking about consciousness in universal terms, one most likely faces the dilemma of the individual versus global (cosmic) aspects of consciousness. On one hand, every one of us feels our own consciousness as a belonging "just to us" with all its follow-up of individual choices, individual responsibility, and so on. Those, existentially, are perceived by us as limiting constrains of our individuality and the finiteness of our consciousness, as boundaries beyond which we cannot go and which we cannot even transcend. On the other hand, reflectively, it is difficult for us to experience our finiteness in any direct form, even if we all are "aware" of our mortality. It is very difficult (perhaps, impossible) for us to imagine our "nonexistence," in particular, our nonexistence before our birth. Such a dilemma, which philosophically can be

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likely qualified as an “antinomy” (unity of opposites) can perhaps remain an inherent paradox, akin to such logical paradoxes as self-contradictory statements or Gödel’s incompleteness theorem. And to subjectively reconcile ourselves with this paradox, we draw the notions of oneness, cosmic extensions of consciousness, and the notions of our interconnectedness with other human beings (past, present, and future), and the whole cosmos.

Yet, regardless of which of these different (and often opposing) metaphors, each one of us uses to express our embedding in the universe; there seems to be a common inference for all these views. This common ground element can be formulated as a notion that we somehow belong to the universe and are produced by it (either for a purpose or at random – if we want to use these terms). Consequently, everything what is created by us, as individuals or as entire human civilization, can be claimed by the universe as belonging to the interconnected totality of its creative dynamics.

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8 Why π is not exactly 3

Everybody knows that π number is close to "3" but not 3 exactly. In fact, it is a strange irrational number 3.14159265 ... and the string of its digits runs to infinity. In a metaphysical fashion, we can wonder "why" it is so? How much simpler (and perhaps far more boring?) the world would be should π be *exactly 3*, why we need this infinite trail 0.14159265 ... after "3" to go to infinity? After all, the difference between π and "3" is less than 5%. But this 5% make an enormous difference.

This chapter offers some more thoughts on the digital informatics that is contained in the infinite strings of normal numbers. As mentioned above (Section 5.3), "normal numbers" have all possible combinations of digits in them, happening with equal probability.

For that matter, we take π number as the most well-known example of normal numbers. It should be noted, though, that, strictly speaking, the "normality" of π number was not [yet?] proven as a rigorous mathematical theorem (Wagon, 1985). Yet, I think that this "minor traffic jam" in the world of higher mathematics should not detract us from dwelling on the ideas discussed here. After all, there is an infinity of normal numbers! They are "inhabiting" the Ideal Platonic World (IPW) of numbers and forms, and we can always construct other examples of them, such as *Champernowne's constant*, mentioned in Section 8.3.

So, let us just hope that some smart mathematician will sometime find a rigorous proof of the normality of π number. Fields Medal – the highest award in mathematics – is guaranteed (there is no Nobel Prize in mathematics, but the Fields Medal is of an equivalent stature).

8.1 Miracle of π and more on prime numbers

The first time we probably hear about π is when we learn that by how much the circle (the circumference) is longer than the diameter of the same circle. Most likely they explain this to us in a junior school. Or, perhaps, even in a kindergarten, if they count us as "Indigo Kids" – a growing population now-a-days. And we are likely even mildly surprised why π is not exactly "3" but some strange number 3.14159 (...).

Then we learn that π, actually, is an *irrational number* and its "full value" can only be written as an infinite tail of digits. Here is the first 100 digits of π:

3.1415926535 8979323846 2643383279 5028841971 6939937510
5820974944 5923078164 0628620899 8628034825 3421170679 ...

And you can easily find on the Web the first 1,000 digits, or perhaps, somewhere, even a million. Now computers have calculated π to a few billion digits. But you will

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never find the *last* digit of π because it does not have the last digit – the string of its digits goes to infinity. Now we can recall from Chapter 3 that the PRIME NUMBERS all end on 1, 3, 7, or 9. But, alas, they are always *finite* numbers. And they all are *integer* numbers. And yet there are some interesting "family connections" here. What are they?

Suppose, we will be cutting the infinite string of π such that the last digit that remains is one of these four (1, 3, 7, or 9) that are allowed to end the Prime Number (in a decimal system, of course, in other N-base systems rules are different).

(to remind: no prime number can end by 0, 2, 4, 5, 6, or 8 – the only exception is "2" itself – the first Prime Number).

Also, before doing this cut, we should drop the "3" that starts π number to produce an integer number.

Here is the first seven such "cuts":

141, 14159, 141592653, 141592653589, 1415926535897,
141592653589793, 14159265358979323, (and so on ...)

All these "cuts" are integer numbers, and there is an infinite number of them, because it is most certain that all decimal digits occur in the infinite string of π infinitely many times. There will be infinitely many cuts ending on "1," or "3," or "7," or "9." Are they all Prime Numbers? Most certainly, not all such "cuts" make Prime Numbers. But some do. Among the first seven "cuts" shown above, second (14159) and fourth (141592653589) are prime integers.

Of course, it should be noticed that the above games of Prime Numbers, which are cut out from the infinite string of π, work differently in various number systems. The above examples are for "our" regular decimal system, based on 10 digits. In the binary system (it has only two digits – 0 and 1), or in any other positional system, the string of π and corresponding "cuts" will be different.

However, for our contemplations and meditations on Prime Numbers and Infinite strings, the above example works better to home.

Here, as an example, the beginning of π in binary system:

Binary base = 2, digits: {0,1}

11.00100 10000 11111 10110 10101 00010 00100 00101 10100 01100 00100 01101 00110 00100 11000 11001 10001 01000 10111 00000 (... to infinity)

(do not be surprised that it begins with "11" – it is not "our" 11, but the number "3" written in the binary system)

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8.2 Super-long prime numbers and self-organization

> *317 is a prime, not because we think so or because our minds are shaped in one way rather than another, but because it is, because mathematical reality is built that way.*
> Godfrey Harold Hardy (1877–1947), British mathematician and number theorist.

Recent models of "cosmological inflation" like Andrej's Linde, "*The Self-Reproducing Inflationary, Universe"* (Linde, 1994), picture the Universe as an infinite fractal of inflationary bubbles. Such bubbles are thought to be hardly (if at all) informationally connected to each other. Such "scary" representation seems utterly discouraging in terms of philosophical "externalization" of the URAM, Ultimate Reality and Meaning (refer previous Chapter for more discussions on URAM).

In search of some invariant foundations of URAM-eternalization of our experience and, generally, of the whole "experience" of "our" baby universe (Andrej's Linde and/or Hugh's Everett Multi-Verse theories), we look for the most fundamental and unchangeable invariants.

Let us adopt such most fundamental "common ground" to be the whole manifold of integer numbers ["ALEPH-ZERO," as named by Georg Cantor]. There are infinitely many "long enough" integers (and Prime Numbers) to "record" any experience of [any] baby universe and "broadcast" it everywhere as a "this-or-that" (particular) Prime Number.

Let us name such "typical" (all-recording, all encompassing) Prime Number as Babylonian Library Number (BLN – by definition "all the books ever written"; refer Sections 8.5, 8.6, and 8.7). For All Practical Purposes (FAPP)-sufficient length of BLN is, say, 10^1000 and, correspondingly, BLN itself is "of the order of" 10^10^10^3 (using tower-exponential notations, A.A. Berezin, "Super Super Large Numbers," *Journal of Recreational Mathematics*, 19, 142–143, 1987). [FAPP = "For All Practical Purposes" – an acronym due to the physicist John Bell].

The critical (bottleneck) issue is how to compactly "label" such BLN, in defiance of Turing's "non-compressibility" (the "Turings's non-compressibility is the request that minimal label of "almost any" number should be as long as the number itself). The way to circumvent this "Gödelian restriction" may be a "tool" that I call "exceptional primological curiosity" (EPC). The EPC is ANY (more-or-less "unique") "special happening" in the distribution of Prime Numbers, compactly relatable to BLN.

For example, add to (a pre-fixed) BLN whatever string of digits and look for some "unusual happening" (say, neighboring inter-prime gaps are "coded" by some fancy pattern). To "broadcast" (or "eternally store") such [much more compact] label is "much easier" task than carrying the "whole" (uncompressed) BLN.

In this model (any), physical Universe can be seen as a "truncation of ALEPH-ZERO infinititude," meaning by this a "process" that is "metaphysically similar" to quantum reductions and/or symmetry breaking models of physics. Corollary to this universal connectedness through ALEPH-ZERO field is the universal entanglement and hence the impossibility of "exact measurements" as sharpened in polemics

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between P.W. Anderson and R.G. Jahn [*Physics Today*, Dec.1990 (p. 9); Oct.1991 (pp. 13–15, 146); March 1992 (p. 100)] that is discussed above in Chapter 7.

8.3 Emergence, eternal records and normal numbers

Practically, all current information storage and information processing systems operate on the principle of digital strings. This means that the information is stored and transmitted in the form of long (usually binary) strings that can be read and manipulated by the sequential processors. Any text or any picture (of any dimension, or color, etc.) can be coded this way.

And the key question here is how to determine whether a digital string carries "real" information, or if it is just a random and meaningless "noise." This question turns out to be a truly tricky one on all levels. This requires us to define "randomness" and to determine (or stipulate) what strings can be considered "random." And the definition of randomness is far from trivial (Wolfram, 1985); one may even, somewhat jokingly, say that the "definition of randomness" itself is in some way "random",

For example, we say that when we throw dice or play a roulette, the outcome is random. But what exactly do we mean here by random? There have been many attempts to define the randomness mathematically, but all of them, when carefully thought through, leave us somewhat unsatisfied. In mathematics, a truly random number is normally known under the term "*Normal Number.*" By definition, the normal number has any sequence of digits of a given length occurring with equal probability. The other side of this is that any unlimitedly long random number contains ALL possible information.

There is the popular metaphor of the "Typing Monkey," which says that a monkey typing at random on a keyboard, given enough time, will eventually type all of Shakespeare's plays (or any other book for that matter).

Never mind that the time needed for that may be beyond human imagination, many, many times greater than the alleged age of the Big Bang Universe. However, the important point is that this "monkey time," no matter how huge it may be, is still *finite*.

In fact, the time needed for that can be quite easily estimated and the result can even be written compactly using Tower-Exponential notations. Example of the latter is the famous "Skewes number" (that is, 10^10^10^34), which is often used as an example of "*super large numbers*" (Skewes, 1933, 1955; Knuth, 1976; Berezin, 1987g). While Skewes number is far, far greater than anything we can realistically count (e.g., the number of electrons in the Big Bang universe is "only" 10^90, or so). Skewes number is still only a four-story exponent and hence it is far, far smaller than the other tower exponents that are used in various mathematical theorems, such as, for example, the Graham number (Ronald Graham), which has zillions upon zillions of levels and can only be written with special (arrow) notations (Knuth, 1976).

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With the definition of "Normal Number" at hand, we can talk on the "Eternal Records." These are also known in more "esoteric" and "spiritual" literature as "Akashic Records" (e.g., Laszlo, 2007). The key idea that can be proposed in this context is to build a logical connection between (the said) "Eternal Records" and the Number Theory. As was argued above, all possible knowledge (all possible information) is eternally coded in the set of real numbers (Prime Numbers is a sub-set of Real Numbers). For example, imagine a real (irrational) number X in the interval $0 < X < 1$, which is explicitly defined as

$$X = 0.1234567891011121314151617192021223 \ldots \text{ (to infinity).} \tag{8.1}$$

This number is known as *Champernowne's constant*. It was proposed by the young mathematician David Champernowne (1912–2000), who proved it to be a Normal Number in a paper that was published in the prestigious mathematical journal in 1933, when its author was 21 (Champernowne, 1933).

To construct it, all one has to do is to write all consecutive integers in a decimal notation (N = 10) one-by-one. Of course, such a process cannot be finished in practice (only in principle), but this does not affect the fact that X is a rigorously defined mathematical constant (Pickover, 2001, p. 105). The above written X can be trivially coded by a simple computer algorithm, yet it "contains" in it all integer numbers written in a decimal form. Similar numbers can be constructed in a binary system (N = 2) or in a positional system with any other N-basis.

Because any message, no matter how long, can be coded by some integer number, all possible records, all possible books, all the detailed descriptions of each possible universe (up to the level of all individual micro-states in them) are recorded in this innocently looking number X. Furthermore, there are infinitely many variations of the number X (e.g., we can write any number of zeros (or any other digits) before starting 123… trail to get another version of X, like X = 0.0000012345…, etc.), or, perhaps, write at every step every next "number" as many times as itself (which will produce a string 0.122333444455555…) and each so-written variation of X still contains the full library of all possible records. There is, of course, an infinite variety of such variations.

The above-written number X (whose decimal expression is infinite) is an example of the so-called *Normal Numbers*. An irrational number is called "Normal" if all possible combinations of digits of a given length occur in it (asymptotically) with equal probability. While we are still lacking a rigorous proof that such glorious numbers as π, or "e," or square root of 2, etc., are normal, they almost certainly are (Wagon, 1985). In fact, it is proven that the set of normal numbers is infinite (with the cardinality of continuum meaning that "almost all" real numbers are normal). Thus, any possible message, any possible pattern and algorithm, is eternally coded within any Normal Number. And there is an infinity (actually, a continuum set, "Aleph-One") of normal numbers.

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Furthermore, EACH normal number contains ANY message INFINITELY MANY TIMES (!). To put it vividly, the above-written number X (as well as any other Normal Number, and there is a continuum of them!) contains (in a digitally coded form) the full text of Bible, or all of Shakespeare's plays (or any other book) *infinitely many times* (!). This is indeed a starting point for deep philosophical contemplations. Indeed, the Ideal Platonic World of Numbers contains any possible book infinitely many times, probably, even continuously many times (!) – to indicate "Aleph-One" (continuous) set whose cardinality is next to the "Aleph-Zero" countable set (Continuum Hypothesis of Georg Cantor).

8.4 Message of "π"

In his novel *Contact* (Sagan, 1986), the astronomer, Carl Sagan (1934–1996), describes a team of scientists who discover a peculiar, seemingly non-random, pattern among the digits of $\pi = 3.14159$ ... This pattern appears somewhere very far in the decimal expansion of π. Say, at some point the decimal expansion of π has a million consecutive zeros, like a string (... 35600000...[million of "0"] ... 000007923). And this finding the Sagan's scientists interprets this as an "eternal message" that was put there by some "Higher Mind." In other words, they interpret this as some "Ultimate Message" from the super-mind, which has created the Universe (they call it "*The Artist's Signature*").

Although such an interpretation may appear tempting, it (fortunately or not) breaks down upon rigorous analysis. The fact is that *any* (normal) number, π included, *does indeed* contain in the infinite expansion of its digits (in decimal or any other positional system) any possible pattern.

Hence, the discovery by Sagan's heroes becomes just a trivial observation related to mathematical properties of Normal Numbers. Yes, of course, any pattern in π occurs infinitely many times. And, yes, there will be zillions-upon-zillions of consecutive "0s" (or any other digits) in the infinite expansion of π. Yes, there are strings of consecutive "0s" in π that are longer than the Skewes number, or any other Tower Exponential Number (Knuth, 1976; Berezin, 1987g). Furthermore, any such super-long trail of a consecutive digit ("0" or other) will show up in the expansion of π infinitely many times!

Thus, there is nothing strange or mystical in the observation of Sagan's scientists. If π is a Normal Number (which it almost certainly is, even though to date there is no mathematically rigorous proof of this), then any sequence of digits will happen in it at some place and, in fact, infinitely many times! So, there will be a million, or a billion, or a trillion (etc.) sequences of 0s, or 1s, or 7s (etc.) somewhere in it and, of course, any book digitally coded in any possible code, will occur in π somewhere (and, again, infinitely many times with all possible variations!). Such is the power of infinity!

The number π is, of course, a universal constant of mathematics, which can be defined in many ways, not just as the ratio of the length of a circle to its diameter. For

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example, it can be defined by the infinite Leibniz series. Repeating from Chapter 5, this series is:

$$\pi/4 = 1 - 1/3 + 1/5 - 1/7 + 1/9 - 1/11 + \ldots \text{ (\textit{ad infinitum})}. \quad (8.2)$$

This very simple-looking series, although it converges very slowly (there other serial expansions for π which converge much more quickly, but they are more complicated) does, nonetheless, converge to the exact value of $\pi/4$, even if this series as such has (seemingly) no clear relationship to circles.

That probably "metaphysically explains" (if such a term can be used) why π is not exactly three. Would it not be nice if it should be so? (except that, perhaps, the Universe would be much more boring). However, π is, and will always be, some strange, irrational, and transcendental (and likely normal) number that places itself somewhere between 3.1 and 3.2. And no talk about "other realities" or "parallel universes" can be entertained here, because in any logically consistent realm, π will be exactly as it is, it is as absolutely eternal and unchangeable as the (infinite) list of Prime Numbers.

Thus, asking why π is not exactly three is, perhaps, like asking why there is an infinity of Prime Numbers. In fact, since Prime Numbers become increasingly sparse as we progress along the number line, common sense may tell us that sooner or later the Prime Numbers will run out and there will be no more of them. However, contrary to such common sense, as early as the third century BCE, Euclid gave a neat and clear proof that there is no "largest" Prime Number and there is infinity of them (refer Chapter 3 for Euclid's proof).

The above comments do not, however, derail the idea of "hidden messages" in normal numbers. On the contrary, the situation with hidden messages is, in a sense, even better than in Sagan's novel. The Platonic world of mathematics is full of them. Furthermore, this idea has enormous constructive power. The fact that real numbers (normal numbers) in their very structure contain an infinite manifold of messages and patterns of all kinds serves as the basis for all the phenomena of emergence and self-organization occurring in the Universe (Berezin, 1998b, 2015, 2016).

This is congruent with the Pythagorean tradition of envisioning numbers (primarily integer and rational numbers) as the "mystical foundation" of the Universe. Noting that one of the meanings of the Greek word logos is "ratio," Charles Seife (Seife, 2000, p 26) gave an alternative translation of John 1:1 from the Bible as "*In the beginning, there was the ratio, and the ratio was with God, and the ratio was God*" (obviously, the idea of the ratio of any two integers implies the whole infinite set of numbers).

In fact, the situation with normal numbers and all possible messages (and books) may be even better than the above lines imply. In spite, as was just said, of the lack (for now, at least) of rigorous proof for the normality of any of the traditional

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transcendental numbers, such as π, "e," square root of 2, etc., in 1909 mathematician Emile Borel proved the *Normal Number Theorem*. It states that "almost all" real numbers are normal in the sense that the set of exceptions (non-normal numbers) has a Lebesgue measure of zero (or, saying it in a simpler way, there are "infinitely more" Normal Numbers than non-normal numbers and if you "hit" any real number at random, the probability of "hitting" a non-normal number is zero). So, there are plenty of good (and bad) books in the "universal library" (Sections 8.5, 8.6, and 8.7) hidden in the set of Normal Numbers (in fact, an infinity of books of all kinds).

Many other examples can be brought up here. For example, Madelbrot iterative sets show the enormous creative and diversifying power of numbers in the world. In this way, the tradition going from Pythagoras through Plato to Euclid and Diophantus and then on to Leibnitz, Euler, Cantor, Gödel, Erdos, and many others, remains a guideline for many people to follow in their philosophical and metaphysical contemplations. Another interesting example here is the metaphor of the "Universal Library" from the well-known short story (novella) by Jorge Louis Borges.

8.5 The library of Babel by Jorge Luis Borges

> *The atoms come together in different order and position, like the letters, which, though they are few, yet, by being placed together in different ways, produce innumerable words.*
> Epicurus (341–270 BCE)

The theme of infinite records has generated some interesting literature. In his story, *The Library of Babel*, Jorge Luis Borges (1899–1986) imagines the whole universe as a huge library (Borges, 1998, pp. 112–118, and many other editions). To the inhabitants of the world (the "librarians"), the Library appears to be infinite, having enormously long galleries of identical storage rooms with bookshelves stretching in every direction. No one knows where the galleries end, or whether they end at all. This "Library of Babel" (LB) contains every possible book in every possible and imaginable language.

Each book consists of an identical number of pages (410, which is of course an arbitrarily chosen number) filled with all possible permutations of letters. Therefore, all possible meaningful books are somewhere on the shelves of the LB, lost amidst an enormous number of books filled with a meaningless jumble of printed characters. There are no two identical books in the LB, but the chances of locating even a single meaningful book are very small. As Borges says, one has to travel many light years over the galleries of the LB to find a single meaningful book.

Yet, all possible books are, by definition, somewhere in the LB. This means that all possible histories, biographies, philosophies, religious texts, and scientific theories already exist, in principle, in the LB. As Borges puts it,

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> Everything: the minutely detailed history of the future, the archangels' autobiographies, the faithful catalogues of the Library, thousands and thousands of false catalogues, the demonstration of the fallacy of those catalogues, the demonstration of the fallacy of the true catalogue, the Gnostic gospel of Basilides, the commentary on that gospel, the commentary on the commentary on that gospel, the true story of your death, the translation of every book in all languages, the interpolations of every book in all books (Borges, 1998).

Furthermore, though enormously huge, the LB is of finite size. It is possible to estimate that all permutations of several million characters (typical book length) amount to some 10^10^10 (10 to the power 10 billion) possibilities (Bell-Villada, 1981; Bloch, 2008). Such numbers, as was said before, are called Tower Exponential numbers (Berezin, 1998b, 2002). No matter how high the tower of "10" is, the resulting number it represents is always finite. Almost all integer numbers are larger than any given one we can think of. With any specific number, we are always infinitely far from the "true infinity" (Knuth, 1976).

Thus, any author (me including) can, theoretically, even pose a metaphysically rhetorical question ["why I have to write this-or-that book when it is "already" on the eternal shelves of the LB?"]. I do not have an easy answer to this question, although it is, undoubtedly, a good point to ponder and reflect, perhaps, at some exhibition of a surrealistic art.

Likewise, codes for all digitized pictures – at ANY resolution – are, of course, on the shelves of LB as well. Yes, for some pictures or, perhaps, multi-dimensional images, it may take more than one 410-page book (that is the standard which Borges assigns for every book in LB) to store a full digital code for such an image. Yet ALL books needed for that are in LB, for sure (by the very definition of LB).

The idea of the LB implies that all possible histories, biographies, philosophies, religious texts, and scientific theories already exist, in principle, in the LB. Keeping in mind what was said above about Normal Numbers, we can safely say that *any* Normal Number will have "inside it" the whole LB (and a lot more).

Furthermore, the LB itself will be in any Normal Number *infinitely many times* in all possible variations (!). This is because, while the LB is enormously huge, it is still of finite size. And no finite number can beat infinity. Thus, *Champernowne's constant* [equation (8.1)] has the LB in itself, and so does π (assuming it is normal, which is almost certainly so), *infinitely many times* (!).

Thus, even the LB is much larger than the observable universe, it is still finite. The "Big Bang" ("our") Universe is about 10 billion light years across – that is "only" 10^10 = T(2). Thus, the LB, though enormously huge, is still eventually finite (it becomes infinite if we allow books with an unlimited number of pages).

The above example, by the way, shows an *enormous* difference between T(3) = 10^10^10 (that is, the size of the LB) and T(2) = 10^10 (the size of "our" Big Bang universe, BBU). While at first glance T(2) and T(3) may appear innocently close (there is not much difference between 2 and 3), but in the world of Tower Exponents, these two items, T(2) and T(3), are fantastically different. In fact, their ratio is T(3)/T(2) =

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10^9,999,999,990, that is, almost as large as T(3) itself. The above ratio shows how much greater the LB than our BBU.

At this point, it is worth to meditate about T(4), T(5), T(1000), or T(T(1000)), etc. No limit to our imagination here!

But there is another problem with the LB, apart from its size. It contains not only all “true” knowledge and facts but also all that is false. There is no outside tool which (even in principle) could help us to separate the “true” from the “false” (except for trivial statements like 2+2 =5, the falseness of which is obvious). This lack of truth criterion for the LB is conceptually akin to Gödel’s undecidability theorem (Berezin, 2002), which demonstrates the existence of unprovable statements. Another analogy is the so-called “Halting Problem” for the Universal Turing Computer (Johnson, 1994, pp. 286–289). The latter is a theorem demonstrating that it is impossible, even in principle, to design an algorithm which can determine in a finite number of steps whether any given computer program will eventually stop (halt).

For Borges, the notion of the LB of all possible books is a metaphor for the Universe itself. By definition, the set of all possible books has the detailed history of all possible worlds written in it, even if by “history” we mean the detailed account of all the microscopic states of each mini-verse. Of course, it takes many, many volumes of the LB to write down the entire microscopic history of any particular Universe (mini-verse), but never mind, it is just fine, because all the required volumes are somewhere in the LB anyway (although any two “consecutive” volumes may be light-years apart, sitting on the shelves of LB).

In other words, in view of the above estimate for the number of microscopic states of each mini-verse (about 10E10E10 = 10^10^10 states), it may take an enormous number of “volumes” on the shelves of the LB to record the full history of even one particular “mini-verse.” Yet, the total number of such books (and all the books in the LB) is finite.

Here, we are dealing once again with the *countability paradox*: for infinite sets any sub-set is of the same size (same “*cardinality*”) as the whole set. We can refer again to the above example by Lewis (Chapter 5) of the table of zig-zagging integers. It apparently shows, that by a proper arrangement, an infinite sub-set of the whole set may appear as arbitrarily greater than the whole set! Thus, in-spite that Prime Numbers are sub-set of all integers, they (Prime Numbers) still run the show!

This brings us to another paradox: that a full set (in our context: all possible universes with all possible time histories) can be simpler than any specific part of it. An algorithm which lists all consecutive integers (1, 2, 3, 4, 5, ...) is a trivial one in comparison with a much more complex algorithm which will list only Prime Numbers.

8.6 Prime numbers in the library of Babel

To re-state the above countability paradox in the context of the Library of Babel (LB), we, first of all, have to recall that the “sub-set” may often appear “larger” than the “total

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set." One such simple example (Lewis, 1986) that was discussed above (Chapter 5), can be constructed using integer numbers – all numbers and primes. Consider all integer numbers, 1, 2, 3, 4, 5, 6, 7, 8, 9, … We know, that some of them are Prime Numbers, which are divided only by 1 and by themselves. These are 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, … [*ad infimum*]. By arranging all integers in a zig-zag (infinite) table (Lewis, 1986), it may seem that there are "infinitely more" primes that are all integers. But, of course, both primes and all integers form infinite ("countable" – ALEPH-ZERO), so trick here is played on the impossibility to "exhaust" the infinity except in the "asymptotic" sense.

Euclid proved 23 centuries ago that there are infinite number of primes, in other words, primes will never "run out." The rest of numbers are composites, that is, they are products of at least two primes, or more (the unit, number "1," has a special status, and in the Number Theory "1" is not counted either as a prime or a composite). At the beginning of an integer set, primes pop up quite often, but for larger and larger integers (N) their probability decreases as 1/ln(N), inverse natural logarithm of "N," this relationship is known as the Prime Number Theorem. Furthermore, there is a proof that there are arbitrary long strings of consecutive integers such that none of them are primes (arbitrary long "prime deserts").

In fact, Prime Numbers give an "easy" ("easy" in a metaphysical sense, not "practical"!) way to convert all books in LB to integer numbers. Each book then is a unique integer number. A very long number is still a finite integer number, nonetheless. And the total number of books (and hence integer numbers coding them) is huge, yet finite.

Here are some estimates to that effect (Bloch, 2008, pp. 16–22). According to Borges, all books in LB have 410 pages; each page has 40 lines with, approximately, eighty black characters (letters) on every line. That gives 410*40*80 = 1,312,000 characters in each book. This particular choice of numbers is, of course, just an arbitrary envisioning of a great metaphysical writer, but other similar choices can be easily tried.

In his essay, Borges says that the alphabet used in LB has 25 different characters. I would be more generous and would allow, say, 500 different symbols, to account for all punctuation marks, spaces, numericals, and, perhaps, letters from different alphabets. If so taking all possible permutations, the total number of books in LB is 500^1,312,000, which comes to about 10^3,541,049 (10E3541049 in "E" notations). This is a huge number by our ordinary scales. It is much, much larger than the number of atoms in the universe which is "only" some 10E90. Yet, it is "just" 10^10^6.549 (approximately) and that is a lot smaller (in Tower exponential terms) than even T(3)=10E10E10. Whether we take T(3) = 10^10^10 = 10E10,000,000,000 or "just" 10E3,541,049 for the size of LB (depending on the details of how we make an estimate), both these numbers are really unimpressive dwarfs in the world of Tower Exponents and Arrow Notations (Knuth, 1976).

How long should be a unique integer number coding each book in LB? Let us, as an example, use the so-called Gödel numbering. Gödel number (GN) is a product of consecutive primes, each one is raised to some integer power representing the symbol in the corresponding alphabet. That is

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$$GN = 2^{A2} \cdot 3^{A3} \cdot 5^{A5} \cdot 7^{A7} \cdot 11^{A11} \cdot 13^{A13} \cdot 17^{A17} \cdot \ldots \cdot P(n)^{AP(n)}. \tag{8.3}$$

[In this equation A2, A3, ..., AP(n) are positive integer numbers and each consecutive Prime Numbers, 2, 3, 5, 7, 11, etc., is raised in the power A2, A3, etc., respectively. This is the way Gödel's numbering works]

Here, P(n) in the last (nth) prime used to code a book. In our case, when GN codes a particular book in LB "n" is equal to 1,312,000, in other words, "n" is the 1312000-th prime. Since nth prime is about "n·log(n)," in this example, it is about 18,500,000 ["log" here is the natural logarithm, log(1,312,000) = 14.087; 1312000×14.087 = 18,482,144].

Integers A2, A3, to, AP(n) all have values from 1 to 500, depending what number in this interval is assigned to represent each symbol from (expended) alphabet. Not all composite numbers are Gödel Numbers, because the latter contain as their factors powers of ALL consecutive primes, up to some maximal. Thus, Gödel Numbers is a small subset of all composite integers (of course, both sets, all composites and Gödel Numbers, have the same Aleph-Naught [countable] cardinality in the sense of the Cantor theory of infinite sets).

The advantage of Gödel Numbers rests on the unique factorization theorem. It states that each composite integer number can be factored on the product of primes in a unique way. That is why Gödel used them (and probably invented them) in his famous Undecidability Theorem. So, what will be the length of a typical GN for book from LB? In other words, how many (decimal) digits it has? Let us make an upper estimate replacing all "n" primes in the above expression for GN by the maximal prime (which for LB book is about 18,500,000) and taking all powers "A" equal to maximal value (500).

To see what the size of GN looks like, we have to take the number 18500000^500 = 10^3634 (approximately) and raise it to the power 1312000 (the number of characters in each LB book). That gives us 10^4767808000 = 10^10^9.679 which is "a bit less" than the above-mentioned T(3). [When I say "a bit less," I understand it in the Tower Exponential sense, in REAL sense, even that 9.679 is "almost" 10, the value of 10^10^10 is enormously greater than 10^10^9.679; in fact their *ratio* is 10^5224707263 (10 to the power over 5 billions)].

The above GN has some 4.76 billion (decimal) digits and to write down such a number with 2 mm-per-digit script will take a tape 10,000 km (quarter of Earth's equator). So, it is still not "really" a "true" Tower Exponential number, for the latter we need tapes longer than the size of the universe. Of course, the above number (10E10E9.679) is an over-estimate of the value of GN for the LB book. This is because not all primes in the expression (8.3) are same as maximal, and not all values of "As" (that is A2, A3, A5, A7, ...) are equal to 500 (and we can reduce this 500 to a smaller integer, even to 25 as in Borges essay), but yet this GN is a three-story (three level) construct (which barely qualify it for the Tower Exponent status).

There are much more economical ways to code LB books by shorter integer strings and that is what the actual communication systems do. Since each book in LB has

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1,312,000 characters, the tape (with 2 mm per character) will be less than 3 km long (2.624 km); however, the very idea that it is possible to code LB books by GNs has some theoretical advantage, or, perhaps, better to say, metaphysical advantage.

This is because Gödel Numbers contain ALL consecutive Prime Numbers as their factors (up to a maximal). Hence, each power (A2, A3, etc.) can be recovered (through the factorization) one-by-one (at least, in principle). Numerous other authors and thinkers pursue similar ideas of all-encompassing library or some variations of this theme. They all come to fantastic, super-cosmic (Tower Exponential) estimates for the size of such a library, whatever metaphors they may be using for it.

Thus, the universal coding of any message by the strings of Prime Numbers (Gödel numbering) connects the idea of the Library of Babel to digital informatics (Berezin, 2015, 2016). This has critical implications for the fundamental mathematics, logic, and metaphysical philosophy (Platonic philosophy). Not surprising that Kurt Gödel, Georg Cantor, David Hilbert, and other key actors in these areas considered themselves as Platonists (followers of Plato and Pythagoras). The author of this book sees himself belonging to the same club.

8.7 Lev Tolstoy in Borges library

Here is another interesting estimate that is adopted from an anonymous Internet posting. How many "almost exact" copies of "*War and Peace*" by Lev Tolstoy the Borges Library has on its shelves?

The Argentinean writer Jorge Luis Borges was one of top metaphysical authors ever lived. Many of his stories deal with mind-expanding themes, including "Blue Tigers," about a handful of stones that do not obey the rules of mathematics, "The Book of Sand," about a book with an infinite number of pages, and "The Aleph," a point in space that allows one to observe all other points simultaneously.

However, Borges' most iconic short story is the one called "*The Library of Babel.*" This story can be seen as an extended thought experiment, about a race of people who live in a cosmos that is bizarre indeed (Bell-Villada, 1981; Borges, 1998; Bloch, 2008). The universe in which these people (Babelians?) live is a vast, apparently endless honeycomb of interlocking hexagon-shaped rooms, each one with two hallways that connect it to other rooms on the same level and a spiral staircase connecting it to rooms both above and below. Every room's walls are occupied by bookshelves that are full of books. Most of the books are complete nonsense, nothing but random combinations of letters, but a few contain tantalizing hints of sense.

Quoting the narrator of the Borges' story:

"One which my father saw in a hexagon on circuit fifteen ninety-four was made up of the letters MCV, perversely repeated from the first line to the last. Another (very much consulted in this area) is a mere labyrinth of letters, but the next-to-last page says *Oh*

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time thy pyramids." No one really understands what these four words could mean, they are probably just a random game of letters among zillions pages of a complete jumble.

As Borges' narrator explains, the people of the Library of Babel have finally discerned the nature of their world, based on two observations: first, that every book uses the same 25 symbols for letters and punctuation; second, that no traveler has ever come across two exactly identical books. These people have come to the realization that the library contains all books – that is to say, not just all books that have been written, not just all books that ever will be written, but all possible books, every single permutation of letters of a specified length.

Life in the library is both a blessing and a curse. The vast – overwhelmingly, crushingly vast – majority of these books are total gibberish, but buried among them, somewhere, there are – there must be – books containing every truth that anyone could ever want to know.

There must be books that tell the true history of the LB and explain how such a fantastic cosmos came into existence. There must be books that contain the truth about the existence, nature, and attributes of God. There must be books that tell the true biography of every individual's life, perfectly foretelling their every action from birth to death, if only there was a way to find them; Borges' narrator refers to these books as the Vindications. Of course, because this library contains all possible books somewhere, every such work of perfection will be undetectably camouflaged among an immense number of sinister counterfeits – books that tell you your life story in perfect detail up to the age of 30, say, but diverge radically thereafter.

Though it is obvious that the LB must be vast, we can do a little calculation to see *how* vast it is. Daniel Dennett in his *Darwin's Dangerous Idea* (Dennett, 1995) gives the following estimate. According to Borges' description, each book in the library is 410 pages; each page is made up of 40 lines each consisting of 80 positions, and there are 25 possible alphabetic symbols that can fill any of these positions. This works out to $410 \times 40 \times 80 = 1{,}312{,}000$ positions per book, each of which can be filled in 25 distinct ways: $25 \times 25 \times 25$... and so on, 1,312,000 times. In other terms, the LB contains 25^(410x40x80) = 25^1,312,000 books. This is a number compared to which the number of atoms in our universe is infinitesimal.

Since it is all impossible to get a handle on the size of this number, let us consider something more manageable: the number of *variants* of just one book, say, *War and Peace* by Lev Tolstoy. Of course, it is not necessary that this particular book actually has 1,312,000 characters – the standard assigned by Borges to all books in the LB – but say for the sake of argument let us presume that it does. In all the vast library, there is only one book that replicates it *exactly* as it was written by Lev Tolstoy. But how many slight variants are there, versions that differ by just one character?

Again, there are 1,312,000 positions in the book, each one of which can differ from the canonical version in 24 ways (since the original character at that position can be replaced with any of the other characters). Thus, there are $24 \times 1{,}312{,}000 = 31{,}488{,}000$ one-character variants. By the same logic, there are an incredible

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991,493,388,288,000, or about 991 trillion, copies of this book that vary by just two characters (31,488,000 ways to vary one character, times 24 × 1,311,999 = 31,487,976 ways to vary a different character).

The number of three-character variants is exponentially larger, and the number of four-character variants is larger still; and then there are the versions that differ by five, by six, by seven ... (Dennett points out that even a copy with several typos on each page would still be quite recognizable.) And none of this includes translations of the book into other languages, retellings of recognizably the same story in different words, abridged versions, summaries, versions with scrambled page order, versions with alternate endings, commentaries, commentaries on the commentaries, reviews, parodies, scholarly analyses, denunciations, deconstructions...

Just how big number is this? The estimated volume of the observable universe is 10^33 cubic light-years, or about 10^87 cm^3. Assume that the thickness of a sheet of paper is 0.1 mm, and that each sheet is of standard 8.5 × 11-inch dimensions (about 21.6 by 28 cm). Then the volume of a single book is 21.6 × 28 × (400 × 0.01) = about 2,400 cm^3. It would take 4.16 × 10^83 such books to completely fill the volume of the observable universe. How many variants on *War and Peace* would this be?

Incredibly, all the books that were exact duplicates of War and Peace, say for a mere 12 or fewer single-character differences somewhere in the text, would more than fill the observable universe.

And the LB must contain these books, as well as all the other character variants, plus all the other relevant books mentioned above. The amount of space required to store all these near-duplicates – "Tolstoy Space," let us call it – is, by many orders of magnitude, larger than the entire observable universe. And Tolstoy Space is just the infinitesimally small, vanishing fraction of Babel Space devoted to the variants of just one book. Borges wrote that for every book in the library there were "several hundred thousand imperfect facsimiles," but we can now appreciate just how much of an understatement that was.

8.8 Diophantine equations and eternal records

Another example pertinent to the "eternal records" issue, in my view, can be based on the so-called *Diophantine Equations*. In mathematics, Diophantine Equation means a polynomial equation with integer coefficients. An interesting aspect of the theory of Diophantine equations is related to the search for their INTEGER solutions. The most popular among Diophantine equations is the so-called *Pell equation* (it is also the simplest of all Diophantine equations). It is a short quadratic equation which looks like that:

$$X^2 - A \cdot Y^2 = 1, \tag{8.4}$$

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where "A" is a positive integer number (which is NOT a square of another integer, so it is ANY integer EXCEPT square integers 4, 9, 25, 36, 49, etc.).

And the challenge is to look for its solutions in INTEGER values for "X" and "Y." Of a special interest is the MINIMAL (smallest) integer solution of Pell equation (8.4) for the particular value of "A." It is a curious fact of the Number Theory (or, more properly to say, of the Platonic World of Numbers itself), that the size of minimal solution is highly chaotic with a growth of the "A." For example, if A = 5 the minimal solution is X = 9 and Y = 4. In this case (and in many other cases), all these three numbers (A, X, Y) are of the same order of magnitude. But this is not always the case, for example, for consecutive integers A = 60, 61, 62 we have:

A = 60, X = 31, Y = 4
A = 61, X = 1766319049, Y = 226153980
A = 62, X = 63, Y = 8

It appears somewhat strange that while for A = 60 and 62, the minimal solutions of the same order as "A," for A = 61 the minimal solution has 10 and 9 digits (for X and Y, respectively). This means that we take a stack of 61 pennies (the thickness of the penny is 1.5 mm) to represent the seed number "A," such a stack will be about 9 cm toll, whereas the stack needed to represent X will be about 2,600 km tall (!). And there are many, even much stronger and impressive, curiosities of this kind along the number A-line, for example, for still relatively small A = 991 (the stack of 991 pennies is 1.5 m tall – a bit shorter than the height of an average adult human), the corresponding X and Y are:

X = 379516400906811930638014896080,
and
Y = 12055735790331359447442538767,

which have 30 and 29 digits, respectively. The stack of pennies for X will be 5.7·10E23 kilometers high which is about 50 BILLION LIGHT YEARS (!) – a few times the (alleged) size of the Big Bang Universe. And that's, of course, is not the end of this story (in fact, this story has no end). For, say, still relatively small A = 3061 (stack of 3,061 pennies is 4.6 m) the MINIMAL solution for X has 1,000 digits, that means the X itself is some 10E1000 large, anyone can calculate that the pennies needed to represent this X will fill some 10^900 (yes, 10 to the power 900 or so) Big Bang Universes (!).

There some theories behind that, to which I do not venture to go in detail. They purport to show that "lim(sup[X/A])" is infinity (I do not have exact proof of that but it seems highly likely to be the case). This means that if we form an infinite (countable, of course) set of ratios "X(min)/A," there are no "largest" term in it, there will be arbitrarily large ratios in such a set.

In other words, there ARE such integers "A" for which the minimal solution of Pell equation is arbitrary larger than "A" itself. To give one more explosive example,

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for an integer A = 1021948981, which is just over 1 billion (pennies will take about 500 m^3 – the volume of a family house), the number of DIGITS in the MINIMAL solutions has 100680 digits, just TO WRITE DOWN this "X" with small 1 mm per character script will take a paper strip 100 m long, Then what about number X itself.

Along the lines of philosophical and metaphysical reflections what this Diophantine example can reveal? In my view, it is quite hilarious that some integer "A" can "generate" (in one step!), or "produce" or "control" some other integers (minimal X and Y) which are ARBITRARY LARGER than A itself. This is some kind of (distant, perhaps, but still likely valid) analogy with the "water memory effect" (refer Chapter 10) in homeopathy, when very small (subtle) effects (like isotopic variations) can control a much larger system at a gross level.

These (and other similar) examples (e.g., Mandelbrot iterative sets) show enormous creative and diversifying powers of NUMBERS in the world. In this way, the line of scientific explorations and deep reflections going from Pythagoras to Plato to Euclid and Diophantus and then to Leibnitz, Cantor, Gödel, Erdos, and many others, remains a guideline for many people to follow in their philosophical and metaphysical contemplations.

Chapter summary

From elementary school, we know what π number is and that it is slightly greater than 3. We may be even surprised why it is so and why it is not exactly 3, but a strange irrational number 3.14159265 ... with string of its digits going to infinity. In fact, in this infinite expansion all combinations of digits appear infinitely many times. We call such numbers "Normal Numbers" and there is infinity of them. This means that any coded message (any book, any digitized image) exists in π (or in any other Normal Number) in infinitely many copies. The idea of the Universal Library of All Possible Books ("Library of Babel" by Jorge Luis Borges) provides a vivid imagery for this idea. Universal coding of any message by strings of Prime Numbers introduced by Kurt Gödel (Gödel numbering) connects the idea of LB to digital informatics.

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9 Quantum Narnia and parallel universes

The quantum theory of parallel universes is not some troublesome, optional interpretation emerging from arcane theoretical considerations. It is the explanation – the only one that is tenable – of a remarkable and counter-intuitive reality.
David Deutsch, *The Fabric of Reality*

Thanks to the great writer and Oxford scholar Clive S. Lewis (1898–1963), *The Chronicles of Narnia* are now among the most known reads for all ages. Along with *The Lord of Rings* by his friend and Oxford colleague John R.R. Tolkien (1892–1973), these stories serve as a spiritual and intellectual inspiration for millions of people across the world. This is where the "real world" and the "virtual reality" of fiction come to close contact. Such a close contact that it takes only a few steps in the wardrobe of old coats to pass the subtle boundary between both worlds.

However, there is more to it. A lot more. The ideas of quantum wormholes as the passages to the parallel universes, quantum teleportation, and instant super-luminal communications (all in the arsenal of novel quantum ideas) fall in the same fold. It fits to say that the ideas of Narnia and quantum physics form a good "resonance loop," the potential of which is almost bottomless. There are numerous other representations of alternative realities in literature and arts (e.g., Poe, 1848; Cowles, 1959; Lewis, 1976; Hofstadter, 1980; Lem, 1981; Egan, 1994, 1997; Tee, 1997; Van Slooten, 1997; Borges, 1998; Kaplan and Kaplan, 2003; Roberts, 2004; Caudill, 2012).

This chapter presents some further thoughts on these issues in the context of infinity and quantum connections.

9.1 Universe at tower exponential scales

Ideas of infinity and the universal (cosmic) consciousness are going hand-in-hand (at least, for this author). In the following few sections, I am putting up a few essays linking cosmology, super-large (tower exponential) numbers, and isotopes and consciousness at all scales of their possible manifestation and operational dynamics.

As discussed earlier, tower exponential numbers (Knuth, 1976; Berezin, 1987g, 1998b, 2002) is a straightforward mathematical (actually, arithmetical) concept that can be understood by people even with elementary school command in mathematics. In view of this "easy-to-understand" idea of tower exponential numbers, it is interesting to ask the question of how the universe will look at tower exponential scales.

This question may well be *un*-answerable and many people would likely qualify it as a metaphysical and/or pure speculative pseudo-quest. If so, this is fine with me, the author, since I have a metaphysical bend strongly imbedded in my personality in a number of ways, as I mentioned a few times in this book.

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In a well-known popular book *Power of Ten* by Philip and Phylis Morrison (Morrison and Morrison, 1994), the authors sweep the entire range of the (known) universe, from nuclei to metagalaxy, though only 42 frames with 10-fold magnification at each step. Each colored picture has a scale 10 times greater than the previous one.

Morrisons' book starts with a nuclear size (some 1/10E15 m) and ends up with a size of the visible ("Big Bang") universe. That is, so to say, "our" universe (Rovelli, 2016). It is about 10E27 (10^27) m in size (a factor of 2, or 3, or even 10 is of no importance in these estimates). Even if we start at the size of Planck units (Planck length is about 1/10E35 m), it will only take a mere 62 frames (62 orders of magnitude) to get to the scale of the whole visible universe. The volume of the entire Big Bang universe (its size is some 10 to 20 billion light years, which is approximately 10E26 m) is "only" about 10E183 cubic Planck units of length.

Yet, this last number (10E183) is not even a "tower exponent", it is "1" followed by "only" 183 zeros. A small card is enough to write it down with all 183 "zeros" one-by-one (about 4 or 5 printed lines). So, the question can then be asked what would happen at a scale of *real* tower exponents. Some theories of inflationary cosmology discuss spatial scales such as 10^10^12 (or, in our notations, 10E10E10). This is number "1" followed by 10E12 (one trillion) zeros.

Trillion is a thousand billion (or a million million). There is a million mm in a kilometer. So, it is easy to estimate the length of a tape that is needed to write "1" followed by a trillion zeros.

Thus, just *to write down* (sic-!) the number 10E12 with a print-size characters (say, 10 characters per inch) we need a paper tape with a length a few times greater than the Earth–Moon distance (!). And when we talk about distances such as 10E10E12 (10^10^12), particular units of length are irrelevant. There are 10E51 Planck units in one light year, so the conversion from light years to the Planck units only adds 51 more zeros to the string of zeros printed by a normal size (newspaper) fonts on a paper tape, which *itself* is about a *million kilometers* long. Would you care about 5 extra cm if you have to walk a road that runs for a million kilometers? This is one of the peculiar features of the tower exponential numbers (Knuth, 1976; Berezin, 1987g; Bloch, 2008).

To remind, the tower exponential function, T(N) is defined by the recursive relation, T(N+1) = 10^T(N); T(1) = 10, T(2) = 10^10, T(3) = 10^10^10 [that is 10 in the power 10,000,000,000] and so on.

And that is not the end of the story (actually, this story has no "end"). Take, for example, the famous Skewes number (Skewes, 1933, 1955). It is 10^10^10^34 (or 10E10E10E24) that we talked about before (Sections 3.6 and 8.5). It is four-story tower exponent (TE). It is "1" followed by 10E10E34 zeros (that is, just the *number* of zeros is 10 to the power 10^34). If we fill the whole ("our," or "Big Bang") universe with (cramped) paper tape, we will still not have enough length just to *write down* the Skewes number. Not even anywhere close. The volume of our universe is some 10E90 mm^3 and hence such a whole-universe-tape will only have enough room for some

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10E90 or 10E92 zeros (depends how we crump the paper). That is a negligible fraction of 10E10E34.

And from that we can go as far as we want. Introduce a simple-to-write tower exponential function T(N) = 10^10…^10 (where "10" repeated N times). For example, T(1) = 10, T(2) = 10^10 = 10E10 = 10,000,000,000 (10 billions), and so on. To write T(4) = 10^T(3), we need a tape about the length of an equator (40,000 km), and T(5) is unwritable even if the whole universe is filled with a cramped paper.

Rephrasing Morrisons, what is the structure of the universe at each next T(N) scale? Can we say anything sensible of, say, universe at T(1000) scale? Here T(1000) is a stack of 1,000 "10s". So it is 1,000 levels tower exponent, whereas the Skewes number 10^10^10^34 has only 4 levels and yet it is fantastically larger than the number of atoms in the universe! Then, what about T[T(1000)], and any other similar monsters?

Carl Sagan in his *The Demon_Haunted World* poses some "random" questions, as, for example, (1) "could there be undiscovered integer between 6 and 7?" or (2) "could there be undiscovered chemical element between atomic number 6 (which is carbon) and 7 (which is nitrogen)?" Here (1) and (2) exemplify "metaphysical" (M) and "physical" (P) quests in their extremes, whereas the sequence of frames in Morrisons' book admits interpretation as a gradual sliding from P to M.

Infinitely structured Platonic mathematical "field" (distribution of prime numbers, digits of π, etc.) is a universal foundation here. It implies some kind of activation energy (and hence "quantization" with, perhaps variable, "Planck's constant"). The "clustering" of primes, or their reciprocals (infinite fluctuations from prime number [n/log(n)] theorem) at TE scales, suggests that the density of states has unlimited (asymptotically) up-and-down scaling that invokes complementarity of a "free will" and "deterministic chaos."

The emanation of entire *aleph-naught field* (ANF) at any point is an analogue of *Huygens principle* for "proto-field". Likewise, *Bohm's quantum potential* (BQP), may lie half way between "pure" P (physics) and "pure" M (metaphysics) extremes (to remind, the *Huygens principle* tells us that every point of the wave front acts as an independent source of secondary waves. This is how the light propagated according to the wave theory of light).

In quantum superpositions, the effects of "quantum entanglement" (connection of disjoint particles and objects) remain active at any distance. One example is singlet–triplet splitting in diatomic molecules (Berezin, 1972) that asymptotically tend to zero, whereas the orthogonality of quantum states remains intact. Likewise, at any (N-dimensional) "distance," ANF and BQP maintain full power for pattern emergence ("M-to-P-transition").

This suggests some sort of cyclic condition at tower exponential upscaling and an antidote to "cyclic universe" (e.g., discussions of an infinite capacity for emergence *a-la* Jorge Luis Borges, *Babylonian library*).

And still, the question "how the uni (mega) verse would look at *this* [say, T(T(1000)), or what] scale?" is a fully valid question. Such a question (never mind

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that it may be unanswerable practically), still remains totally legitimate both logically and physically. Same as it is logically and mathematically correct to ask the question “what is the last 20 (decimal) digits of the T(T(1000))th prime number?” And if we can take a snapshot of the universe at any of the above-mentioned scales, how it will look? A perfectly uniform? With some visible structure?

If the (infinite) megaverse has some sort of a fractal structure (Tegmark, 2014), maybe we can see its self-similarity at each scale of space and time? After all, there *must* be some structure of the megaverse at *any* scale, yes? (Can anyone disprove such a statement?). And, furthermore, space (and time?) can well be multidimensional at such gross scales. And if we take as a prime axiom the *infinity* of the entire universe (of which “our” “Big Bang universe”[BBU] is just a tiny speck), then such questions posed for any theoretically conceivable scale are scientifically legitimate, yet, perhaps, practically unanswerable.

9.2 Quantum cats and Maxwell demons

Who have not heard of a Schrödinger’s cat and/or a Maxwell’s demon (MD)? Both of them are important playing partners of modern physics. The first one is a somewhat sinister illustration of the main principle of quantum mechanics – the superposition principle. Quantum particles (and, perhaps, we too) can be in many places in the same time. Why it is “sinister?” Its “creator” was Erwin Schrodinger (1887–1961, Nobel Prize in 1933), one of the founders of quantum physics.

Main equation of quantum mechanics is called *Schrödinger equation*) and his “cat” is as an illustration of the *quantum superposition principle*. This is an imaginary cat that can simultaneously be in two states: alive and dead. How? It the second state (as dead), the cat is killed by poison kept in the glass jar broken by a hammer that is put in action by some random quantum process (decay of a radioactive isotope). In the first state, the glass jar is not broken (isotope does not decay) and the kitty remains alive and well.

Yes, killing cats is not a very pleasant thing (even in imaginary experiments with quantum randomness, not to mention veterinarians), and some people may find this example ethically unappealing. Yet, it gives a powerful imagery of the superposition principle and, as a result, this Schrödinger pussy has her invariable and well-deserved presence in almost any book on quantum physics.

Another popular animal friend in the physics world is MD (Berezin and Nakhmanson 1990; Leff and Rex 1990). No, he/she is not a “medical doctor,” that is what “MD” commonly means. He is a somewhat older gentleman (or, should I say, a lady to be politically correct?). This MD came to the scene even before the start of the quantum age. He/she was introduced to the club (do demons need introductions?) by a great Scottish physicist James Clerk Maxwell (1831–1879) – the author of the famous

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“Maxwell’s equations” – the central tool in the theory of electromagnetism. He would most certainly got a Nobel Prize for it, should they had exist in his time (Nobel Prizes started in 1901).

But the MD is the player not in the electromagnetism, but in statistical physics – another area where Maxwell did the fundamental work (his famous Maxwell’s distribution). Unquestionably, Maxwell would get a second Nobel for it.

So, this guy, MD, sits on the borderline between statistical physics and information theory. He or she is in no way an “evil” character (that’s what some demons are thought to be). On the contrary, MD is a physics-friendly guy (gal) who can determine parameters of the individual atomic particles without disturbing their motion.

By operating a shutter, MD can separate fast and slow molecules in the gas and in doing so, he/she can allegedly violate the second law of thermodynamics (the law of entropy). This is a little trick that our friend, MD, is supposed to be able to do. Yet, there are serious problems with the said ability of MD; these problems are coming from the theory of information and quantum observation effects. For more info on MD and the pictures, you can find plenty of both on the web.

9.3 Common-sense nonlocality: magnetism

Quantum physics as it is understood today is a theoretical construct that makes a strong emphasis on the so-called nonlocality. By “nonlocality” we mean the existing tangible connection between objects that are separated by large (often – arbitrary large) distance. There are numerous discussions on the nature of quantum nonlocality between microparticles (electrons, photons, and atoms) separated by large distances (Bohm, 1980; Bell, 1988; Bohm and Hiley, 1993; Deutsch, 1997; Grib and Rodrigues, 1999).

Nonlocality often goes under the term *quantum entanglement* (Selleri, 1990), and quantum interconnectedness effects have recently come into the focus in a variety of areas from quantum informatics to nanotechnology and biomedical sciences. For surfaces and contacts of micro- and nanoscale devices, quantum nonlocality effects open another exploratory area (Berezin, 2011). However, there is even a better introduction to the idea of nonlocality that we all have easily at hands: magnetism.

We, as children and adults alike, love to play with magnets. When we take two magnets and try to move them together with the same poles facing each other, we feel that they resist. It is like there some elastic spring is placed between them that we are trying to compress. But there is nothing (*nothing*!) visible between them! And this will certainly work the same way in a vacuum when there is no air around. Of course, thanks to Maxwell and many others, there is a formal theory of magnetism that talks about the energy of the magnetic field and has a good mathematical description of

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magnetic actions and all of that. And yet, it does not help much to our direct feelings and senses to comprehend this phenomenon. We still remain openmouthed and puzzled with this enigma: how do these magnets "know" of each other, how do they communicate?

While these effects were discovered and described long before the advent of quantum physics (or even, *any* physics for that matter), they can be seen as down-to-earth illustrations of nonlocal effects. Magnetism as a precursor of (quantum) nonlocality, and the very idea of a "field" (be it magnetic, electrostatic, or gravitational) has an inherent notion of nonlocality built in it. And from these analogies, we can move to quantum nonlocalities in a proper sense. To this, we can add the so-called morphogenetic field(s) proposed by Rupert Sheldrake (Sheldrake, 1988) of which a few more words are discussed later in this book.

More examples of "nonlocality" (although in some metaphorical sense) can even be found in the area of our human perceptions. A popular illustration of this kind of nonphysical "nonlocality" may be a rainbow. We see a rainbow in the sky, as if it is "up there". And we perceive it as a "whole", as some kind of a connected object.

But as Allen Utke argues (Utke, 1996), in reality, the rainbow is the result of some spectral perception in our eyes. And if we will fly to the sky (say, by a helicopter) to "catch up" a rainbow, we will find nothing except of a moist air. The rainbow "exists" as a result of the game of waves of light in our eyes and their processing by our brain/mind. It is a bit like those objects that we see in a mirror, they do not actually "exist" in the mirror but only in our perceptive system.

9.4 We are quantum waves

A physicist is just an atom's way of looking at itself.
Niels Bohr (1885–1962)

In my experience, many people are scared of physics. For many times, I head things like this: "Oh, I don't understand physics, it is soooo hard, etc., etc." Sometimes, I heard even "I hate physics." Yet, there are still T-short with Albert Einstein. Go figure...

However, the fact is that much contrary to all such sentiments, physics, actually, is pretty simple. Unless you are talking about pages and pages of incomprehensible equations from the *Journal of Mathematical Physics* and alike, the *principles* of physics and the *facts* of the physical world are really quite simple and lucid.

What the *superposition principle* of quantum mechanics really says is that all possibilities do coexist before the choice is made. In the famous double experiment, the beam of electrons is shone on the screen with two slits. Common sense tells us that each electron ("a little ball") can pass only through one of the slits. It is like if you go

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to (say) a concert hall with several entrance doors, you can only enter through one of them. You can't enter through two doors simultaneously, that is absurd. Yet, electrons do precisely can pass through both slits simultaneously. Not as particles ("balls"), but as waves.

Yes, small particles, like electrons or photons (quants of light) have a double nature – as particles *and/or* waves. This is called *wave–particle duality*. What of these two aspects (particle *or* wave) turns out as a prime characteristic depends on the circumstances (e.g., how the measuring experiment is set up). But bigger objects, including ourselves, also have this double nature! We both are "particles" (though pretty heavy by atomic standards!) and waves. And the faster we move, the shorter our wavelength is. We (as any material object) obey the same universal relationship between the velocity and the wavelength. It is called de Broglie relationship, by the name of the physicist Louis de Broglie (1892–1987; Nobel Prize 1929). It has a very simple formula for it:

$$L(\text{Lambda}) = h/(mV) \tag{9.1}$$

where "h" is the Planck's constant, "m" is the mass of a particle or an object, "V" is the velocity, and "L" (lambda) is the quantum wavelength, which is known as "de Broglie wavelength."

The above-mentioned *de Broglie relationship* works for any moving object. And as a matter of interesting curiosity, it was mentioned (Wadlinger and Hunter, 1990; Zeilinger, 1990) that the value of de Broglie wavelength (Lambda) for a person weighting 70 kg (average adult weight) and walking with a typical speed of 2 ft. (0.6 m)/s, will be about the *same* as the value of the Planck length (1.6*10^–35 m).

Taking into account that Planck length is fantastically small (see Chapter 5 and equation [5.2]), this amazing coincidence, as the above-mentioned authors suggest, is not just a random fact, but may indicate a deep connection between our human existence and super-small scales of ultra-sub-nuclear world. The amazing coincidence that the de Broglie wavelength of walking human is of the same order as Planck's length led the above-mentioned authors introduce the term *homo sapiens wavelength* (Wadlinger and Hunter, 1990).

Yet, on a more practical level, our "quantum wavy nature" lies in the choices that we make. Suppose, you plan your weekend. Many options, shopping, movie, park, sport, spa, visiting friends, and so on are normally open to you. But before the actual choice is made, all these options coexist as *potentialia*. You are a "wave" at this stage. After the option is selected, your further behavior becomes particle like: you go for the option that you have chosen.

And this wave–particle duality comes in million forms and on all scales. Virtually, every minute, if not second. What jacket of blouse to put on today. To drop a quarter to the cap of a subway musician or pass by. How much milk to add to our coffee? Every atom counts and every atom changes the universe!

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9.5 Multiverse and living cosmos

> *We are an impossibility in an impossible universe.*
> Ray Bradbury (1920–2012)

But more to this. Coexistence of all possibilities of all possible outcomes of any situation comes to any part of the universe. For all scales, objects and creatures. For all of us. Every step, every second. This mighty superposition principle applies well outside physics to human situations, our thoughts, desires, dreams, choices, and so on.

And "our" universe splits itself on uncountable number of parallel universes every moment, every microsecond. This is the many-world interpretation of quantum mechanics proposed in 1957 by Hugh Everett (1930–1982). Adding to this, are recent developments, such as "inflationary cosmological models," that are discussed by numerous authors (Andrej Linde, Alan Guth, Richard Gott, and others).

Parallel universes, the infinite universe, is all there, yet it is (physically and metaphysically) a "connected whole" through the principle of oneness. The metaphysical oneness of everything. And the universal connecter here is the ideal Platonic world and its prime actor – the infinity of prime numbers. No matter to what fantastic branch of multiverse we can get, the prime numbers are all there and all the same and unchangeable. Like a most faithful friend, they never betray us, we can always reply on them for all our hopes and dreams.

Many-worlds (Multiverse) theory of Hugh Everett brings us to the gates of eternity. We all exist in many, infinitely many, copies with all possible variations in our destinies. Through quantum entanglement and universal connectedness, we access the reality of the imaginary worlds. This is a multidimensional *quantum Narnia*: we *really* do exist in parallel (quantum) realities. And like in C.S. Lewis story, the wardrobes to get there are everywhere around. And here we can talk and contemplate more on quantum tunneling to parallel universes. Wormholes and "individual black holes," and all these fascinating and eternally optimistic things are all here in this nonstop multidimensional show.

9.6 We are eternal

Like the prime numbers, we are eternal. Not in a metaphorical sense, but in a real one. That is what Robert Lanza and Robert Berman tell in their recent hit "Biocentrism":

> The question, "What is it like after you die?" can make you wonder about taking the time to ponder such philosophical babble. You might reply, "The only way to know is when you die." Not so. You won't know any more than you do now. Increasingly, scientists are beginning to realize that an infinite number of realities may exist outside our old classical way of thinking. ...) we genome-based creatures all share a common biological (spatio-temporal) information-processing

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> ability. I‘ve previously written how reality isn‘t a hard, cold thing, but rather an active process that involves our consciousness. According to biocentrism, space and time are simply the tools our mind uses to weave information together into a coherent experience – they are the language of consciousness (in fact, in dreams your mind uses the same algorithms to create a spatio-temporal reality that is as real, 3-D and flesh-and-blood as the one you‘re experiencing now). “It will remain remarkable,” said Nobel physicist Eugene Wigner, referring to a long list of scientific experiments, “that the very study of the external world led to the conclusion that the content of the consciousness is an ultimate reality.” At death there is a break in our linear stream of consciousness, and thus a break in the linear connection of times and places. Indeed, biocentrism suggests it‘s a manifold that leads to all physical possibilities. More and more physicists are beginning to accept the “many-worlds” interpretation of quantum physics, which states that there are an infinite number of universes. Everything that can possibly happen occurs in some universe. Death doesn‘t exist in these scenarios, since all of them exist simultaneously regardless of what happens in any of them. The “me” feeling is just energy operating in the brain. But energy never dies; it cannot be destroyed.
>
> Lanza and Berman Biocentrism: How Life and Consciousness Are the Keys to Understanding the True Nature of the Universe (Lanza and Berman, 2009).

And while physicists argue all this from the science side, the artistic imagery had the same notions of our eternity for centuries. Imaginary art, surrealism, fractal art (like infinitely deep patterns of Mandelbrot sets, etc.) – all brings the same message in many different forms. To this we can add music, science fiction, and romantic literature and perhaps even such forms of human expression as dance. All point to the absolute values and bear the signatures of eternity.

9.7 Are “same” particles “same”?

Richard Feynman (1918–1988) was once asked the following hypothetical question. Suppose, at some point the whole humankind and all our civilization will disappear and we can leave only one short message (one sentence) to a (hypothetical) civilization of some future living beings that may emerge after us. What such a sentence (in Feynman’s opinion) will be?

To this Feynman replied: “Everything is made of atoms.” Yes, these 5 words (in Russian language you can say it in just 4 words) give the most important result of what our science has achieved to this point. And what the second sentence in such a quest would be?

Not claiming equal fame with Richard Feynman (but, on the other hand, why not? – aren’t we all supposed to be “equal” in our age of universal human rights?), I, Alex Berezin, can propose that my own “second sentence” will be “All Atoms have Isotopes.” And now we go to the next quest “Are all (same) atoms (isotopes) indeed same?”

Among the most important and commonly held assumptions of modern physics is the principle of quantum indistinguishability of the elementary particles. Within

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the conceptual framework of the present-day quantum physics, identical elementary particles (electrons, protons, neutrons, etc.) are supposed to be "exactly" the same. They are not allowed to carry any "personal labels" and, correspondingly, the interchange of any two particles of the same category (e.g., two protons) does not lead to any observable physical changes. Therefore, physically speaking, such permutation is a "non-event." Similar indistinguishability applies to identical atoms and molecules.

According to this principle, if two particles (say, two electrons, call them A and B) are colliding and then fly apart, it is impossible to say which of them "was" A and which "was" B. This indistinguishability is well reflected in the mathematical apparatus of quantum physics (the symmetry properties of the multiparticle wave functions).

This "sameness" of elementary particles is usually taken for granted and is supported by authoritative philosophical arguments (e.g., Popper and Eccles, 1977, p.71). Nevertheless, at its very foundations, the principle of quantum indistinguishability is far from trivial. Although at the present time there seems to be no strong experimental or theoretical motivations for a radical rejection of this principle, there are some continuing ongoing attempts to challenge it, or at least to suggest some amendments to it. At the present moment, any admission of individual characteristics of elementary particles will likely require a major revision of the basic principles of quantum physics (as we have them now, but who says that "principles" can never be changed? – in real life they often do).

In view of this (relatively complicated and problematic) situation, such seemingly odd and fancy trend as to look for possible "individual" features of microscopic particles culturally (and even to some extent scientifically!) is quite understandable. (Berezin and Nakhmanson, 1990). Indeed, almost all "serial" entities that we know from our direct experience have individual variations. People or animals of the same biological species are never exactly the same. Even twins, people or cats, are not exactly the same. So are all other tangible and intangible, natural or man-made objects, from snowflakes or hamburgers to stars and galaxies. No two of them are ever exactly identical. As a result, it might be even quite humanly natural to feel some kind of antipathy toward the theories that deprive elementary particles of their "individual rights."

An example of such attempts to attribute some sort of personal labels to atomic particles is a long-standing issue of "hidden parameters" initiated by David Bohm (1917–1992) many years ago (Bohm, 1952; Weber, 1987; Bohm and Hiley, 1993). In a rather crude and largely metaphorical sense, hidden parameters can be portrayed as changeable individual features of particles. In the last decades, the issue of the existence (or not) of hidden parameters was put into a relationship with a so-called Bell's theorem (Bell, 1988; Deutsch, 1997).

Numerous recent experiments on quantum correlations seem to suggest that hidden variables could not be consistently kept in theory as local (particle specific) labels and the widespread trend now is to interpret these experiments as confirming to the existence of quantum nonlocalities. This change of emphasis, however, does

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not discard the issue of particles' "individuality," but rather moves it into another domain related to nonlocal interparticle connectivity.

9.8 Quantum statistics and isotopic individuality

At the present time, the whole matter of quantum nonlocalities remains a hot scientific topic with a high likelihood of unforeseen twists in the forthcoming experiments and interpretations. Fortunately, however, in the context of isotopic diversity and isotopic patterning (Berezin, 2015, 2016), the issue of a proper interpretation of hidden variables and nonlocal quantum correlations is relatively peripheral. Isotopes, as *classically distinguishable* (!) particles, are quite robust ("insensitive") to these issues. Isotopic diversity (*isotopicity*), to some extent, breaks down the above-described quantum indistinguishability of identical atoms.

Contrary to a quantum indistinguishability of identical microspecies, nuclei of different isotopes are classically distinguishable particles (word "classically" means here that they are different entities even from the point of view of classical physics). Therefore, structurally identical micro-objects (molecules, atomic clusters, etc.) having different isotopic configurations do indeed attain some degree of "individuality." Isotopes can be freely moved and rearranged within chemically fixed structures and this leads to microscopically distinguishable patterns.

Furthermore, such isotopic pattern can be informationally loaded, that is, it can store some externally input information that will be coded in a specificity of isotopic distribution. It is important to note that "isotopic freedom" (possibility of isotopic permutations between the sites of the same chemical element) exists within the constraints of a chemically fixed (in terms of given chemical bonds) structure. The latter remark applies not only to solid crystal lattices, but also (to some degree) to quasi-crystalline structures of liquid systems. The latter case may be relevant to the ideas of water memory and the information stored in the (so-called) "homeopathic solutions" (Berezin, 1990a, 1990b, 1994c, 2015, 2016). More on water memory will be discussed in the next chapter.

One specific example of the spontaneous pattern formation, especially worthy to be mentioned in a homeopathic context, is the so-called oscillatory patterning in minerals. Characteristic features of oscillatory patterning in natural crystals may vary over several orders of magnitude – from macroscales (i.e., centimeters or even meters) to micrometers (and, probably, down to nanometers, i.e., to atomic scales).

A similar patterning sustainable over a wide range of scales might be a characteristic feature of a robustness of the homeopathic efficacy upon dilution (Berezin, 1994c). The point of importance for us here is that (contrary to a popular belief), an oscillatory zoning in minerals is not always caused by varying sedimentation conditions, but may also (at least in some instances) be interpreted as spontaneous pattern

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formation in a system governed by nonlinear kinetic equations (Turing, 1952; Nicolis and Prigogine, 1977; Haken, 1978).

Generically, positional isotopic correlations in various condensed matter systems may originate by several alternative (or complimentary) scenarios. Additionally, to a spontaneous patterning in nonlinear nonequilibrium systems of distinguishable species (due to, e.g., mass differences), isotopic variations in diffusion rates can also result as a consequence of the Pauli exclusion principle. This principle governs the structure of electronic shells in atoms and is one of the foundations of the periodical law of chemical elements. Quantum statistics divides all particles in two categories – *fermions* and *bosons*. Bosons have an integer spin; it obeys Bose–Einstein statistics and disrespects Pauli principle. The fermions have half-integer spin, obey Fermi–Dirac statistics and follow the restrictions on the occupation of quantum states imposed by Pauli principle.

It is peculiar that different isotopes of the same element may obey different quantum statistics. For example, oxygen isotopes 16O and 18O have even number of nucleons and therefore behave as bosons, whereas isotope 17O with an odd number of nucleons is a fermion. Likewise, 12C isotope is a boson and 13C is a fermion. This discrimination by statistics among the atoms of the same element may result in further (additionally to the mass effect) isotopic variations of tunneling rates and lead to a buildup of spatial isotopic nonuniformities of a varying size.

9.9 Maxwell demon plays with isotopes

As was mentioned above, James Clerk Maxwell, discussing the second law of thermodynamics (or, perhaps, better to call it “principle”), introduced his famous “demon” – an imaginary intelligent being of a molecular size. By its definition, MD sees individual atoms or molecules and can change their trajectories at his will (Ehrenberg, 1967; Leff and Rex, 1990). For instance, he/she can let fast molecules pass through the gate while stopping slow molecules by shutting the gate.

The prime purpose of such a personification was to sharpen the logical tensions between statistical and informational aspects of the second law of thermodynamics (Haken, 1978; Gleick, 1988; Allahverdyan and Nieuwenhuizen, 2006; Gray, 2009).

MD can seemingly decrease the total entropy of the system. Despite an apparent fictional nature of this concept (but again, who knows?), MD (and its quantum mechanical relatives) keeps embarrassing physicists till today as there seem to be no sufficient arguments to convincingly rule him (them) out (Berezin and Nakhmanson, 1990).

Another well-known and related image akin to MD is a notion of the “wave-pilot” introduced by Louis de Broglie. With some imagination, an elementary particle can be seen as a kind of a microcosmic spaceship moving through the microcosm

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for the purpose of investigation, patrolling, and so on, and guided by a “captain” (similar to our astronaut or computer). The “captain” navigates his ship according to the set course with random deviations. The course and the part played by choice are defined by goal of the trip, initial conditions of motion, and some principles of motion (for example, the least action principle, or other optimization strategies), whereas the deviations are given by a random function generated at every moment of time.

In this visualization, the PSI-function (the main theoretical construct to describe particles in quantum mechanics) can be related to the manifold of diverging roads in the field. In physics, this picture corresponds to Feynman paths, whereas in literature there are other, less physical, examples for this. For instance, the novella *The Garden of Forking Paths* by Jorge Luis Borges (Borges, 1998) talks about numerous alternative paths. Each “road” in such “journeys” is provided with an inscription plaque telling what would be, roughly, the destiny of the traveler choosing it, and the “captain” makes his choice by casting lots taking into account these inscriptions.

Looking more specifically to crystal examples, we can build a bridge between Isotopic Randomness and MD in the following way. Isotopic disorder in crystals can lead to suppression of thermal conductivity (Klemens, 1981), as well as to lead to the mobility variations and (weak) Anderson localization on isotopic fluctuations. The latter (Berezin, 1984f) is akin to the polaron effect (self-localization due polarization).

Possibility of isotopic patterning increases near melting point (thermally activated isotopic hopping swaps). Crystal near melting threshold become “informationally sensitive” as if its isotopic patterning is operated by some external MD. In this case, it will be more appropriate to call this gentleman (or a lady?) *Isotopic MD* to account for his (her) capacity to distinguish between different stable isotopes of the same element.

At the situations described above, the short range (e.g., electrostatic inverse square) forces may evolve into the long-range interactions (due to the divergence of the order parameter) and the information sensitivity can be further amplified by (say) a single fast electron (e.g., beta particle from the decay of 14C or another radioactive isotope). This, in turn, may result in a cascade of impact ionization events and (short timescale) enhancement of screening by impact-generated nonequilibrium (nonthermal) electrons.

In this state, the informationally driven (MD-controlled) isotopic patterning (Eccles effect) can result in a decrease of positional entropy signifying the emergence of the physical complexity out of pure information. This is the “Eccles effect” (Eccles, 1986). In a word, Eccles effect is a direct action of consciousness on the physical reality at the atomic level. It bears some similarity to the above-mentioned peculiar “jinni effect” on closed time loops in relativistic cosmology (Davies, 1993, 2002; Gott and Li, 1998; Yourgrau, 1999; Gott, 2002), or to Wheeler’s “It from Bit” metaphor (Wheeler, 1988; Wilczek, 1999).

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It is instructive to look at isotopic MD from the point of view of the neutron tunneling between isotopes (Berezin, 1992a). Can isotopic MD (even if he/she/it is understood in virtual terms) exponentially enhance the (normally negligibly low) quantum probability of such tunneling? Considering such an abnormally high (by the common quantum estimates) neutron tunneling event as a large-scale fluctuation, MD can be called upon to "help" such a fluctuation to occur by the way of selective (stroboscopic, so to say) observations (Ehrenberg, 1967).

Alternatively, we can conceptualize quantum MD who will be manipulating probabilities of quantum events in favor of giving a greater weight to low probability processes. Clearly our family of demons keeps growing! Perhaps, for its operation quantum Maxwell's demon (QMD) needs to use a much smaller spatial and timescale than the atomic events. Maybe, QMD even actually operates at the level of Planck's length and/or Planck's time (1/E35 m and 1/E43 s, respectively). Can we ever detect QMD there, or, perhaps, even cooperate with him/her/it? Of course, this remains an open quest at this point.

9.10 Beyond the threshold

The problem of the "ultimate fate" or "ultimate disposal" of gained experience can be traced back to ancient times. Recently modern physics, somewhat unexpectedly and acutely, reinjected fuel into this problem by formulating the issue of the evaporation of cosmological black holes and the nature of time (Penrose, 1989a). This problem is akin to questions such as the already mentioned quest "Why is there something rather than nothing" (Stannard, 1993).

Such an approach puts the notion of ultimacy in the context of the nature of time and cosmic dynamics (e.g., Peirls, 1991). Several ideas that may be quite important for the ultimate reality and meaning (URAM) problem were introduced into scientific circulation from theoretical astrophysics and cosmology. Two of them are, perhaps, central to this discussion.

The first is the idea (speculative at this point) of an unstoppable and omnipresent "breeding" of the universes. This process is believed to go through the relativistic effects related to time-space-energy fluctuations at extremely small (Planck) scales (Penrose, 1989a, 1994; Linde, 1994; Deutsch, 1997; Garriga and Vilenkin, 2001).

This results in a model of "cosmic inflation" and a connected spatiotemporal "foam" of "baby universes." The hierarchy of these "foam universes" is likely infinite, and they exponentially breed in the manner describable by the tower exponents (Knuth, 1976; Dyson, 1979a; Berezin, 1987g). These universes keep breeding all the time (whatever the definition of "time" we use here), and there is infinity of such parallel universes.

According to the most radical versions of these views, in virtually every spot and in every instant the "new" and "full-right" universes are created as tiny black

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holes enclosed in themselves. In a fraction of a microsecond (by "our" time count), these universes pass all the stages of cosmic evolution, similar to our post-Big-Bang expansion. This "Russian doll" hierarchy of the universes (each has "its own" time and space) is infinite in both directions. A vivid metaphor for this scenario will be to extrapolate *ad infinitum* the book *Gulliver's Travels* by Jonathan Swift in both directions.

Another metaphor is a "fractal symmetry" of powers of ten, that is...10^–3, 10^–2, 10^–1, 1, 10, 10^2, 10^3... .This string is, of course, infinite (scale invariant) in both directions (Dyson, 1988).

The tricky question here is whether the "number" of such "baby universes" keep increasing at every instant. Looks like, if you breed something, you increase the total score. But, alas! Because there is "already" infinity of them, adding more and more of them does not change their "total number"! Why? Because, adding anything to infinity does not make it any "greater." It is still the same infinity, whether it is a countable infinity (*aleph-zero* in Cantor's terminology), or uncountable (*aleph-one*), or (even) any other higher class of infinity (in Cantor's set theory, the hierarchy of infinities is itself infinite!).

It is almost inevitable that the contemplation of "our" universe as just being a tiny instant bubble in this mega chain of baby universes puts a heavy constraint upon any scientific thinking. How are the experiences gained in each and every one of the myriads of these universes, completely isolated from each other, communicated and eternalized in all other universes? Perhaps, the only available route hear is the ideal and infinite Platonic world (IPW) with such "items" of it as the infinite and eternal pattern of prime numbers. But how the communication though the Platonic world can really (physically) proceed? That remains an open quest for our contemplations and metaphysical insights.

The second (and seemingly even more "dangerous" notion is the ultimate "destruction" of information inside the black hole. Modern cosmology admits a finite possibility that a black hole would "evaporate" (Penrose, 1989a). From the point of view of an observer in the "embedding" universe, such evaporation of a black hole would forever destroy all its informational content.

Thus, all the experience gained inside this "evaporating universe" (which appears as a black hole to the outside observer), would vanish from the network of Baby Universes. The eternalization and/or "eschatologization" of the informational content could probably be imagined along some non-material (spiritual) lines, or by using other metaphysical tools of an equivalent nature. This whole issue should, I believe, constitute an open challenge to the thinkers on Ultimate Reality and Meaning (URAM) problems (Berezin, 1994b, 2015, 2016).

Likewise, the artistic imagery of alternative realities (Surrealism, Visionary Art, Yves Tanguy, Salvador Dali, etc.) can provide an insightful asset to the meditations on these issues. Especially, if artistic vision is combined with contemplations on the IPW and the infinite eternal sequence of prime numbers.

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9.11 Isotopicity and quasi-stationary states

One bridge that can be suggested as relating *isotopicity* and *quantum nonlocality* can be built on the foundation of nonstationary (quasi-stationary) states. Speaking thermodynamically, isotopically mixed system is almost always a nonequilibrium system in some kind of an excited (metastable or quasi-stationary) state above its true ground level. Therefore, such a situation can be commonly classified as a spatially extended nonequilibrium nonlinear system. This means, the quantum state of such systems is not exactly a genuine ground state. For example, any crystal containing oxygen is like this. It is energetically possible for the reaction of isotopic rearrangement to go spontaneously through tunneling of a neutron from one 17O-nucleus to another 17O-nucleus. The reason for this is that in this particular set of isotopes the asymmetric state ("16"+18") has lower total energy than the symmetrical state ("17"+"17").

Owing to this, we can expect that the asymmetrical quantum superposition may form spontaneously to attain the true ground state. It well may take cosmological (or, perhaps, super-cosmological) timescale since neutron tunneling is very slow (due to heavy neutron mass and high potential barriers in nuclei), yet it can, hypothetically at least, be (exponentially) accelerated by the Penrose-type gravity quantum reduction mechanism.

$$17O + 17O \rightarrow 16O + 18O \tag{9.2}$$

In the above-mentioned example, the reaction of isotopic rearrangement goes spontaneously through tunneling of a neutron from 17O-nucleus to another 17O-nucleus (Jiang and Berezin, 1998). This, again, is an example of a spontaneous symmetry breaking when a symmetrical system (both atoms are "17") transforms itself spontaneously to an asymmetric one ("16" + "18"). On the basis of the total binding energy of these nuclei, it is easy to show that such a reaction is exothermic (with a release of extra energy). The excess of energy released in such reactions can, in principle, dissipate to low-grade forms (such as crystal lattice vibrations) instead of being emitted as a high-energy gamma photon.

Tables of stable isotopes are among standard physics data available in many forms. They normally list stable isotopes of all elements along with total energies of each isotopic species. For example, for 3 stable isotopes of oxygen, 16O, 17O, and 18O, the total energies (in a.m.u. – atomic unit of mass) are 15.994915, 16.999132, and 17.999160, respectively (for atoms the atomic unit of mass is defined as 1/12 of the mass of 12C atom, its energy equivalent is 931.5 MeV; MeV is megaelectron volt). It is easy to calculate that the energy release in the reaction (9.2) is 0.004189 atomic units or 3.9 MeV, a pretty large energy at the atomic scale.

To take this value into a common perception, it is easy to estimate that 1L of 17O-water (all oxygen atoms in it are 17O) can (at least, in principle) produce, due to

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reaction (9.2), an energy release of 2 · 10E13 J, which is equivalent to burning of about 650 m^3 (!) of gasoline. The corresponding energy release of just 1 mL (milliliter = 1 cm^3) of 17O-water is 2 · 10E10 J (20 billion J). This is the energy that is equivalent to the kinetic energy of 20 jet aircrafts (kinetic energy of one jet is about 10E9, one billion J). Likewise, a reader can easily calculate what would be an energy equivalent of a standard bar shot (30 mL, an ounce) of 17O-water.

To make this estimate even more impressive we can look at all water on Earth. The total volume of Earth's hydrosphere is about 1.3 · 10E9 km^3. That is 1.3 billion km^3, or 1.3 · 10E21 L. Thus, considering that the natural abundance of 17O isotope is 0.039% (1 atom of 17O per 2,560 all oxygen atoms), we can estimate that if all the water on Earth will go through the reaction given by equation (9.2), it will amount to the total energy release of some 10E31 J. For comparison, the total annual global energy used by humans is about 5 · 10E20 J. And the above-mentioned estimate (10E31 J) refers only to reaction (9.2) involving oxygen isotopes; the total energy of the hydrosphere that can be released by the hydrogen fusion is estimated as 10E34 J.

Therefore, such a reaction can go spontaneously due to the energy minimization principle, no matter how "difficult" it may be for a neutron to tunnel from one 17O nucleus to another 17O nucleus. However, in physics, there are cases when the energy needed for a particle to tunnel through a potential barrier can be obtained from other sources in the system. For example, a multicenter Auger effect (Berezin, 1969), or stray cosmic particles that can bring an extra energy. Or, perhaps, some kind of a "MD" (Leff and Rex, 1990) can be a convenient delivery service for it, as it can play well with the law of entropy.

Or perhaps, some clever manipulation of quantum nonlocalities can enhance tunneling probability from (tower)-exponentially small to (almost) macroscopic ranges. In this case, such reactions may proceed at our (human) timescales (macroscopic) as was suggested by Luis Kervran in his work on the alleged biological nuclear transmutations (Kervran, 1972).

Similar acts of neutron tunneling can be responsible for effects of nuclear transmutations in palladium-based systems (like Pd-D) that were used in claims of cold nuclear fusion. (Pons and Fleishmann in 1989 and later claims) Some research activity in this controversial area of low-energy nuclear reactions still goes on at a few isolated places. The author of this book takes no personal position on the issue considering that, in his opinion, the "pros" and "cons" theoretical arguments for this are approximately of the same weight.

The above-described reaction of the spontaneous neutron tunneling in the system of oxygen isotopes is just one of many possible reactions of this kind. If a chemical element has several stable isotopes (as many elements do), then there is always a "lowest energy" combination that can (at least in principle) be reached through neutron hopping from one nucleus to another. Such a possibility exists for any element with at least three stable isotopes with consecutive atomic numbers (e.g., O, Mg, and Si).

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For example, for magnesium (stable isotopes are 24Mg, 25Mg, and 26Mg) isotopic pair such as (24Mg, 26Mg) and (25Mg, 25Mg) are mutually convertible into each other through a single neutron tunneling jump. The dependence of two pairs on each other have lower total energy, the reaction (24Mg, 26Mg) $\leftrightarrow$ (25Mg, 25Mg) is exothermic in either right or left direction. In either of these cases the reaction can be sufficed by a single neutron tunneling – either from 26Mg to 24 Mg or from a single 25Mg to another 25Mg. For elements with even greater number of stable isotopes many more combinations are possible, some may involve more than two participating centers. This is physically similar to the correlated electron tunneling in poly-center systems of impurities in crystals the theory of which was developed by this author in mid-1980s (Berezin, 1984a, 1984b, 1984c, 1984d; Berezin and Jamroz, 1984). In spite that the direct quantum-mechanical calculations for the tunneling of neutrons between nuclei give negligibly low probability, the exponential (or even, super-exponential) enhancement of quantum probabilities cannot be excluded since no violation of energy conservation law happens in such cases.

It well may be that similar neutron-tunneling reactions between isotopes are occurring in the Earth's crust and its interior. If so, this may be one of the contributing mechanisms to the generation of geothermal heat, along with the decay of radioactive isotopes of uranium, potassium, and other elements. This, I believe, may be another open line for further research and contemplations.

Chapter summary

The popular idea of alternative worlds (a known example is *The Chronicles of Narnia* by C.S. Lewis), can be translated to a mathematical (digital) language using superfast growing functions. An example is T(N) function that is the "tower" of N "10s" such as 10^10^...^10 (N times). While "our" ("Big Bang") universe is "only" about 10^27 m in size [that is less than T(3)], using T(N) function we can talk about the universe at fantastically greater scales. Scales such as T(1000) m, or such. Quantum unfolding of these scenarios brings in the ideas of quantum nonlocality and quantum interconnectedness with such metaphors as Schrodinger cat and MD. A simple common-sense illustration of nonlocal effects is provided by the interaction of two magnets that seem to attract or repel each other through "nothing." Ideas of "cosmological inflation" and ever-breeding manifold of "parallel universes" call for metaphysical contemplations about the connection of this scenario to the IPW and, in particular, the infinity of prime numbers. Some isotopically mixed systems (including water) are, in fact, quasi-stationary quantum states. Neutron tunneling between isotopes in such systems can result in a net energy release, similar to the claimed "cold fusion" effects.

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10 All is water

As an author, I do not need to tell you, my reader, what you most certainly know already. And you heard and read it many times. That the water is *the* most important chemical compound for our life and we all, actually, *are* water, made of water, so to say. In average adult, some 60% of weight is water (percentage somewhat vary with age, body type, etc.). And this is so for most other life forms on our planet. Even that relative proportion of water may differ. How much water is in the fish, you may ask …

And this primality of water, water as a primordial substance, was realized in the philosophies and traditions since the start of human civilization. As the most important chemical substance for human life, water often plays a central role in many forms of art, folklore, mythology and philosophical reflections, religious rituals, and recreational activities. Baptismal, use of Holy water, Sacral Baths, and all of that, goes along for millennia. So, let us look at water from several viewpoints. So to say, different *vistas* of water.

10.1 Planetary water resources

Water is an immense planetary resource. Out of some 500 million km^2 of the Earth's surface, water covers about 3/4. The total volume of the hydrosphere is about 1.3 billion km^3. To vividly appreciate that, one can imagine that some "extraterrestrials" will be stealing Earth's water at a rate of 1 km^3/s (imagine 1 km^3 – a cube with a side of 3 Eiffel Towers!).

It will take these extraterrestrial water thieves 40 years to finish the job (!). It will take 20 million years (!) for all Earth's water to go through Niagara Falls (average flow rate of NF is about 2,000 m^3/s).

Despite such a seemingly enormous amount of water in the Earth's hydrosphere, the contamination of oceans and beaches by various forms of human activity becomes a serious global issue (Berezin and Gonzalez, 2012). Tourist activities, such as cruise ships and numerous beach resorts, contribute significantly to the problem. For smaller aquatorias, especially closed lakes (such as Dead Sea or Great Salt Lake), similar problems exist.

Yet, all is relative. While 1.3 billion km^3 of water may seem a lot (and, of course, it is!), if we calculate how many WATER MOLECULES this amount of water contains, we will get "only" about 5*10^46 molecules. If we recall what was said above in this book about Tower Exponential numbers, Superfactorials, and Prime Numbers, this number of water molecules may not appear that impressive.

In fact, this number of molecules is far (far!) less than just T(3) = 10^10^10, which is 10 to the power 10^10 = 10000000000. And if we recall the definition of the

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Superfactorial (N$ – refer Chapter 3), and take just 3$ (which is 6^6^6^6^6^6), it will be enormously greater than the said number of water molecules on Earth. And if we label every molecule in the Earth's ocean by the Prime Numbers (2, 3, 5, 7, ... P), the last one in the raw will be "only" 47 or 48 digits-long. This is another avenue for the Prime Number Contemplations.

10.2 Water as a "strange attractor" and Laplace Demon

In non-linear physics (physics of chaos), the concept of a "*Strange Attractor*" is used to signify a repetitive return of a dynamic trajectory of the system to the same locality in the phase space (Berezin, 1991b, 1991c). In human affairs, constant return of individuals to same localities, interests, or behavioral patterns (which can be metaphorically called "magnetism") also can be described in the same fashion. In this way, our constant strives and returns to water in all its forms and contents are among prime anchors of our lives.

From the standpoint of a naive everyday ("common") reasoning, hardly anything can be more "chaotic" than the (seemingly) totally disorganized gaseous system, such as dusty plasma or partially ionized sprays (Berezin, 1994d). Currently, the term "chaotic systems" primarily designates systems belonging to a domain of a so-called *deterministic chaos*. The latter is a branch on non-linear (classical) dynamics governed by the equations having a very high sensitivity to the initial conditions of the system. This is popularly known as the "*Butterfly Effect*" (an extra wing-swing of a butterfly in Brazil today can produce a tornado in Texas a few days later).

There are many other examples of the said "*Butterfly Effect*." For example, if we consider all the air molecules in the sealed glass jar (say, 1 Liter volume), such a jar under normal pressure contains about 2.5*10^22 molecules. They all move chaotically. However, if we know exactly their positions and velocities at any given moment, then, theoretically at least, we can calculate their positions and velocities for any future moments using the laws of classical mechanics. This is called "*Laplace Determinism*" by the name of Pierre–Simon Laplace (1749–1827). For that, he introduced (in 1814) the idea of a "demon" (*Laplace Demon*) that preceded the idea of Maxwell Demon introduced decades later. As the quote goes, this is how Laplace phrased it:

> Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective positions of the beings which compose it, if moreover this intelligence were vast enough to submit these data to analysis, it would embrace in the same formula both the movements of the largest bodies in the universe and those of the lightest atom; to it nothing would be uncertain, and the future as the past would be present to its eye.

Thus, we have the whole team of "demons," especially, if we let the Schrodinger Kitty to join the club. So, assuming the world is deterministic, Laplace Demon will know the precise location and momentum of every atom in the universe. All past and future

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values of the positions and velocities of all atoms in the Universe can be known to Laplace Demon. All these parameters can be calculated (in principle, at least) from the laws of classical mechanics. That seems a bit ambitious and there are several key problems with that, in particular, quantum indeterminism (Heisenberg Uncertainty Principle). Yet within the purely mechanistic universe, Laplace Demon can make the job to the end.

Back to our jar with air, assumption here is that the jar is fully isolated from all outside interactions. So, it is an "ideal model," and physics knows many ideal models. In fact, physics can hardly work successfully without ideal models. In case of our jar, if we let some, even extremely weak, outside interaction, it will mix-up parameters of molecules quite quickly. That will render the Demon's calculations meaningless. For example, it was estimated (Kautz, 2011) that the gravitational interaction from a single electron (!) at the Andromeda Galaxy will be sufficient to randomize the positions and velocities of all the molecules in the jar within less than 100 seconds (!).

Another popular example (and more directly related to water!) of how small events can have drastic consequences is the case of Titanic. Just imagine if the sailor on the mast who watched the ocean, would notice an iceberg a few minutes earlier, then we will most likely never heard about the Titanic, and no movie with Leonardo DiCaprio and Kate Winslet exist in our world (in Parallel Universe – who knows?).

Practically every person can recall many examples of the "Butterfly Effect" in his or her life. My dear wife of 37 years Irene (1943–2005) was a girl sitting next table from me in a big academic library. Well, I could easily sit at another table a few sits away to never met her … Chaos Theory rules supreme.

10.3 Quasi-psychology of water

It is not an occasion that in many mythological systems water is assigned with properties of some quasi-alive substance (e.g., "dead" and "life" water in Russian folklore). At the foundation of Ancient Greek philosophy, Thales of Miletus (ca 624–547 BC) considered water as the foundational and primordial substance of the universe. In early nineteenth century, William Prout has postulated (correctly!) that all atoms are made of hydrogen.

In view of the fact that hydrogen is the first element of the Periodical Table (and hence all other elements, in a sense, are built from hydrogen), such a view is, actually, not far from the modern science. Taking into account the mentioned fact that water makes up about 60% of human body weight, our fascination with water is well-grounded physiologically, culturally, esthetically, and philosophically.

Informational and healing qualities of water are interesting and controversial area. Of course, water plays an important role in many religious and spiritual

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practices (e.g., baptismal, sacred baths, etc.). Several non-mainstream medical practices (most notably, homeopathy) are based on the use of diluted water solutions. In these activities, the purported healing action is claimed on the basis of water ability to retain some form of memory (Berezin, 1990a, 2015, 2016).

Some researchers attempt to look for possible physical foundations of these effects, while others dismiss such claims out-of-hand as akin to the use of “holy water,” or similar practices as they are not “validated” by the “mainstream science” and not “endorsed” by the “Anonymous Peer Review” (refer above what this book says about the “Mainstream Science” and “Peer Review”).

Yet, inspite of all the skepticism of these claimed effects, such practices (homeopathy, etc.) are broadly used across the world with some known centers of “healing tourism.” This alleged “memory effect” in water (which sometime is attributed to its complicated structure of hydrogen bonds and isotopic diversity), and its capacity to act as a depository of informational patterns (akin to “*Babylonian Library*” by Jorge Luis Borges), may be one of the reasons that so many people, consciously of sub-consciously, are attracted to water in its many manifestations.

10.4 Allure of running water

Excitement and allure of running water as a source of inspiration can be amply attested from literature, poetic and artistic sources. Much of the touristic attraction to waterfalls and water cascades comes, implicitly and explicitly, from this – almost spiritual – impact on human creativity and imagination. The range of water expenditure in objects with running water runs over some 10 orders of magnitude, from majestic waterfalls (Niagara Falls), to small Baroque fountains with a few drops per second (e.g., miniature cascade fountains in the *Pavilion Hall* at the Hermitage Museum in Saint-Petersburg, Russia).

Romantic attraction to major waterfalls and water cascades comes not only from their majestic views and light effects (e.g., rainbows at Niagara Falls) but also from refreshing air humidity around them, as well as specific sound effects (noise spectrum of running water with abundance of low frequencies). That is what brings non-stop touristic crowds to them all around the year.

Many attributes of water are conveyed literally, metaphorically, symbolically, or allegorically in mythology and religion. This happens because of the rich attributes and power of the water, as one of the four primordial elements on our Planet and Cosmos. The other three are Earth, Fire, and Air. In this anthropomorphic frame of reference, human attraction to running water can at times invoke a kind of quasi-religious adoration (as if the water cascades or waterfalls call for some “worship” by the viewer). In fact, many popular waterfalls do indeed produce these kinds of feelings which often leave everlasting memories in people.

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10.5 Water as gravitational equalizer

Interaction of water with Earth's gravitational field is another "hidden" reason for human fascination with running water and waterfalls in particular. While the obvious dynamics of running water and water cascades is governed by classical principle of energy minimization, the more subtle effects may take place as well. Like, for example, the postulated links between the gravity and human consciousness (as proposed by Roger Penrose and others) may have their role in the allure of running water.

Water in entertainment is another source of tourist activity with numerous water parks, water slides, recreational boat trips, and private boat marinas. Example is a Marineland Water Park with marine animals at Niagara Falls, Ontario, which is among major touristic attractions in the area.

10.6 Isotopes and water memory

> *The vast majority of human beings dislike and even actually dread all notions with which they are not familiar. Hence, it comes about that at their first appearance innovators have generally been persecuted and always derided as fools and madmen.*
> Aldous Huxley (1894–1963)

As was mentioned above (Section 9.7), one of the greatest physicists of the last century, Richard Feynman, was once asked a question: "what if in some cataclysm, all our scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words?"

His answer was: "I believe it is the ATOMIC HYPOTHESIS that all things are made of atoms – little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied."

This idea of atoms as fundamental and tiny building blocks from which everything is constructed was with us long before we invented any instrumentation to discover their existence. It is sufficient to recall the great ancient atomists (Leucippus, Democritus, Epicurus, Lucretius – and, most certainly, there were many more), who talked about the atomic world, sometimes with amazing insight and imagination. Skipping through centuries, we come to a revival of atomistic ideas in such figures of pre-experimental atomism as Giordano Bruno, Rene Descartes, and Robert Boyle, to name just a few.

As we have figured out in the last 60 or so years, information carrying strings in all living systems (at all levels of complexity) operate on the combination of several base units that, in turn, consist of several key chemical elements (Cobb, 2015). The

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prime elements in DNA and RNA bases are hydrogen (H), oxygen (O), carbon (C), nitrogen (N), and phosphorous (P).

Out of these five key elements, only phosphorous has a single stable isotope, while all other elements have either two (H, C, N) or three (O) stable isotopes. Natural hydrogen is a mixture of light (one-proton) H (99.985%) and a heavy (proton + neutron) deuterium (0.015%), carbon is a mixture of C-12 (98.89%) and C-13 (1.11%), oxygen has three stable isotopes: O-16 (99.756%), O-17 (0.039%), and O-18 (0.205%), and nitrogen has two stable isotopes: N-14 (99.64%) and N-15 (0.36%).

Elementary combinatorial analysis leads to an enormously large number of possible isotopic permutations within chemically fixed structures. For example, a small segment of a DNA string with 1 million carbon atoms has about 10,000 randomly distributed C-13 atoms. The number of isotopically distinguished distributions (the number of possible placements of the 10,000 atoms among 1,000,000 sites) is about 10E24000 [yes, 10 to the power 24,000 (!)]. This is a far (far!) greater than the number of atoms in the Universe, the latter is estimated to be "only" between 10E90 and 10E100. If we include the spatial arrangements that can be produced by point substitutions in other stable isotopes, such as O-16 by O-17 and O-18, or N-14 by N-15, the possibilities for information transfer and information diversification carried parallel to "macros" information (such as the genetic transcription of codons or chromosomal crossover) increase enormously (tower exponentially; here we can recall the famous "Skewes Number" [10^10^10^34] that is explained on many Google postings and discussed above in this book).

And here the key quest comes in. Can isotopic permutations in DNA chains enhance the information carrying capacity of DNA segments over and above what is carried by the "regular" chemical diversity? In other words, can different stable isotopes of the key elements (H, C, O, N) be "read" as distinct "letters" of the genetic alphabet? (to remind – isotopes of the same element are macroscopically different in mass, magnetic moments, vibrational frequencies, etc.). In other words, can there be an additional "*isotopic genetic code*" over-written "over-and-above" the "regular" genetic code based on the combination of chemical elements? And since the pattern of isotopic combinations is different in each person, can it define our unique individuality? These are the questions that I was asking in many of my publications where I proposed a hypothesis of "Isotopic Biology," as an alternative to what we know as common chemically based biology (Berezin, 2015, 2016 and earlier publications).

To conclude, the prime quest behind the concept of isotopic biology can be formulated in the following way:

If Nature is smart enough to find ways to use the diversity of chemical elements for biology (almost all elements in the Periodic Table have some biological functions), then it may look somewhat odd that Nature would omit to apply such a mighty additional informationally rich resource as the diversity of stable isotopes for the structuring and functions of biological systems at all levels of evolution and complexity.

The likely "answer" to such a "puzzle" is that, yes, Nature most likely uses it (isotopic diversity), but we have so far failed to detect this and even (largely) failed to look

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at it, even at the level of a hypothesis, not to mention any targeted experimentation. One of the aims of this book is to draw attention of the world's research community to this incipient research area of stable isotopicity and isotopic engineering – a direction that (with some luck) may turn out to be a newly found gold mine for physics, biology, biomedicine, material science, cognitive sciences, and informational technology in a broader sense.

Apart from some sporadic mentioning of isotopic effects in biological systems (e.g., Mann and Primakoff, 1981; Keswani, 1986), I am not aware of any targeted studies of isotopic connections to bio-informatics, apart from some studies of the effects of isotopic replacements on physiological and reproductive processes in animals (e.g., Katz, 1960). At the same time, I certainly do not exclude the possibility that some more recent studies in this regard (isotopic effects in bio-informatics) have been done (or, perhaps, are in progress). If so, and any interested reader can try to find such studies in the mountains of the existing literature and/or Internet sources.

10.7 Benveniste "homeopathy" SAGA

The following story of the "water memory" may be the catchy part in this book. Those (hypothetical readers) who may proceed to read this book, will most likely find that the matter I am talking about below is utterly baffling and non-orthodox. Yes, it is nothing less than a scientific attempt to propose a physical model for the homeopathy, one of the most hotly disputed practices of the (so-called) "alternative medicine." In fact, to avoid up-front accusations of excessive claims, I must right away make it clear that my show here is far less ambitious.

In brief, my work in this direction was to propose the idea that the (claimed) memory effects in water may be related to the isotopic self-structuring of (oxygen) isotopes in a liquid matrix of water. That idea (and related to it the proposition that "healing crystals" form information-carrying "*Isotopic Neural Networks*") was developed by me over a number of years (from 1987 to 1994) and was published in a number (about 15) of publications referred in the bibliography part of this book.

No, I will not go to discuss the whole "art and science" of homeopathy, or anything on a practical side of it. In no way, I myself a medical doctor or even a "medicine man," as this term traditionally understood in the context of Native or Aboriginal realm. What I actually proposed in some papers published in early 1990s, is the isotopic model for memory effect in water. If THAT can be substantiated (or at least plausibly argued) on the basis of isotopicity (isotopic diversity), then others, who are specifically interested and better versed in the actual art of homeopathy, can use these ideas among their investigative tools.

Now to the actual story on how my involvement with water memory was started and then was kept unfolding. In the late 1980s, the renowned British magazine

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"*Nature*" has published some reports which allegedly supported claims broadly held by the members of the Alternative Medicine community. These reports came from a group headed by a French immunologist Jacques Benveniste (1935–2004) who was working in one of the reputable research Institutes in Paris.

The most peculiar thing about these reports was that they seem to provide a validation for the practice of homeopathy – one of the most controversial areas of Alternative Medicine. In essence, the homeopathy posits that when a certain drug is repeatedly diluted in water many times over (to a degree that not a single molecule of the original drug remains in the vessel, or, as chemical physicist would say, diluted "below the Avogadro limit"), the water still somehow "remembers" the action of this drug and hence it is still capable of a delivering a healing action.

Such an inference (that water can have a "memory") stays at odds with traditional chemistry and physics because these sciences (so far, at least) have been unable to produce any credible mechanism for such a memory in liquid substances. Likewise, mainstream medical professionals (with rare exceptions) do not recognize homeopathy as a valid medical practice and, hence, dismiss it as a quackery and charlatanism. For example, a known evolutionary biologist Richard Dawkins famous for his work in genetics ("*The Selfish Gene*"), and for more recent fuss with his book "God's Delusion," writes that "(we should not)… be seduced by homeopaths and other quacks and charlatans, [who must be] consistently be put out of business" [quoted from *This will make your smarter,* edited by John Brockman, Harper Perennial, 2012].

My question here is how Dawkins (and many others) can be so up-front sure that there is no physical mechanism for a memory in liquid substances like water? Do we already know everything about physics, chemistry, or how the Nature works? For me such a bold inference sounds at the very least as a grossly unwarranted arrogance.

However, the fact is that inspite of all the scientific negativity toward homeopathy, it remains a broadly spread practice. Millions of people are using it and often claim positive results. I, personally, became interested in this whole Benveniste story from the time it became public.

Almost immediately after the Nature Magazine has published reports from Benveniste group (in 1988), there was a deluge of articles and letters in the same magazine, as well as in many other research and public outlets, that vehemently denied these "outrageous" claims. At the same time, a small minority of scientists, the author of this book among them, took a more cautious attitude of a kind of "why not?" query, a stance commonly known as "*what if*" quest.

Here is one example of an "argument" against homeopathy (comment to some Web poster): "Homeopathy claims water can cure you, because it once held medicine. That's like saying you can eat off an empty plate because it once held food." Smart objection, ah?

But indeed, WHAT IF water, inspite of been a liquid, has nonetheless some physically based capacity to retain a "memory" of its past and, specifically, can "remember" what substances it was in contact with?

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After all, there are some ideas around about "water psychology," or water as a "strange attractor" (Berezin, 2012, 2015, 2016). Maybe indeed, physics and/or chemistry (and, actually, for these matters "chemistry" and "physics" are almost the same thing) can come up with some plausible mechanism for such a memory effect in water? After all, there were many claims in science which at first appeared odd and unbelievable, but later turned out to be genuine discoveries and became a part of the mainstream science. Why same thing cannot happen with the water memory?

Thus, in spite of numerous upfront denials from the mainstream science community that this (memory in water) "cannot happen because it cannot" (they never give any cohesive and sustainable explanations as to why it cannot), there were here and there some voices of dissent. This is what, for example, the Nobel Prize physicist Brian Josephson of Cambridge University (the "Josephson effect" in superconductivity and "Josephson junctions") says in his letter to the *New Scientist*:

> Simple-minded analysis may suggest that water, being a fluid, cannot have a structure of the kind that such a picture [of water memory] would demand. But cases such as that of liquid crystals, which while flowing like an ordinary fluid can maintain an ordered structure over macroscopic distances, show the limitation of such way of thinking. There have not, to the best of my knowledge, been any refutations of homeopathy that remain valid after this particular point is taken into account. (B. Josephson, New Scientist , 1 November 1997, p. 66)

Likewise, in some of my publications, I discussed the effect of polarizational stabilization of isotopic clusters in water. This is an effect based on classical electrostatics (Berezin, 1983, 1995). In isotopically random liquids, including water, this polarizational effect can lead to sustained information-loaded patterns. These patterns are similar (in terms of the information content) to memory patterns that exist in neurological structures (Berezin, 1994c).

10.8 Isotopic ordering in liquids and "soft structures"

> *Science fiction is any idea that occurs in the head and doesn't exist yet, but soon will, and will change everything for everybody, and nothing will ever be the same again. As soon as you have an idea that changes some small part of the world, you are writing science fiction. It is always the art of the possible, never the impossible.*
> Ray Bradbury (1920–2012)

To re-state the above stories in a somewhat different way, I have the following words to offer.

So, the key question here is how can *isotopicity* help water to "remember its past"? Such a question, no matter how odd and esoteric it may seem, can (in the view of this author, at least) be scrutinized on the basis of microscopic atomic physics and the ideas of self-organization and informatics.

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In science (and especially in physics), the ground rule for any research is to look for all thinkable (and, sometimes, even unthinkable) options and ideas that may explain the observable effects. Or, this may even concern the effects that are claimed to exist by a sufficient number of people (like flying saucers, or the recently announced "cold fusion").

And whether the end results (although there can hardly be "end results" in science) lead to the confirmation of the effect or its refutation (the latter is really a hard thing to do), or, otherwise, leave the issue wandering in the limbo of uncertainty – to put all the possible options on the table is still a worthy thing to do (at least, in my humble opinion).

As for the refutation (especially, "ultimate refutation" – "once and for all" kind), it is indeed often a tough call. Yes, the ultimate refutation of the "Flat Earth," or "Stars Clipped to the Crystal Sphere" are unlikely to produce too much opposition (although, who knows – there are still defenders of both!), but how about "Witches flying on the Broomsticks"?

Here, I would be more cautions. Despite it being a popular stuff for the fairy tales for centuries, my bottom line as a (theoretical) physicist is not so certain. Who says that it is not possible to discover "anti-gravity materials" (maybe, from "Dark Matter"?) and then anti-gravity brooms (any flying carpets?) may be on sale at the department stores … and not just for witches, for all of us … no need for cars, no need for gas stations, good for the environment … perhaps, my young readers, can take a note? … (Nobel Prize, for sure …).

So, what about this "Water Memory" story? Let us assume for a minute that it is a demonstrated fact that water has a memory effect. Now, what our guesses may be as to what possible physical basis this effect might have? Several guesses had been offered, for example, in the book *Ultra High Dilution – Physiology and Physics*, which featured several authors, including myself (Berezin, 1994c). Without dismissing any alternative or competing (or complementary?) explanations (e.g., Bellavite and Signorini, 2002; Del Giudice and Pulselli, 2010), I will follow my "isotopicity track" here.

Maybe indeed, there is something in the water (yes, in pure water!) that makes possible for it to have a memory akin to our own. If this assumption sounds too fantastic, let us recall how we humans store our memories and process our thoughts. We do it through the complicated chemistry and physiology of the neurons in our brains. And what are they? Quite involved structures made of polymer molecules which are capable of forming multiple microscopic connections and interactions. Information is stored in them in a way that is not unlike the information storage in computer hard drives, memory sticks, or digital cameras.

There are several types of memory (magnetic, optical, electrostatic, etc.), but they all come down to digital "bits and bytes." Now, the natural question to ask is whether water has some underlying structure in it that makes it a system capable of holding bits and bytes.

An affirmative answer to this question can be sought at the atomic level. The idea that the present author suggested (Berezin, 1990a, 1990b, 1994c, 2015, 2016) focuses

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on isotopic diversity in water. Water, as everybody knows, is H2O, it consists of oxygen and hydrogen; chemically speaking, it is hydrogen oxide. But both hydrogen and oxygen are mixtures of stable isotopes. Hydrogen has two stable isotopes, H (normal hydrogen) and D (deuterium), while oxygen has three isotopes (16O, 17O,- and 18O). To restate, isotopes are atoms that have the same position in the Periodic Table (i.e., they are the same chemical elements), but differ in mass. This is because they have different number of neutrons in their nuclei.

For example, the nucleus of ordinary hydrogen has just one proton (positively charged particle), while a deuterium (D) nucleus consists of a proton and a neutron (a neutron has almost the same mass as a proton, but it carries no electrical charge). Likewise, the above three stable isotopes of oxygen all have eight protons each, but they differ in the number of neutrons they have (eight, nine, and ten, respectively). Thus, due to their mass difference, isotopes of the same chemical element are distinguishable atoms and, hence, their different combinations can carry information. For example, the chain of 16O and 17O isotopes can, in fact, be interpreted as an information-carrying binary string, say, 011010001101001 … (etc.).

In a series of papers (Berezin, 1990a, 1990b, 1994c), I suggested that this is indeed what may happen in water. Memory in water can be "plugged in" and retained in the combinations of isotopes. In fact, this would be a case of isotopic information storage. But water is a liquid. So, is there any plausible physical mechanism to stabilize the possible information content in water against the motions of water molecules? Several possible options for that were proposed in my papers, such as electrostatics (Berezin, 1984a, 1984b, 1984c, 1984d; Berezin and Jamroz, 1984; Berezin, 1994b, 1995, 1997), polarizational effects (Berezin, 1983), and the Anderson localization mechanism (Berezin, 1982a, 1982b, 1984f, 1986a, 1986b).

Theoretically at least, there are six isotopically different kinds ("brands"?) of water in which two isotopes of hydrogen (H and D) can be combined with three isotopes of oxygen (we are talking here of stable isotopes, of course). In addition to this, there are almost unlimited ("continuous") possibilities for the mixing of isotopes in any desired proportions to obtain all kinds of isotopically enriched water. While D makes only 0.0156% of all the hydrogen atoms in water (one deuterium atom per 6,420 hydrogen atoms), in absolute numbers it comes to very impressive figures. One small drop of water (say, 1 mm^3) still contains some 10^15 atoms of deuterium. Using artificial methods, D and H can be separated and the so-produced water (in which most hydrogen atoms are D) is known as heavy water (D2O). Deuterium, and hence heavy water, is not radioactive, so you cannot contract radiation sickness if you bathe in it (inspite, that many people wrongly believe that heavy water is radioactive).

But what would happen if you accidently drink a glass of heavy water? Some experiments in which mice were fed with heavy water showed some adverse effects due to the slowing of the metabolism (Katz, 1960). Although, I am unaware of any

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such tests involving human subjects, I would not recommend drinking heavy water (bottled or not), even if heavy water is not radioactive. Deuterium is a stable isotope. However, in the general spirit of the tenets of homeopathy (in which highly diluted substances can be medically active), some small departures from the standard isotopic abundance may, perhaps, have some therapeutic effects (isotopic drugs?). As an author, I am unaware of any such studies in the health sciences field.

To repeat what was said in the Introduction and early sections of this book, many areas and aspects of stable isotopicity that are considered here have been discussed by this author in previous publications. To repeat some quests, can isotopicity be used, for example, to build a new type of random number generator (Berezin, 1987d), or a new type of isotopic optical fiber (Berezin, 1988b, 1988c, 1988e, 1989a, 1989b, 1992b; Berezin, Chang and Ibrahim, 1988; Chen et al., 1991), or can it be used to make microchips for quantum computers (Berezin, 2009)? And what about compact information storage (Berezin, 1984i)? Do isotopes affect brain function?

Or, perhaps, could isotopes be an essential aspect of the very mechanism of consciousness (Berezin, 1987c, 1990b, 1992a, 1994a, 1994b)? Could there be an "isotopic life form" out there in the Cosmos, as an alternative to the "regular" chemistry-based biology (Berezin, 1984h, 1986c, 1988e, 1987f, 2015, 2016)? Can life be based on a single chemical element (Berezin, 1984e)? In addition to this, some philosophical and metaphysical discussions appear here and there in the quoted publications and in this book.

As my prior experience indicates, some people may likely take the view that much, if not the majority, of what is presented in this book should be classified as "fringe science," "pseudo-science," or whatnot. Some of these ideas may challenge the established mainstream scientific orthodoxy, as many radical ideas have before. Many such ideas are indeed dead-end offerings, yet some "off-line" ideas have at times turned out to bear fruits, and not always of the kind the original authors expected or intended.

To that effect, I always was, and remain, on the side of those who believe that unusual and off-mainstream ideas and suggestions should be heard and studied, rather than dismissed outright as "rubbish," as some critics are rushing to suggest (e.g., Rousseau, 1992). The history of science offers many confirmations of this. It is abundant with examples of premature dismissals and ridiculing of unorthodox ideas because they "did not fit," as in famous Lavoisier's "no stones can ever fall form the sky." Even abstract mathematical ideas have a history of rejection and opposition. It is sufficient to mention the resistance to the idea of "zero" (Seife, 2000), or Cantor's theory of Infinite Sets (Dauben, 1977, 1979).

To my best knowledge at the time of this writing (2018), the above ideas regarding isotopic information storage in living and quasi-biological systems [if we grant water the status of (semi)-living substance] have not been picked up by the research community or followed up through targeted experiments (in spite of the fact that I suggested some experiments in my papers).

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So, what can these ideas do for a controversial area of alternative medicine such as homeopathy? While rejected by the majority of the mainstream medical professionals (yet, there are some exceptions), homeopathy, as well as other forms of the so-called "alternative medicine" (also known as "energy medicine") remains broadly popular and used by millions of people all across the world and cultures (e.g., Moyers, 1993; Bellavite and Signorini, 2002; Caudill, 2012).

In this book and prior publications, I discuss the possible role of isotopic diversity in providing a rational basis for two widely claimed phenomena – the homeopathic effect and so-called "crystal healing." Both of these practices are commonly associated in the public perception with the notion of "holistic medicine," and both are often debunked outright as a nonsense and charlatanism.

In brief, homeopathic action is defined as the ability of some specific drugs to retain their activity even after a number of multi-staged dilutions in water. Some activity has been claimed even for the dilutions of such degree that virtually not a single molecule of the original drug remains in the container. As was just mentioned, in 1988 a widely publicized controversy occurred in connection with the so-called Benveniste affair – experiments with ultra-diluted water solutions of drugs. Although the experiments showed poor reproducibility and were severely criticized, the sources of the presumed errors (whether the whole phenomenon is an artifact or "real"?) were never completely identified. The whole history of homeopathy is, of course, not restricted to this one particular experimental claim and, therefore, it seems justified to discuss the physical models for the presumed homeopathic effect as such, regardless of the value of Benveniste's experiments.

The physical model of the homeopathic effect should explain, at least hypothetically, how the water matrix could "template" information on the nature and/or type of action of the primary (seed) drug molecules and then "broadcast" this information down to subsequent dilution stages. In the case of the H2O matrix, there are three isotopic degrees of freedom (H to D and 17O or18O to16O), and the concentration of the minority isotopes is not at all negligible: for example, for 18O it is 0.2% (one 18O atom per 500 atoms of 16O). Such concentration corresponds to only eight lattice spacings [(500)^1/3 = ~8] for the average separation between two neighboring 18O atoms. For comparison, 1/500 is an enormously high impurity concentration in doped materials (such as p- or n-doped silicon in computer electronics).

Therefore, although the effects related to isotopic diversity are generally considered to be weak by common chemical standards, the ubiquity of isotopic diversity at practically every micro-spot might lead to some non-trivial consequences. In the stream of our "isotopic paradigm," it is possible to suggest that the inherent isotopic diversity of water is at work and that some positional correlations of stable isotopes (H, D, 16O, 17O, and 18O) might work as "templates" ("copy-prints") of the originally dissolved molecules. The induction of isotopic correlations is equivalent to the choice of a particular isotopic pattern out of the highly rich manifold of potential patterns. This process bears some similarity to the reduction of the

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wave function of a particle (or a more complex system) during quantum mechanical measurement.

The very possibility of different positional organizations for minority isotopes (D, 17O, 18O) within the main H2O matrix leads to an enormous degree of "isotopic redundancy" for the potentially available isotopic patterns. The essence of the proposed isotopic physical model for Benveniste's observations is that the presence of certain molecules (e.g., antibodies) might produce some specific readjustments in the positional distribution of minority isotopes in the vicinity of a given molecule. There might be several plausible ways by which this selection could work for the process of isotopic ordering. In other words, how the information on the nature of a dissolved molecule could be "templated" into a positional arrangement of isotopes. For example, it is known that ionic polarizability is mass-dependent [the vibrational frequency is proportional to M^(-1/2); M – atomic mass] and should, therefore, be rather sensitive isotopically.

Some positional combinations of isotopes (e.g., clusters of 18O) could enhance the local values of the polarizability of the media. The deepening of the polarization potential wells may serve as a stabilizing factor in a similar way to the polaronic self-stabilization in crystals (Berezin, 1983). This may explain the possible robustness of isotopic correlations against disordering thermal effects and, likewise, can account for the reduplication ("Xeroxing") of isotopic correlations at sequential dilution steps.

Moreover, spatially correlated isotopic arrangements could eventually explain the oscillation effects in Benveniste's experiments (the bioactivity shows an oscillating rather than a monotonic dependence on the dilution level). The clue to this could lie in an analogy with the commensurate–incommensurate transitions in partially ordered isotopic superlattices (Berezin, 1987a, 1987b, 1987e, 1988a, 1988d, 1988e, 1989b, 1991b).

A similar scenario could lead to a variable (oscillating) degree of isotopic ordering in the water matrix. The mechanism of such transformations is often referred to in solid-state physics under the term "devil's staircases." It acts in some specific crystalline (so-called Ising) systems with lattice frustration. The latter results in oscillating patterns of crystal ordering with a continuous change of the coupling constant or the concentration ratio.

These are my tentative guidelines for a possible rational explanation of the "unbelievable" effect reported by Benveniste and others. It is based on the concept of *isotopic patterns* and the ability of isotopically organized structures to store, transfer, and, perhaps, even amplify information. This explanation does not dismiss the possibility of alternative explanations, as discussed in a variety of sources. Moreover, it could turn out to be complementary to them. I should also note that the above hypothesis offers a line of experimentation, since isotopic ratios are relatively easy to change artificially (e.g., through increasing the concentration of the 18O isotope in water), and the described isotopic effects could, therefore, be rather easily enhanced or suppressed in terms of their role in these processes.

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10.9 Isotopic engineering

In the order of things, it is pertinent to say a few words about a new area of "*isotopic engineering*." Interested readers can consult numerous publications listed in the reference section of this book.

Overall, the ideas and concepts of *isotopic engineering* and *isotopicity* (Berezin, Chang and Ibrahim, 1988; Berezin, 1989a, 2015, 2016; Haller, 1995, 2002) still largely await their development in many areas of research, technology, and biology.

On the side of the solid state and condensed matter physics, there are several lines for the research and engineering developments. Here is a short list:

(1) Role of isotopes in the structural strength of materials (Epling and Florio 1981; Berezin and Ibrahim, 1988; Hoffman and Scherz, 1990; Itoh et al., 1994; Eberhart, 1999, 2003; Ishida, 2002; Soda et al., 2002; Flakus, 2003; Kojima et al., 2003; Huger et al., 2008),
(2) Thermal properties and heat conductivity (Klemens, 1981; Hu et al., 2002),
(3) Optical properties and isotopic fiber optics (Berezin, 1987a, 1987b, 1987e, 1988a, 1988b, 1988c, 1989a, 1988e, 2004b, 2009, 2011; Berezin, Chang and Ibrahim, 1988; Chen et al., 1991),
(4) Isotopic information storage systems (Berezin, 1984e, 1984i, 1986c, 1988e),
(5) Isotopic random number generators (Berezin, 1987d),
(6) Geology and paleontology (Thode, 1980; Berezin, 1988d),
(7) Isotopic effects in corrosion and corrosion passivation (De Sa and Berezin, 1989; Berezin, 1993a, 1993b, 2011),
(8) Isotopic structuring in solid state physics and nanotechnology (1986a, Goldman and Berezin, 1995; Berezin, 2009, 2015, 2016),
(9) A somewhat separate issue is "isotopic tribology" which is outlined in the next section. It has specific connections to the ideas of Quantum Singularities.

We can add to the above list, that on the biological side, there are studies of isotopic replacements that were started many decades ago (e.g., Katz, 1960). This activity resulted in many publications by a variety of research groups that are too numerous to be cited here.

Here are key points on some areas of isotopic engineering that are outlined in detail in the above-quoted publications.

Isotopic Fiber optics

Imagine an isotopic interface, that is, a boundary between regions with the same chemical identity but of different isotopic composition. Difference in the refractive index at both sides of isotopic interface could lead to a possibility of the total internal

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reflection of light and, consequently, could provide an alternative route for the light confinement. Thus, "isotopic fiber" is a structure in which core and cladding have the same chemical content but different isotopic composition. The boundary between isotopically different regions forms an isotopic interface.

The difference in the refractive index on both sides of the isotopic interface could lead to a possibility of total internal reflection of light and, consequently, could provide an alternative route to the confinement of light. This is a prime requirement for any fiber optic system. For example, consider a boundary between SiO2 (the main component of silica) where both side are identical chemically and structurally but have a different isotopic composition, say, one side is made of 28Si/16O and the other side is made of 30Si/18O. Isotopic separation technologies can certainly provide starting materials to fabricate such isotopic interfaces.

In isotopic fibers in which core and cladding are made of different isotopes, the half-angle of the acceptance cone of light confinement could be up to several degrees. The resulting lattice mismatch and strains at the isotopic boundaries are correspondingly one part per few thousand and, therefore, could be tolerated. Further advancements of this "isotopic option" could open way for the essentially monolithic optical chips with built-in isotopic channels inside the fully integrated and chemically uniform structure. The above idea of isotopic fiber optics was suggested in a few of my publications in 1988–1989, and at the time of this writing (2018), I am unaware if any further theoretical and/or experimental up-takes of this idea have been pursued.

Isotopic Information Storage

As atoms, isotopes go one-by-one and that fact alone makes them inherently "digital" entities. They can be "read" as if they are the letters in some atomic-scale alphabet. That fact prompted me to come up with an idea of isotopic information storage. While I do not know if anyone came up with the same idea before me, it well may be the case, all I can say that I came up to this idea independently of any prior inputs. In the same way that neither Copernicus nor Darwin may be the first to come up with the ideas of (respectively) Heliocentric System and Bio-evolution as Survival of the Fittest, yet they both took the major credits for these ideas on the pages of history.

As was mentioned above, infinite periodical structures are much easier to describe mathematically than non-periodical and/or finite structures. From informational point of view, it means that non-periodical structures have a far greater capacity for carrying information than an ideal periodical (and hence a feature-less) structure. A book, all pages of which is filled with letter A (AAAAA…), contains a lot less information (actually, almost none) than a real book of unrepeated meaningfully arranged characters.

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Applying similar argument for crystals with isotopic diversity, one cannot fail to notice that isotopically mixed crystals can potentially carry much more information than single-isotope lattices. Information can be coded in the positions of various isotopes within the crystal lattice. Or, perhaps, in some more "holistic" ("holographic") structures as, for example, created by the spatially extended magnetic fields which, in turn, are produced by nuclear moments of isotopes (such as, say, 13C which have non-zero nuclear magnetic moments).

Thus, isotopic differences can lead to novel systems of information storage at a nanoscale level. Isotopic information storage consists of assigning the information "zero" or "one" to monoisotopic micro-islands (or even to single atoms) within a bulk crystalline (or thin film) structure. This technique, if developed, could lead to a very high density of information storage of up to 10E20 to 10E23 bits per cubic cm. This is because isotopic information storage (unlike other information storage techniques) allows the information bit to be carried by a single atom.

One can estimate that the information content of the Library of Congress is about 10E17 bits (estimate: 10E8 volumes of 1,000 pages, each with a generous allowance of 10E6 bits per page – the latter to account for the digitized photographs). This means the entire content of the Library of Congress can be isotopically stored in 1 mm^3 (!). Of course, proper three-dimensional methods of writing and reading are required for that. These can be developed along the lines of the atomic force nanotechnology, which allows manipulation of individual atomic species.

Furthermore, main potential advantage of isotopic information storage lies in the fact that the information is incorporated in a chemically homogeneous matrix. There are no chemically different impurities (such as those existing in optical storage with color centers) or grain boundaries between islands of drastically different magnetization (which is a limiting factor in common magnetic storage techniques). Information stored in isotopic recording exists as a part of a *regular* (in principle, ideal) crystal lattice. By "ideal" we mean here that the structure does not need to contain any of the "common" defects inevitable in heteroatomic coding, and as such isotopically stored information is protected by the rigidity of the crystal lattice itself.

Isotopic Random Number Generators

Under the assumption of a perfect (or almost perfect) isotopic randomness in solid and quasi-solid structures, individual counting of isotopes atom-by-atom can be utilized for the creation of nanoscale random number generators. Typically, generation of random numbers in computers is based on mathematical procedures of truncation of various functions. Random numbers which are produced this way are, in fact, pseudo-random: due to a deterministic character of the computer codes, the strings of random numbers are repeated every time the same seed numbers are used. Mixture

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of stable isotopes, provided they can be probed at the atomic level, is free from this limitation. Alternative way to use isotopes for random number generation is to use isotopic jets produced by gas streams (Berezin, 1987d).

Under the presumption of the existence of the functional nanoscale reading technology capable to determine isotopic identity of individual atoms (e.g., isotopically adjusted Atomic Force Microscopy, AFM), it is possible to produce strings of physically random numbers by scanning surfaces of crystals. By counting different isotopes of the same chemical element (say, carbon) as digital 0s and 1s, a genuinely random non-repeatable binary string can be generated. This will include a proper normalization (scale adjustment) of the so-produced strings to account for the relative isotopic abundances. Like random strings produced by time-clipping of the individual decays of radioactive isotopes, strings produced by counting of stable isotopes, are free from hidden correlations which are typical for the strings produced by algorithmic methods on computers.

Isotopic Superlattices

It looks as almost a trivial statement that the elements with two or more stable isotopes should form random distribution over the regular sites of crystal lattice. This is usually taken for granted because isotopic differences in lattice binding energies are considered to be negligibly small to affect the dynamics of lattice formation at, say, crystallization from melt.

Isotopic disorder in solids affects the whole variety of thermal, optical, and electrical phenomena. The most profound effect of isotopic randomness is, probably, the modification of lattice thermal conductivity. Indeed in some study cases, there exists a significant difference between natural (isotopically mixed) and isotopically purified samples (Klemens, 1981; Berezin, 1992b). This effect is attributed to the isotopic phonon scattering, which can be treated as a separate scattering mechanism (Berezin, 1984g). Similar (although somewhat weaker) isotopic scattering could affect the mobilities of charge carriers and in some extreme cases could lead to the electronic localization in narrow conduction bands (Berezin, 1984f).

Consider defect-free periodical crystal lattice which, however, has some large-scale structure of isotope distributions. Generally speaking, one could think of some mechanisms leading to the spontaneous isotopic ordering and even to the formation of “isotopic superlattices” (Berezin, 1987a, 1988a, 1988d, 1988e, 1989b, 1990c, 1992b; Flakus, 2003; Kojima et al., 2003; Bastian et al., 2010). This could be similar to the known ordering of voids under irradiation. It is easier, however, to think of such a non-uniformity as created artificially within the otherwise perfect (i.e., free of ordinary defects) crystal lattice. Creation of such isotopically ordered structures is obviously a technically achievable task at this stage (e.g., Haller, 1995, 2002).

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Some heterogeneous systems, as a rule, exhibit a trend to a variety of segregation and ordering scenarios for spices under consideration (Berezin, 1987a, 1988a, 1988d, 1988e, 1989b, 1990c, 1992b; Goldman and Berezin, 1995). Isotopic shifts of vibrational frequencies in anharmonic crystal lattices result in isotopic variations of lattice constants, which (under specific crystallization conditions) may lead to positional isotopic correlations and, in extreme cases, to the formation of isotopic superlattices.

Isotopic Quantum Wells

Isotopic non-uniformities can originate by a variety of phase-separation non-linear processes. For concreteness, let us consider an isotopically pure crystal (e.g., 28Si) inside which there is a spherical inclusion of 30Si. We use here the sphere just to simplify the estimate, the particular shape of this "isotopic island" is, in fact, unessential.

Estimates show that the above isotopic inclusion could work as a potential well for electrons (Berezin, 1987b, 1987e). It is known that lattice constants of isotopically pure crystals are slightly different. The observed differences are usually of the order of 1 part per thousand. These isotopic variations of lattice constants are explained by the differences in bond lengths for various isotopic pairs (e.g., for 28Si-28Si and 30Si-30Si in Si crystal). The latter, in turn, are related to the anharmonicity of zero-point vibrations.

The above-described isotopic inclusion produces a lattice constant mismatch of the order of one thousandth (1/1,000). This, in turn, will result in some strains qualitatively similar to the now actively discussed case of strained superlattices. Although the magnitude of the effect is much smaller than in the case of chemically different atoms (e.g., Si/Ge superlattices) it is, nevertheless, non-zero. Assume that in a certain isotopically mixed crystal (e.g., in Si), one isotope is replaced by another (e.g., 28Si by 30Si) in just one lattice site. In view of the said, such change will result in the adjustments of the equilibrium positions of the nearest neighbors. These shifts can be of an order of d/1,000 (d: inter-atomic spacing) and are equivalent to the presence of random strains varying from site-to-site. The variations of bond lengths in isotopically mixed lattice can now be equated to the presence of some randomly varying (because of random location of isotopes) central forces emanating from each atom.

Consider now the net (i.e., "subtracted") interaction between the two atoms of the same isotope, for example, between two 28Si atoms in a 30Si host lattice. Depending on a particular case, this net effect can have either sign, that is, it can be either attractive or repulsive. The first should generally favor isotopic precipitation, the second – isotopic ordering (same isotopes tend to avoid to be close neighbors). Not in all cases, therefore, should we expect the ordering tendency. However, the character of this resulting net interaction between minority isotopes in a majority matrix can be regulated by a particular ratio of the isotopes (i.e., 99% to 1% mixture of D2O and H2O will apparently behave oppositely to a 1% to 99% mixture of the same).

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To estimate the size of isotopic fluctuation needed for the formation of the bound state, we can use the Kronig-Penny's three-dimensional model of Zero-Strength Delta Potentials (Berezin and Kirii, 1970; Berezin, 1973, 1986a). This model contains only one parameter: the lattice spacing "d." Each lattice site (atom) is replaced by a three-dimensional delta-potential well with zero value of the strength constant (the latter is understood in asymptotic sense that the strength constant tends to +0). In physical terms it means that the bound state for such an isolated well has an arbitrary small binding energy (+0). It is known that two (or more) delta-wells of zero strength separated by a finite distance has a bound state with a finite (that is non-zero) binding energy, even if each such delta potential taken individually, is unable to support the bound state (Berezin, 1982b, 1984f, 1986a). This may appear paradoxical, yet this is a purely quantum mechanical effect.

Isotopic Effects in Corrosion

Physical phenomena occur in space and time. Although this trivia is generally true for any physical process, description and modeling of various phenomena, such as the disintegration of material and structures (Eberhart, 1999, 2003), differ in emphasizing their temporal and/or spatial aspects. Some phenomena (e.g., phase transitions) can mostly be understood in terms of corresponding elementary steps, that is, for them the "historical" (evolutionary) aspect is relatively unimportant. For some other processes, the more-or-less profound understanding requires their visualization in terms of the entire development, rather than as a mere sequence of elementary steps. The latter processes encompass such different phenomena as crystal growth, geological patterning (e.g., sedimentation), growth and aging of single organisms and bio-evolution as a whole. For such processes holistic and descriptive models like Catastrophe Theory can provide integrative imagery (De Sa and Berezin, 1989; Berezin, 1991c).

Corrosion is a multi-faced physico-chemical process with elements of a non-linear behavior (Berezin, 1993a, 1993b). Phenomenologically, it exhibits a number of distinguishable scenarios, such as pitting corrosion, crevice corrosion, stress corrosion cracking, corrosion fatigue, inter-granular corrosion, biological corrosion, etc. Despite this diversity, most of the underlying microscopic mechanisms have certain common features. Namely, one can almost always indicate some non-linear dependencies of the characteristic rate parameters (e.g., dissolution currents) on the concentrations of reagents, applied external electrical biases, etc. As such, corrosion process is usually seen as an interplay of several chemical processes (anodic, cathodic, acid-base) which, as a rule, have various feedback loops resulting in a formation of the overall non-linear diffusion-reaction system. Thermodynamically, an interactive system "metal plus active surrounding" is a non-equilibrium system. Therefore, the resulting situation can be commonly classified as a spatially extended non-equilibrium non-linear system. Such systems are generally prone to all kinds of fluctuations and isotopic fluctuations may play some role in pattern formation dynamics.

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An interesting and scientifically challenging point here is the possible role of isotopic fluctuations in corrosion dynamics. According to the line of thinking advocated in this book, isotopic diversity (isotopicity) may have some (perhaps, subtle and tangential) relevance to the physical aspects of corrosion (Berezin, 1993a, 1993b). The role of isotopic diversity in corrosion initiation and propagation can be traced along two lines: (1) isotopic fluctuations as corrosion seeds and (2) informational and pattern-forming aspects of corrosion, as discussed below. In terms of corrosion patterning, we can even talk (in a somewhat metaphorical way) of the "creativity" of isotopic fluctuations as pattern-forming factors.

Isotopes in Quantum Computing

The rapidly unfolding area of quantum informatics and quantum computing is presently an impressive growth industry at the frontier of physics and electronics. While basic principles of quantum computing are becoming generally known, technological applications are still mostly at an infancy stage. Some authors go as far as ascribing (perhaps, somewhat metaphorically) enormous potential of quantum computers to their ability to borrow computing power from parallel universes (Deutsch, 1997; Lloyd, 2002, 2006). In spite of an obvious up-front speculative flavor of these ideas, many people find them fascinating and mind boggling.

At the time of this writing (2018), there are several research lines attempting to implement quantum computing in practice. Some of them use nuclear spin states of specific isotopes in crystalline matrices. In practical implementation on the basis of solid-state structures, quantum computing is isotopically selective. Thus, quantum computing naturally falls into the domain of isotopic engineering. Specifically, because of the quantum identity (indistinguishability) of the same isotopes (as opposed to the quantum distinguishability of different isotopes of the same element), *isotopicity* provides a natural playground for the establishing of quantum entanglement among large clusters of atoms (Chapters 2 and 5). The latter (sustained quantum entanglement) is one of the key requirements needed for a functional quantum computer.

One of the most acute problems facing quantum computing is the need to maintain a quantum-coherently superposition of a system for a sufficiently long (often, macroscopic) times. To attain that, the quantum system should be sufficiently isolated from thermal bath and other stochastic perturbations. The latter perturbations produce decoherence and, hence, interrupt the process of quantum computation. For that matter, nuclear spins of some specific isotopes may turn out to be systems of choice (nuclear spins are reasonably well insulated from the said perturbations). A number of concrete realizations can be tested for that matter. For example, small atomic complexes of isotopes with non-zero nuclear magnetic moments encapsulated inside fullerene balls may be reasonably well protected against outside interactions leading to decoherency.

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10.10 Isotopic tribology

Tribology is the area of science and engineering related to the effects of friction between two surfaces sliding upon each other. While at a macro-level, friction is a big area of engineering and material science, some recent advancements have also been made in regard of surfaces at micro- and nanoscales. In the common technological context, the control and the reduction of friction effects are usually done by some form of lubrication (oils, micro-emulsions, etc.).

In engineering context, the friction effects at contacts are usually discussed in the realm of a purely classical physics and mechanics. However, at the microscopic level, quantum behavior can become significant and in some situations quantum effects can become dominant. One particular example of that is *quantum lubrication effect* (Cranston and Gray, 2006; Feiler et al., 2008; Lamoreaux, 2009; Munday et al., 2009) and its possible modifications are coming from isotopic randomness and isotopic structuring.

Electrostatic effects play a significant role at the interfaces and contacts between surfaces. Numerous forms of frictional charging are often discussed in quantum mechanical context (Berezin, 1995). *Isotopicity* can affect these processes in several ways, such as formation of electronic trapping centers on isotopic fluctuations, change of electronic mobility (Berezin, 1984g), or affecting characteristic times of electronic delocalization.

Among interesting quantum effects taking place at nanoscales is the so-called repulsive *Van der Waals effect*. Van der Waals forces, also known as quantum dispersive forces, can be attractive and repulsive. The repulsive van der Waals effect, also known as the repulsive Casimir-Lifschitz effect (Feiler et al., 2008; Munday et al., 2009; Cranston and Gray, 2006; Lamoreaux, 2009), is not exclusively related to isotopic diversity. It is based on quantum electrodynamics and its explanation involves pressure effects from zero-point vibrations of virtual electromagnetic fields in the contact region. The play goes on the differences of the dielectric constants of both contacting surfaces and the thin layer of the liquid medium between them. Experimental and theoretical studies of quantum lubrication effects are now in progress in a few laboratories over the world. In such a context, "isotopic tribology" can then be seen as a subset of the quantum lubrication effect (Berezin, 2011).

In this regard, a careful Isotopic Engineering can possibly amplify quantum repulsive mechanisms. No experimental verification of this alleged isotopic effect is known to me at this point. Of a special interest will be to relate these effects with earlier studies by Neumann and Wigner of quantum-,bound states in repulsive potentials (Von Neumann and Wigner, 1929). At the early years of Quantum Physics von Neumann and Wigner have constructed a simple-looking potential of the form

$$V(r) = 2/r^2 - 9r^4. \tag{10.1}$$

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The first (positive) term falls off faster than the Coulomb field (Coulomb potential is proportional to 1/r), while the second (negative) term (fourth power of “r”) grows very quickly toward minus infinity. As a result, this potential is everywhere repulsive and yet it (contrary to a “common quantum mechanical sense”) has a discrete bound state (!). Normally, bound states are expected only for the potential wells (attractive forces), not for the forces that are everywhere repulsive. As follows from the above equation, dV/dr is *negative* for all “r” and this means that the force is always directed *from* the center point, r = 0.

It is noticeable, that it took two genius physicists to figure out such an amazing example (a few more potentials of that kind were proposed later). The explanation for such “crazy” behavior lies in the combination of a singularity at r = 0 and the very fast growing repulsive second term which grows as 4th power of “r.” It is as if a particle is reflected from the infinity back to the center and hence remains in a bound state in the vicinity of the origin.

In fact, according to classical mechanics, a particle in the repulsive potential (10.1) reaches infinity in a finite time (Von Neumann and Wigner, 1929; Ulam, 1958). Some other potentials that can retain bound states with energy everywhere above the potential V, where also suggested by Von Neumann and Wigner as well as in numerous follow-up papers.

Quantum Paths to Infinity

One of the prime articles of faith of the modern physics is the premise that the speed of light is highest physically possible speed. Nothing, according to this principle can move faster than light. That is 299,792 km per second or 186,282 miles per second. The fact that it is almost exactly 300,000 km/sec makes it easy to remember in metric system. So, nothing can move faster, the modern physics says. Oh, yes, there are some talks here and there about “*tachions*” (faster than light particles), but so far nothing of that kind was experimentally observed and some claims that have been made to that effect remain controversial and disputed.

And yet there are some interesting paradoxes of Quantum Physics that, I believe, may show the way to circumvent the said speed of light limitation.

As early as in 1929, at the dawn of Quantum Physics, two young scientists, John Von Neumann (1903–1957) and Eugine Wigner (1902–1995), have published a paper (Von Neumann and Wigner, 1929) in German Physics Magazine *Physikalische Zeitschrift*. At that time, most physics was still published in German language and the paper was titled “*Uber Merkwurdige Diskrete Eigenwerte*” (“On the miraculous discrete quantum levels”).

We can appreciate that at that time both authors were still in their mid-twenties and both later went to become world-known first-class stars. John Von Neumann is one of the founders of computer science, while Eugine Wigner has break-through

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contributions to quantum physics (Nobel Prize in 1963). What the above paper has is an example of some potential field in which a particle moves to INFINITY within a FINITE time. That means, it gains an infinite speed, reaches the infinity and reflected back from it (from infinity!) as if the infinity is some kind of a "magic mirror" from which the particles can be reflected back to the origin!

This example by Von Neumann and Wigner has opened an area in Quantum Physics of the so-called "*singular potentials*" to which I also made some contribution by solving a few related problems (Berezin and Kirii, 1970; Berezin, 1986a, 2015, 2016).

Thus, what was said above about "us living in distant galaxies" has another illustration in the form of singular potentials – delta-potentials first introduced by Enrico Fermi and Paul Dirac. These singular potentials (delta-potentials) are used in many areas of physics from nuclear to solid state physics (e.g., Demkov and Ostrovsky, 1975).

Whether Isotopic Engineering can be employed for the actual experimental implementations of such potentials and, if so, can it be of a practical use for quantum lubrication, remains to be seen. In this regard, Isotopic Engineering, as a tool for "fine quantum adjustments" (due to a general weakness of isotope effects) can serve as a way to form such refined situations when quantum states contributing to quantum lubrication are becoming metastable (quasi-stationary).

Several other isotope-related effects can also likely play some role in the formation of the above-discussed repulsive forces. For example, nuclear magnetism, being isotopically selective effect, can play especially prominent role at the contacts of two surfaces (quasi-two-dimensional systems) through the formation of network of magnetic moment interactions. The latter resembles artificial (spin glasses) neural networks (Berezin, 1992b, 2015, 2016) and can enhance energy exchange processes. This, in turn, may affect (reduce) friction between sliding surfaces acting in analogy with repulsive Van der Waals forces, leading to quasi-lubrication effect (when the "lubrication" is provided by quantum interactions rather than some specific material ingredient).

Another class of largely unexplored possibilities may be related to energy transfer and electron hopping effects between nanoscale isotopic clusters at the interface region (Berezin, 1987e; Goldman and Berezin, 1995). Resonance energy transfer between clusters (or isotopic fluctuations) can affect the inter-surface tension and change (reduce or increase) the effects of quantum lubrication. Possible areas of application are, again, most likely related to small-scale devices like MEMS (Micro-electro-mechanical systems) and bio-medical electronics.

While the application of quantum physics to surface and contact mechanical effects is it its incipient stages, some advanced models of quantum lubrications have been recently discussed (Feldmann and Kosloff, 2006).

It should be pointed out that our examples of isotopic effects in contact physics and quantum lubrication phenomena bear a largely heuristic character as indicating possible new directions of research. It is fair to say that not necessarily all these examples will be actively pursued in further developments and, conversely, some new, yet unexpected, isotope-related aspects may come forward.

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10.11 Isotopic neural networks and "healing crystals"

The scientist is not a person who gives the right answers, he is one who asks the right questions.
Claude Levi Strauss (1908–2009, French anthropologist)

Studying for a number of years the effects of isotopic randomness (isotopicity), I was particularly interested in the *informational aspects* of isotopic diversity. The following are some of the quests that I have discussed: Can isotopicity be used, for example, to build a new type of random number generators (Berezin, 1987d), or a new type of isotopic optical fibers (Berezin, 1988b, 1988c, 1988e, 1989a; Berezin and Ibrahim, 1988; Berezin, Chang and Ibrahim, 1988), or can it be used to make microchips for quantum computers (Berezin, 2009)? And what about compact information storage (Berezin, 1984i)? And do isotopes affect brain functioning? Or, perhaps, can isotopes be an essential aspect of the very mechanism of consciousness (Berezin, 1987f, 1992a, 1994a, 1994b, 2015, 2016; Pui and Berezin, 2001)? Can there be an "isotopic life" out there in Cosmos, as an alternative to the "regular" chemistry-based biology (Berezin, 1984h, 1986c, 1987c, 1988f, 1990b)? Can life be based on a single chemical element (Berezin, 1984e)?

All the above quests (that are repeated at several places in this book) remain open for further contemplations, as well as theoretical and (hopefully) experimental studies. My job here was (and is) to open these inquiries, rather than giving well-shaped "finite" answers. To that, the above given quote by Claude Levi Strauss gives a perfect endorsement.

Below are my thoughts on the possible role of isotopicity in the "work" of the (so-called) "Healing Crystals."

At the atomic level, we can easily see that in isotopically mixed crystal lattices, there could be a number of similarly structured isotopic micro-complexes. This might lead to low-frequency vibrational resonance effects and account for memory storage phenomena. For example, holographic-type memory effects in quartz crystals may be related to complexes that involve minority isotopes of oxygen and/or silicon (e.g., 17O and 29Si) and they could be describable as the formation of interactive connections that we provisionally can call *isotopic neural networks*.

These *isotopic neural networks* can (hypothetically) operate in a manner similar to the known neural networks in spin glasses (Hopfield, 1982; Sompolinsky, 1988). Such non-linear interactive systems are capable of spontaneous self-organization in the sense of developing highly correlated patterns of site states in time and space. The latter may be showing "behavioral patterns" of chaos and organized activity and may imitate evolutionary processes such as self-complication.

Quartz is often claimed to be the most popular of the alleged healing crystals. It is interesting to note that quartz has more than one isotopic sub-lattice. This provides a basis for the possibility of a "natural division" of functions in which one isotopic sub-lattice (e.g., 17O) plays the role of neural sites (two possible spin states), while the other (e.g., 29Si) plays the role of a synaptic network.

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The "healing action" in this context could eventually mean that the informational interaction between the human body and/or mind ("consciousness") and a crystal "locks" the latter in a state in which a particular physiological or psychological pattern is templated into the crystal. This templated pattern can, in turn, provide informational feedback to support the originally chosen modality of the physiological or psychological state. In other words, the isotopic degree of freedom could provide a basis for the establishment of an informationally interactive linkage between a crystal and a human body. Poly-isotopic neural networks probably possess a high(er) degree of information storage redundancy and, therefore, they are likely to be quite robust in terms of pattern storage and resistance against disordering factors (Berezin, 2015, 2016).

As the above discourse points out, the informational aspects of isotopicity can be advanced in terms of the currently important paradigm of neural networks. As was mentioned above, in isotopically mixed crystal lattices, there could be a number of similarly structured isotopic micro-complexes. This might lead to low-frequency vibrational resonance effects and account for the memory storage phenomena, which are strongly advocated by some adherents and practitioners of so-called crystal healing.

To this effect, many people share the feeling that crystals are somehow (almost) "living beings," that they are some alternative life forms with whom people can establish personal connections. These views have a long history and tradition in many cultures and are connected to a number of mythological and esoteric teachings and metaphysical systems. Some crystal owners consider their crystals as similar to pets. The recent so-called New Age movement revived the popularity of these ancient views and practices in a modern context.

Without discussing, or in any way critically assessing, every aspect of "New Age" claims in this book, I would still like to indicate that *isotopicity* could provide (at least hypothetically) a physical model for some of the effects claimed in connection with healing crystals (Berezin, 1991a, 1992b, 1994c).

I am leaving it up to the taste of individual readers to look for further arguments to support or refute the hypothesis that is outlined here. Although, in my personal view, it would not be much easier to refute these claims "once and for all" than it would be to refute "convincingly" the efficacy of placebos, or, for that matter, to refute the existence of parallel Universes or any other "transcendental reality." Or, indeed, to refute the notion that we all may be living in a simulated reality, in other words, that we may be virtual beings simulated in some super-computer (Bostrom, 2003, 2016; Berezin, 2006, 2015, 2016).

Let us consider the isotopic diversity of the most popular of the healing crystals, namely, quartz. As a silicon dioxide (SiO2), quartz has as many as six isotopic sub-lattices (both oxygen and silicon have three stable isotopes each). The alleged holographic-type memory effects in quartz crystals could be related to complexes that involve minority isotopes of oxygen and/or silicon (e.g., magnetically active 17O and 29Si isotopes) in a manner describable as the spontaneous formation of "*Isotopic*

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Neural Networks," which would be similar to the neural networks suggested for spin glasses (Hopfield, 1982; Sompolinsky, 1988).

To re-state, the fact that most crystals have more than one isotopic sub-lattice provides the basis for a natural division of functions, with one isotopic sub-lattice (e.g., 17O) playing the role of *neural sites* (two possible spin states), while the other (e.g., 29Si) plays the role of the *synaptic network*. In a quartz crystal, there are about 60 atoms of 29Si per one atom of 17O. Thus, we can envision the whole "community" of those 29Si atoms (say, 20 or 30) that are located between any two neighboring 17O atoms as providing a synaptic link between the latter. Such a 29Si cluster has many inner spin states, that is, each of the 20 or 30 atoms may have two nuclear spin directions, so there are many possible combinations.

As a result, the so-designated 29Si sub-network has the potential for almost continuous synaptic adjustments. As far as the virtually boundless informational capacity of isotopically diversified crystal is postulated, the problem of interaction between the crystal and the host (e.g., human body) becomes relatively secondary since such an informational exchange could be attained by a whole number of means (e.g., through resonance at infra-sound frequencies or through magnetic or electrostatic effects, etc.). To conclude the above argument, it should be pointed out that this whole hypothesis could, in principle, be subjected to experimental tests, for example, using crystals with different isotopic compositions.

However, there may be another "cosmic" angle to these ideas. In the context of electrostatic self-organization (Berezin, 1994d, 1997), it is interesting to note the recently discovered DNA-like plasma structures. An important recent development in the area of dusty plasma self-organization was the discovery of the formation of helical spiral structures. Experiments performed in the weightless (microgravity) conditions at the International Space Station (ISS), as well as theoretical simulations, revealed this amazing phenomenon occurring in charged dusty plasmas. They showed a propensity to spontaneously self-organize themselves into helical (spiral) structures that resemble double DNA spirals (Nefedov et al., 2003; Melzer, 2006; Tsytovich et al., 2007; Kamimura and Ishihara, 2012; Hyde et al., 2013).

As the above-quoted ISS experiments showed, complex plasmas may naturally self-organize themselves into stable interacting helical structures that exhibit features normally attributed to organic living matter, and in particular, DNA-double spirals. These interacting complex structures exhibit thermodynamic and evolutionary features that are thought to be peculiar to living matter, such as bifurcations that serve as "memory marks," self-duplication, metabolic rates in a thermodynamically open system, and non-Hamiltonian dynamics. Likewise, these structures reveal faster evolution rates by competing for "food" (surrounding plasma fluxes). In other words, these structures could have all the necessary features to form "inorganic life." Thus, we could be facing the fascinating possibility that inorganic life "invents" the organic life (Tsytovich et al., 2007).

A radical assumption here will be to say that the Infinite Pattern of Prime Numbers works as a "template" for the self-organization of these molecular chains

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and, subsequently, for the emergence of life. So, the "consciousness" ("consciousness of Prime Numbers") is both a cause and the effect of the origin of life.

These far-reaching hypotheses, coming out of this plasma work, may point to the possibility of alternative (perhaps, non-carbon) forms of life, "plasma life in the cosmos." This may provide some alternative scenarios for the origins of life on Earth (and perhaps on other planets). In view of the ideas on the possible role of isotopicity (isotopic diversity) presented in this book ("isotopic biology"), it seems tempting to propose that isotopic effects may, in turn, lead to some non-trivial effects in these "plasmodic structures."

At the same time, I realize that speculating further on these possibilities in more concrete terms at this stage may be tantamount to science fiction along similar lines to such masterpieces as Lem's *Solaris* (Lem, 1981). However, as is well known (there are many examples), science fiction more often than nothing has predicted the things that sooner or later become a reality. And sometimes the actual reality may even out-do the predictions of science fiction, many examples of this can be pointed out. So, "*isotopicity in plasma DNA*" remains an open quest until further data can be obtained and analyzed.

However, looking at the ISS experiments on dust plasma self-organization in microgravity conditions (Nefedov et al., 2003), which are supposed to imitate similar effects in the open cosmos, we can observe the following. Taking 5 mm as a typical size for dust particles (Nefedov et al., 2003; Tsytovich et al., 2007), we can estimate that such a particle typically contains a trillion (10^12) or so atoms.

Such a number could provide ample opportunity for all sorts of isotopic arrangements. Hence, the arguments about the possibility of the formation of isotopic neural networks presented in this book and in my earlier publications (Berezin, 1990b, 1991a, 1992b, 2015, 2016) may well be applicable to such dust particles. If so, such an "isotopic enhancement" of the situation with "plasma DNA in the cosmos" could greatly magnify the information processing and information storage capacity of such structures.

10.12 Isotopicity and Salvador Dali

One may wonder what Surrealism and Salvador Dali in particular have to do with isotopes. Yes, surrealism and isotopicity may appear odd bedfellows. Yet by the reasons which I already briefly explained in the Introduction, I feel it may be (somewhat) relevant in the entire isotopicity context. As I have pointed out in the Introduction the idea of "isotopicity" as a singular concept bears some spirit of surrealistic vision. I even venture to say that, perhaps, my affinity to the surrealistic art (and Salvador Dali is just one of many in this regard) has affected my envisioning of the isotopicity concept, even I have absolutely no personal talents in producing any kind of visual arts. In any case, in the midst of all these mind-boggling hypotheses (aka speculations) on isotopes and isotopicity some kind of an afternoon virtual trip to the Art Museum may bring some relief from the isotopic headaches.

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As a scientist and a scholar, my "second line" of interests was always in arts, architecture, and alike. In this way, I see myself as a follower (and, perhaps, to a degree, an imitator?) of my late mother Valentina Nikolaevna Berezina (1912–1987), who was one of the top art experts during her life-time career as a curator of the French collection at the Hermitage Museum in Leningrad (now this city is called back again by its historical name Saint-Petersburg). While she never personally did any art, she had an excellent "eye" on it and was known for her many artistic attributions and numerous books and articles on art (and not only on French art).

I had a great luck of living during my formative years (1950s) very close to the Hermitage, and for many years, I have attended lectures by my mother (as well as by many other wonderful art experts) and also attended weekly seminar of school-age children at the Hermitage. In this regard, I may be in a good company, since many physicists (especially theoretical physicists) are also admirers of arts and architecture and some (not me) have personal collections of arts. Now I go to my narrative on Dali.

Spanish (Catalonian) artist Salvador Dali (1904–1989) is almost unanimously considered the most important and most influential actor in the Surrealism movement. While generally seen as a Surrealist painter, Dali was also an illustrator, sculptor writer, film producer, as well as a jewelry maker, mostly from gold – and I feel sorry for the gold as it has only one stable isotope – hence no isotopic diversity in it! (in this regard, both silver and copper are more lucky as they both have two stable isotopes each). One of the most prolific artists of the twentieth century, his fantastic imagery and flamboyant personality also made him one of the best known.

As the central figure in Surrealism, he was also one of the most eccentric artists of the modern age. A brilliant painter and draftsman, Dali described his style as "paranoid-critical." The following biographical data on Dali are compiled from several sources such as articles on him in "The Dictionary of Art" (London: Macmillan, 1996), "New Catholic Encyclopedia" (2nd edition, 2003, Washington: The Catholic University of America), "Contemporary Artists" (St. James Press, 2002) and a few unattributed (mostly Web) sources.

Because the nature of space economy, as well as copyright reasons, none of Dali's pictures are reproduced in this book; it should be noted that books with his art are abundant in libraries and bookstores (e.g., Salber, 2004) and any interested reader most likely can find reproductions of Dali's pictures mentioned in this article. To be specific, the text below referrers to pages of the comprehensive edition of Dali's artistic heritage (Descharnes and Neret, 2001), later referred as DN. This book contains most (perhaps, almost all) works of Dali. Needless to add that much of his art can also be found online.

Salvador Dali was born on March 11, 1904 at Figueras, Spain (Catalonia) into a family of a respected notary. His father was a Republican and an atheist; his mother was a Roman Catholic. He was named Salvador in memory of his recently dead brother. This had a profound effect on him in his subsequent experimentation with identity and with the projections of his own persona into his art. This may have developed out

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of an early understanding of himself as a "reply" and a "double." In 1921, he entered the Art Academy in Madrid and became a friend of a poet Federico Garcia Lorca.

Dali's artistic vision was initially influenced by British Pre-Raphaelites and the great baroques masters, Velazquez and Vermeer. Later (in 1928), Dali encountered the French surrealists (Max Ernst, Yves Tanguy, and Andre Breton), whose artistic philosophy shaped the young Spaniard's vision.

Dali's greatest influences were the texts of Sigmund Freud, the poetic-philosophical vision of the Italian metaphysical painter Giorgio de Cirico, and cubism. In 1929, he befriended a French poet Paul Eluard and his Russian-born wife Gala who later left Eluard to become Dali's life-time partner, his wife and his muse, whose image in one form or another, presents in many of Dali's key paintings.

Surrealism is largely a contrarian's art. Its way to stimulate the viewer thinking about the deep issues is to provoke a peculiar mixture of human feelings such as an outrage, lust, disgust, and admiration. It is an art in which almost everything is the other way around. Most people who ever venture to write their autobiographies and memoirs, usually do it toward their senior years, when they have their life stories to tell. Not so for Salvador Dali. He writes his autobiography in 1942 at the age 38 when he still has 47 years to live. That's how he explains such a time reversal:

"Customary writers begin to write their memoirs "after the life is over," toward the end of their life, in their old age. But with my vice of doing everything differently from others, of doing contrary of what others do, I thought that it was more intelligent to begin by writing my memoirs, and to live them afterwards. To live! To liquidate half of life in order to live the other half enriched by experience, freed from chains of the past" (Dali, 1942, p. 393).

Dali did not suffer from the shortage of self-aggrandizement. He starts his autobiography with these words: "At the age of six I wanted to be a cook. At seven I wanted to be Napoleon. And my ambition has been growing steadily ever since" (Dali, 1942, p. 1). And he remains faithful to his words: his megalomania and his opinion of himself as the greatest artist of the modern times (with which many people undoubtedly agree) never showed any signs of abating.

By the time of his autobiography (1942), when Dali was still relatively young, he already became internationally known by many of his famous pictures, such as a masterpiece The *Persistence of Memory* (Soft Watches) (1935; DN p. 163), *The Burning Giraffe* (1936; DN p. 254), or *Woman with the Head of Roses* (1935; DN, p. 252).

By that time Dali has also acquired some odd press notoriety for his outrageous appearance (unusually long moustaches, and "mad" look) and his many provocative comments – the traits that, however, are normally excusable by public in individual who is perceived to be a true genius (a public status which Dali gained relatively early in his carrier).

The "Soft Watches" are an unconscious symbol of relativity of space and time ("Camembert of Time and Space," as Dali described them), a Surrealist meditation of the collapse of our notion of a fixed cosmic order. Dali wrote much later in his 1951

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"*Mystical Manifesto,*" that the theory of relativity substituted the substratum of the universe and thus brought time back to its relative role already accorded to it by Heraclitus when he said "time is a child."

Likewise, Dali, when he painted his famous "Soft Watches," apparently means to say that the Universe seems filled with this unknown and delirious substance (time), which, along with the explosive equivalent mass-energy, points that it is up to the metaphysicians to "work out precisely the question of substance" (Ades, 1982, pp. 179–180).

Dali constantly returned to "recycling" his favorite themes and images, but invariably in a new and unusual combinations, such as his *The Dreams of Venus* (1939; DN, p.327), where the images of melting watches and burning giraffes where put together. The liquid watches can be read as a symbol of the relativity and transcendentality of Time (and possible "quantum tunneling" escape to Eternity), while the burning giraffes (on his picture giraffes are in flames, but seem calm and not bothered by the fact that they are burning!) can point toward purification and a transcendental, *atemporal* existence in which the physical perishability is eliminated.

These notions where later amplified in his The *Disintegration of the Persistence of Memory* (1952–1954; DN, p. 461), where the images of numerous symmetrically arranged cubes (reminding pixels on Integrated Circuit chips) project a message of the discreteness of time (according to Quantum Physics time is quantized in fantastically small discrete portions, called Planck time units, which are shorter than a second by 43 orders of magnitude). For Dali, as well as for the modern science, the prime problem facing metaphysics was the nature of the underlying primordial substances, such as "time," "space," "matter," and "energy" (and now I have to add "information" to this list).

From his first exhibitions in Paris (1929) and New York (1933), Dali captivated the public with his visualization of the modern subconscious hot buttons, such as sexual anxiety, the eminent destruction of civilization, the fear of war, and the recognition of violence as both a plague and an irredeemable element of the modern society. Like many Old Masters, Dali is skillful in using a background panorama as one of his strongest interpretive tools. For a careful viewer, Dali's panoramas invariably invoke sense of eternity and transcendence. Dali saw the panoramic-critical method as a mean of destabilizing the world, believing that everything the viewer saw was potentially something else.

His initial public embrace of Roman Catholicism occurred during the Spanish Civil War when he supported the Monarchy, for him to be Spanish was to be simultaneously Catholic and Monarchist. His religiosity became more public and more profound as a result of personal crises that shifted his thinking toward traditional Christian subject matter in his painting during 1940s and 1950s, such as *Madonna of Port Lligat* (1950; DN, p. 443), *Christ of St.John of the Cross* (1951; DN, p. 451), and *The Sacrament of the Last Supper* (1955; DN, p. 488).

In the latter picture, the scene of the Last Supper is embedded in a semi-transparent figure of the Dodecahedron (it is one of the five Platonic symmetrical

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bodies). This artistic choice points toward the Ultimate Eternality in the ever-present antinomy of dynamism and unchangeability. The double semi-transparent figure of Christ (one inside and another outside the Dodecahedron) may be interpreted as a scale-invariance (another physical term) of the whole scene which points to its' significance at all time scales.

Everything in this picture is based on numerological play around the number 12: 12 hours of the day, 12 months of the year, 12 pentagons of the dodecahedron, 12 signs of the zodiac, 12 Apostles around Christ. "The painting is, on examination, held together by the architectural form of the dodecahedron," points out Dali. The fact that Dali is so fascinated by the Divine Proportion [the Platonic Golden Mean ratio found in dodecahedron geometry] helps to explain his interest in all pattern themes. The examples are the Logarithmic Spirals of sea shells, or the Pentagonal Symmetry of the beautifully composed sea shells he collects (Cowles, 1959, p. 234).

Within the focus of this book (on isotopes and symmetries), this can be put in a conceptual resonance with the so-called Pentagonal Quasi-Crystals which has a specific type of symmetry (Penrose Tiles). As for the symmetric number "12" for someone like an author of this book who is fascinated by the idea of *isotopicity* and "*isotopic numerology,*" it befits to recall that the main stable isotope of the most important element of life is 12C, which is carbon-12.

An interesting account on the Dali's Catholic connection is provided by the following passage from the Descharnes and Neret book: Father Bruno Froissart wrote (DN, p. 424): ["Salvador Dali has told me that nothing has as stimulating effect on him as the idea of the angel"]. Dali wanted to paint heaven, to penetrate the heavens to communicate with God. For him, God is an intangible idea, impossible to render in concrete terms. Dali is of the opinion that he is perhaps the substance being sought by nuclear physics. He does not see God as cosmic; as he said to me, it would be limiting. He sees this as a thought process contradictory within itself, one which cannot be summarized in a uniform concept of structure.

At heart of a Catalonian, Dali needs tactile forms, and "that applies to angels, too" (...). If he has been preoccupied with the Assumption of the Virgin Mary for some time now, it is, as he explains, because she went to heaven "by the power of the angels" (...). Dali conceives Protons and Neutrons as "Angelic Elements"; for, as he puts it, in the heavenly bodies there are leftovers of substance, because certain beings strike me as being so close to angels, such as Raphael of the Saint John of the Cross."

Some of Dali's landscapes include winged angelic figures on the background of his favorite landscape (the Catalonian shoreline where the Pyrenean Mountains meet the Mediterranean Sea). These are *Landscape near Port Lligat* (1958; DN, p. 508), *Port Lligat at Sunset* (1959; DN, p. 509), as well as compositions with dubious angelic/anti-angelic interpretation apparently aimed to draw attention to the inseparable dichotomy of Good and Evil, for example, *White Monster in an Angelic Landscape* (1977; DN, p. 654). The specific (and always almost the same) deserted shoreline background is repeated over and over again in many of Dali's pictures in the course of all his artistic carrier.

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Odd objects in surrealistic art are, nonetheless, almost invariably involved in some underlying interaction, some kind of a subtle "polarization" of each other in such a way that it always points to some background theme. The latter typically brings a viewer to a transcendent mood of Eternalization and Ultimacy in which the meaning often is just hinted, but not clearly revealed. As a thought-provoking and contemplation stimulating instrument, this approach leaves a lot to the human imagination.

The physical analogy here will be a so-called *Mossbauer effect* (Nobel Prize in Physics, 1961), which refers to the situation when the whole system of atoms in a crystal simultaneously takes up the recoil momentum of a single nuclear transition of a particular radioactive isotope. That means that all atoms act as a holistic unity, not as separate "individuals." At a human level, similar steps, which often constitute "forbidden transitions" in our every-day reality, are becoming "allowed" in the surrealistic imagery, as if some restriction become lifted and the game of the free will takes over.

It is now the well-understood premises of quantum physics that the short algorithmic programs are most common and most efficient in creating a variety of patters in the visible world. This explains a visible complexity of the world we see around, a complexity which is actually a mirage of the underlying simplicity and symmetry (Lloyd, 2006, p. 185). Simple programs, together with lots of information processing ("the Universe as a huge computer" metaphor) give rise to complex outputs.

In this vein, surrealistic combining of seemingly unrelated objects, twisting of them to the ugliness, metamorphising them into something totally "else" which is so characteristic of Dali's creativity, bodies very well with the inherent randomness (or pseudo-randomness), which underlines the fundamental premises of mathematics. Examples are the seemingly "random" popping up of Prime Numbers, "random" appearance of decimal digits in infinite strings like "π" number, etc.

Numerous pictures by Dali are testimonial of his fascination with atomic physics and his ability to offer his artistic transcendental interpretation of them. Such paintings, *Melancholic Atom* and *Uranium Idyll* (1945; DN, p. 385), *The Three Sphinxes of Bikini* (1947; DN, p. 411), *The Splitting of the Atom: Dematerialization near the Nose of Nero* (1947; DN p. 408), or *Leda Atomica* (1949; DN, p. 425), point toward attainment of serenity and eternity through the apparent confusion and anxiety of the emerged atomic age. [Atoll Bikini was a test ground for American nuclear weapons in 1940s and early 1950s].

His "Bikini" picture shows mushroom nuclear explosion cloud as human heads seen from behind. This can act as a grim reminiscence that the horrors of nuclear weapons invoke in our human mental process prior to their actual use.

In his *The Temptation of Saint Anthony* (1946; DN, p. 406), Dali anticipated the theme of "levity" (anti-gravity), which he later applied in his notorious images of Crucifixion. The distant view of El Escorial in this picture refers to the spiritual and temporal order and renders some dynamical stability to the scene.

Significant share of Dali's artistic heritage is devoted to Christological and Mariological themes. As he puts in his "*Mystical Manifesto*" (which he dates 15 April 1951):

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[(...) I want my next Christ to be the painting containing the most beauty and joy that has ever been painted up to today. I want to paint a Christ who will be absolutely the contrary in everything from the materialist and savagely antimystic Christ of Grunewald!] (quoted in DN, p. 471). For Dali, the path toward this claimed goal was the extensive use of visual effects like opening up of multidimensional vista (holographic vision), as well as all arsenal of the surrealistic effects, such as odd combinations of objects, transforming of images, "exploded" (almost "surgical") views of humans and bodily parts, eroticism in the most strange and unusual forms, etc.

However, in-spite of esthetic ugliness which is so striking in many of Dali's pictures, these approaches had led him (and the viewer of his pictures) to the elevated vision, often resulting in the sense of ecstasy. His efforts to bring us to a multidimensional vision are well in accord with the views of modern physics that our three-dimentional world (or four-dimensional, if we add time axis) is, in a fact, just a subspace in a higher dimensional super-space (physicists working on the so-called String Theory are talking of an 11-dimensional super-space).

So, all entire visible universe can be just a slice in a space of higher dimensionality, the same way as a two-dimensional plane (say, a sheet of paper as a page in a book) is embedded into a three-dimensional space (say, the whole book).

Here again, his compositions make good use of Platonic ideas of multidimensionality and such physical effects as (alleged) anti-gravity. His *Christ of Saint John on the Cross* (1951; DN, p.451) and a double composition *The Christ of Gala* (1978) depict Jesus on the Cross as suspended in the air in a seeming violation of the gravity laws. His *Corpus Hypercubus* (Crucifixion) (1954; DN, p. 467) shows the same effect ("anti-gravity") on the background of three-dimensional projection of four-dimensional cube. This excurse to the fourth dimension can be seen as a reference to the eternality of the Crucifixion scene and its *a-temporal*, time-transcending eternal meaning.

This is how physicist Michio Kaku, who extensively writes on issues of modern physics and cosmology, multi-dimensionality and plurality of worlds, attests Dali's vision (Kaku, 2006, p. 184): "A hyper being [being of higher-dimensional space – A.B.] looking down on us will see us in our entirety: front, back, and sides simultaneously. In his famous painting *Corpus Hypercubus* (Crucifixion), Salvador Dali painted Jesus Christ crucified in front of an unraveled four-dimensional hypercube, or tesseract. In his painting, *The Persistence of Memory* (probably, his most famous painting), Dali tried to convey the idea of time as fourth dimension with melting clocks."

Similar holographic representation is used in his *The Madonna of Port Lligat* (1950; DN, p. 443), where the "exploded view" of the human body (as if it consists of isolated "parts") prompts the viewer to perceive a multidimensional meaning in which different time moments are integrated into a singular message.

The apotheosis of the Dali's Catholic theme is represented in his monumental frames such as *The Discovery of America by Christopher Columbus* (1958–1959; DN, p. 510) in which Columbus holds a banner with Virgin Mary symbolizing the forthcoming Christianization of America. In his *The Virgin of Guadalupe* (1959; DN, p. 513) and

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The Ecumenical Council (1960; DN, p. 530), Dali manages to fit his auto-portrait as well as a figure of a woman with the Cross which looks like his wife Gala.

Dali's dedication to relate his artistic theology with modern science remained strong till his last days. One of his last pictures, (*The Swallow's Tail – Series on Catastrophes*, 1983; DN, p. 723), represents a mathematical image taken from the Theory of Catastrophes. This theory, which was started by the French mathematician Rene Thom (1923–2002), was trendy in physics in 1960s and 1970s (e.g., De Sa and Berezin, 1989; Berezin, 1991c). It provides a lucid graphical image of sudden transitions in physical systems and turned out to be applicable to the visual descriptions of such diverse "non-physical" processes as Stock Market crushes, starts ups of military conflicts, falling in love, etc. (Berezin, 1991c).

Theory of Catastrophes is also seen as one of the pre-curses of the modern Theory of Chaos (Abraham, 1994), which later turned out to be an important accessory to the discourse on the dichotomy of Freedom and Determinism (Miller, 1991). To his last interest, Dali added the following remark (quoted in DN, p. 722): ["Now it is no longer a matter of pure imagination, of my moods and dreams, of automatism. Now I am painting the meaning that derives directly from my existence, my illness or my vital memories"].

Salvador Dali may thus be considered as a natural pre-mystic, possessing a "will to angelic power," to use his own terms. Dali, this great admirer of Saint Theresa of Avila and of Saint John of the Cross (…), feels that beyond Surrealism, Christian mysticism, too, opens the way to the Unknown and the Immeasurable (Cowles, 1959, p., 263).

Therefore, it appears to this author that the unfathomable depth of Dali's imagery and what was said in this book about the links of "isotopic randomness" to "consciousness" and "creativity" may well have a common generic background. Maybe indeed, our spontaneous creativity may be triggered (at least, on occasions) by the random decays of radioactive isotopes in our brains and bodies (Keswani, 1986), as was discussed earlier in this book? Anyway, the contemplation on the possible links between Surrealism and Isotopicity may be an enlightening experience to dwell upon.

Chapter summary

As a central substance for our life, water bears many mysteries and fascinating puzzles. While a simple substance in a chemical sense (only oxygen and hydrogen), water has five different isotopes (two for hydrogen and three for oxygen) and that results in a high density of information content that the water can carry in a digital form. For human psychology, water often acts a "strange attractor" – one of the prime items of the Chaos Theory. Extreme sensitivity of chaotic phenomena to minute variations of parameters ("Butterfly Effect") has many ramifications for human life. Isotopic randomness and isotopic ordering in water provide a digital model for the

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“water memory” that is one of the foundations of homeopathy. In a similar fashion, isotopic ordering in crystals such as quartz leads to the formation of “isotopic neural networks” that may explain the healing properties of such crystals. Isotopic randomness in water and its possible informational consequences open the logical platform to review major aspects of Isotopic Engineering. The last essay in this Chapter discusses the surrealistic art of Salvador Dali in connection with atomic physics and isotopic randomness.

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11 Infinity reloaded

By definition, contemplations on Infinity can themselves be infinite. Infinite Ideal Platonic World (IPW) and the infinity of Prime Numbers can never be exhausted. Dwelling on them opens the path with no end. But this is not a tragedy. On the contrary, it is an invitation full of excitement and eternal optimism. This chapter has several essays that at first glance may appear somewhat disconnected, yet they have a unifying theme behind them. The theme of Infinity.

11.1 We all live in other galaxies: Cosmic scales of nuclear wave functions

> *If the Sun is 1 cm in diameter (size of a blueberry), the closest star (4.3 light years away) will be 240 km (150 miles) from the Sun.*
> Trivia (anybody can calculate this)

The above quote (repeated from Chapter 7) shows how empty the Universe really is. Now (some) physicists say that it is filled with "Dark Matter" and "Dark Energy." These concepts are hardly yet tested experimentally, but quickly came into vogue and are becoming an article of faith of the mainstream science orthodoxy. What a substance, if any, these theories have behind them, I am not discussing here – there are plenty of PROs and CONs on the Web on this subject.

Instead, I would say (or rather, remind) what FOR SURE "fills" all the Space, Time, and the Universe – it is the Infinite and Eternal IPW. Mathematics, if you wish, is outside Space and Time, it is nowhere in particular, yet it is everywhere. And so are the Infinite Cantor's Sets, an infinite pattern of Prime Numbers, fractal Mandelbrot Sets, and the whole zoo of other similar ideal "objects."

But back to more physical and tangible items. Atoms and isotopes, the stuff we are made of. And here Quantum Physics and Cosmology open up truly exciting vistas. We are not "just here," but everywhere in the distant galaxies. And not just metaphorically, but in a true literate sense. The actors of this play are Radioactivity and Quantum Quasi-Stationary States.

Quantum physics distinguishes between stable and unstable systems. The best-known unstable systems are radioactive isotopes that decay with a specific rate. For example, radioactive carbon, 14C, has a half-lifetime of 5,730 years, which means that half of all 14C atoms will decay within the said period. The fact that this lifetime is relatively short makes carbon-14 a useful tool for the dating of historical objects (The "Shroud of Turin" is one of the best-known examples).

Yet, the notion of absolutely stable particles (atoms, electrons, protons, etc.) is an idealization. In fact, even the so-called stable atoms (stable isotopes) have a finite

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life-time, never mind that these lifetimes are estimated to be orders of magnitude greater than the presumed age of the Big Bang Universe (BBU) (which is about 14 billion years). Decaying states in quantum physics are called "*quasi-stationary states*" and, strictly speaking all states and systems are quasi-stationary.

An interesting, and perhaps challenging, comment may be appropriate in relation to almost-stable (weakly radioactive) isotopes, such as bismuth-209 (209Bi) or germanium-76 (76Ge). These isotopes are usually considered to be stable because their lifetimes are of an order of 10^19 to 10^21 years, which is billions of times longer than the presumed age of the (Big Bang) universe.

And yet, technically, these nuclei are radioactive and hence their ground state is, strictly speaking, a quasi-stationary state. The latter states belong to a continuous energy spectrum in terms of the standard quantum mechanics (more on the quasi-stationary states in the context of isotopicity is in Section 9.11).

Thus, because all matter is eventually radioactive, quantum mechanically, all stable states are *quasi-stationary states* (QSSs). For QSSs, the asymptotic behavior (fall off) of (the spatial part of) the wave function at large distances (r) can be approximated by the equation (Landau and Lifshitz 1963, p. 592; Baz et al., 1966, p. 169):

$$\psi(r) = (1/r)*\exp[(\tau /TL)*r] = (1/r)*\exp(r /R), \tag{11.1}$$

where "τ" (Greek tau) is the characteristic nuclear time, T is the lifetime of an isotope, and L is the characteristic length of a quantum confinement (in this case, L is the "size" of the nucleus in a quantum mechanical sense, which may not be exactly the same as its formal geometrical size, but is [usually] of the same order of magnitude).

The combination of the factors TL/τ is designated as R. According to the formal reading of the above equation, at the characteristic distances of an order of R, the (spatial part) of the wave function starts to grow exponentially and for "r" tending to infinity the amplitude of the wave function tends to infinity too. As an estimate (given a few lines below) shows, the value of R is typically astronomical lengths (light years).

The integral of the square modulus of the wave function given by the above equation is, of course, divergent, as is always the case for quantum states which belong to the continuum spectrum (and QSSs in a strict quantum mechanical sense belong to a continuum spectrum). The seemingly paradoxical result here is that the wave function in the above equation falls off so slowly that most of the wave function "exists" in the area outside the sphere with a radius of many light years.

This whole situation with an unlimited growth of the wave function, when "r" tends to infinity, may appear truly paradoxical. However, as Landau and Lifshitz noted (Landau and Lifshitz, 1963, p. 592), the QSS is actually a non-stationary (decaying) state. Hence, the full wave function is exponentially decaying like exp(-t/T), which, however, does not negate the fact that the normalization integral of the wave function diverges. This is because exp(-t/T) remains finite at all t, here T is the lifetime for the decay of a particular isotope.

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The paradoxical result represented by the above equation can be interpreted as indicating that the decaying QSSs (in this case, radioactive isotopes) do actually "exist" (for the most part, at least) well "outside" their formal locations "here," and indeed some astronomical distance from "here."

As a specific example of the above, let us take the 14C isotope. It has a lifetime (T) of 5,730 years against beta-decay with a decay energy of E = 0.156 MeV = 2.5 × (1/10^14) J (Joules). Take for L = 1/10^14 m (the size of the nucleus) and for "τ" the value 0.42×(1/10^20)s – the characteristic nuclear time which is 20 orders of magnitude shorter than a second. With these values, we obtain R = 3.75 · 10^17 m, which is about 40 light years.

Yes, strange as this result may look, "most" of the 14C atoms we have around us are (according to this result) somewhere beyond Sirius (eight light years from us), or Vega (26 light years away).

For slower decaying isotopes (and according to the above, all radioactive isotopes are in QSSs) with greater values of T (and hence R), this logic leads to even more remote regions for the "prime residence" of these isotopes (or, rather, their QSSs). These may be thousands, or millions, or billions of light years from us. For such isotopes as the above-mentioned 209Bi or 76Ge, we are looking for residential distances that are far greater than the size of our BBU. That is where they "actually" are.

Does this same logic apply to macroscopic objects like ourselves? Do we "exist" in some other distant galaxies, or, perhaps, even outside "our" visible universe (BBU)? These are the issues for some wild (and, perhaps, weird) metaphysical speculations and contemplations that I am leaving at this point as open quests for my readers to dwell upon.

Another possible comment here is that the above result (or hypothesis) may open up a new vista on Bell-Bohm-type quantum non-localities and/or the classical interpretation of Newtonian inertia through the action of the "remote universe." The spooky partner of Schrödinger's Cat may "in reality" live some 10^100 light years away (!). Our apparent localization "here" may, in this context, be an illusion.

We, and everything else around us, may (in this picture, at least) be *delocalized entities*. So to say, "angel type" (or, use any other "divine" image, if you like). And, with specific regard to isotopes, we can also note the following. Because the lifetimes of (quasi-) stable isotopes are exponentially different on super-cosmic time scales, variations in contributions to QSSs from remote parts of the (mega-) universe (a vastly different R for different isotopes) may drastically enhance the informational aspects of isotopic effects. The latter aspect may likely make isotopic diversity to work as the pattern-forming connector between microscopic and ultra-cosmic mega scales.

To summarize, let me put the above argument in a more common-sense way. Quantum physics basically tells us that the "objects" (like ourselves) that we perceive as localized in a particular place are, in fact, de-localized and exits "everywhere." The estimates on the principles of quantum physics lead to the conclusion that such de-localization distances may be astronomical. To simplify this even more, we can say

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that we *indeed* do exist in other galaxies in the same fashion as the Schrödinger's Cat can be "simultaneously" dead and alive. Whether you may like such conclusion or not is, perhaps, a matter of your metaphysical and esthetic choice.

11.2 Quantum paths to infinity

One of the prime articles of faith of the modern physics is the premise that the speed of light is highest physically possible speed. Nothing, according to this principle, can move faster than light. That is 299,792 km per second or 186,282 miles per second. The fact that it is almost exactly 300,000 km/sec makes it easy to remember in metric system. So, nothing can move faster, the modern physics says. Oh, yes, there are some talks here and there about "*tachions*" (faster than light particles), but so far nothing of that kind was experimentally observed and some claims that have been made to that effect remain controversial and disputed.

And yet there are some interesting paradoxes of Quantum Physics that, I believe, may show the way to circumvent the said speed of light limitation. As early as in 1929, at the dawn of Quantum Physics, two young scientists, John von Neumann (1903–1957) and Eugine Wigner (1902–1995) have published a paper in the German Physics Magazine. At that time, most physics was still published in German and the paper had a title "*Uber Merkwurdige Diskrete Eigenwerte*" ("On the Miraculous Discrete Quantum Levels") [J. von Neumann and E.P. Wigner, *Physikalische Zeitschrift*, Vol. 30, pp. 465–467, 1929].

This paper was discussed above in Section 10.10, and now I want to repeat a few points.

We can appreciate that at that time both authors were still in their mid-twenties and both later went to become world-known first-class stars. John von Neumann is one of the founders of computer science and informatics, while Eugine Wigner has break-through contributions to quantum physics (Nobel Prize in 1963). What the above paper has is an example of some potential field in which a particle moves to INFINITY within a FINITE time. That means, it gain an infinite speed, reaches the infinity, and reflected back from it (from infinity!), as if an infinity works as some kind of a "magic mirror."

This example by von Neumann and Wigner has opened an area in Quantum Physics of the so-called "singular potentials" to which I also made some contribution by solving a few related problems (Berezin, 2015, 2016).

Thus, what was said above about "us living in distant galaxies" has another illustration in the form of singular potentials – delta-potentials first introduced by Enrico Fermi and Paul Dirac. The latter (delta-potentials) are used in many areas of physics from nuclear to solid-state physics (e.g., Berezin and Kirii, 1970; Demkov and Ostrovsky, 1975; Berezin, 1986a). Delta-potential is the simplest model of the singular potential in quantum physics.

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The popularity of delta-potential model comes from the fact that this model allows to simplify many calculations in atomic, nuclear, and molecular physics. Also, in recent years, the ideas of a possible forthcoming social and demographic singularity (Bostrom, 2003, 2016) have added additional fuel to the singularity concepts, in particular, in the context of discussions on “Transhumanism” and the overall globalization (Fukuyama, 2004).

11.3 Virtual realities and quantum computing

What is briefly discussed below is based on the Everett’s model of Multiple Breeding Universes or Parallel Universes (Barrow, 1998, 2002; Wolf, 1990; Albert, 1992; Halpern, 1992; Kaku, 1994, 2004, 2006; Gott, 2002; Tegmark, 2003, 2014). A “parabolic” (grotesque) statement of the issue might be helpful to open up the discussion.

Suppose, an asteroid of about 100 km in size suddenly hits the Earth (happens rarely, but possible). Or, imagine that the finite possibility of the Sun exploding as a Superstar occurs. Or, consider the possibility that AIDS virus or other bad germ would suddenly mutate into an easily communicable form and wipe out the entire human race.

Would any of these events really bring an “ultimate end” for all of us, or would we continue to exist in “parallel universes”? Do virtual realities exist “somewhere”? Does “our” three-dimensional (or four-dimensional in the Einsteinian sense) Universe find itself embedded in some Superspace and Supertime of infinite dimensions?

Using an analogy with Hilbert Space in “ordinary” Quantum Mechanics, we could equate Hilbert space with the manifold of all possible quantum states. All the terms of a quantum superposition may have “an independent” existence in “some other” space-time (Carloye, 1992). This is somewhat similar to a Cyberspace of Virtual Realities.

To some extent, the notion of Virtual Reality can also be applied to religious and metaphysical systems. Almost all notions of an after-death existence can be fitted into these metaphors of quantum virtual realities. The other global trend to offset the notion of a complete annihilation can be related to an almost universal desire to leave a trace behind. This ranges from the procreational proclivity of all living nature to almost all spectra of creative human ventures, whether they be the pyramids of Egypt, or just the graffiti on tourist monuments and subway stations (Berezin and Nakhmanson, 1990; De Freitas, 1992; Verheyen, 1992).

Speaking in quantum terms, such striving for self-extension can be described by the metaphors of quantum delocalization effects like the tunneling and spreading of the wave function, and the effects of the non-local nature of space as reflected in the so-called Einstein–Podolsky–Rosen correlations (Bell, 1988).

Virtual realities were recently put in the perspective of the idea of Quantum computing. Quantum computing (Feynman, 1985; Penrose, 1989a, 1994; Lloyd, 2002, 2006), or the closely related theory of quantum automata (Albert, 1983, 1992; Lloyd, 2002, 2006), is a new segment in theoretical physics and informatics. Its emerging

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importance is quite interdisciplinary and may far transcend the physics of computational systems in the proper sense. It relates such apparently quite disparate things as "cosmology through the entropy of black holes," the nature of time, evolution, emergence of information in non-equilibrium systems, and the physics of consciousness (Berezin, 1990b, 1992a, 1994a, 2015, 2016).

Generally, any physical computation is a process that produces outputs, which depend in some desired way on given inputs. The nature of inputs and outputs should normally have some informational interpretation. This generalized vision admits under the notion of computing such processes as ontogenesis, bio-evolution, the operation of the immune system, and many other bio-related processes, including consciousness and other manifestations of mind-matter interactions (Miller, 1991).

In this context, *Isotopicity*, as a level of informational diversity, additional to "common" chemistry, could be the missing link between the requirements of conscious processing and quantum measuring systems operated on the principle of Quantum Superpositions of alternative states or outcomes (Albert, 1983, 1992).

The combination of *Isotopicity* and *Quantum Computing* suggests that we view isotopically patterned molecular or crystalline structures as a kind of quantum mechanical measuring system or a "quantum computer." The fundamental capability of isotopicity to perform such a task lies in its information potential as explained on the basis of the "freedom-within-fixed-structure" paradigm (Berezin, 2015, 2016).

Although still *Gedankensystems*, Quantum Computers, differ conceptually from their classical counterparts, they are systems which make use of the superposition principle of quantum mechanics, that is, the notion that in some sense a quantum system can be simultaneously in a number of mutually alternative ("virtual") states. The paradigm of quantum computing (Albert, 1983, 1992; Feynman, 1985; Lloyd, 2002, 2006) can also be productively combined with the ideas of the human mind as a (quantum) filter (Drogalina-Nalimov, 1990).

One can also think of possible links between Quantum Computing and more traditional notion of Synchronicity (Combs and Holland, 1990). Such an analogy can be based on a highly "non-local" connectivity between synchronistic events resembling quantum non-localities.

11.4 Numerology and platonic reality

Many people intuitively believe that "mathematical objects" are "just there," and somehow have an absolute existence. For example, it is known that the infinite sequence of positive integer numbers 1, 2, 3, 4, 5, 6, 7, ... has an infinite subsequence of Prime Numbers (2, 3, 5, 7, 11, ... etc.). Prime Numbers are not divisible by other integers except themselves. The division of all integers into composite and prime is, of course, absolute: in no conceivable universe (no matter how bizarre it can be physically) can a Prime Number become a non-prime or the other way around.

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Does the *Numerology* and *Primology* give us room for some workable *universalias* in terms of URAM (Ultimate Reality and Meaning) values? Even restricting the whole of mathematics to just Number Theory, still gives us an inexhaustible exploration domain (Schroeder, 1986; Ribenboim, 1989). Even more so, it remains true for all (possibly infinite) upgrades of Number Theory like the theory of Diophantine Equations (Casti and Karlqvist, 1991). It is quite possible that other areas of mathematics, such as the fractal structure of iterative maps (e.g., the Mandelbrot set) are homological to Number Theory.

For instance, the interplay of infinities of the Prime versus the Composite numbers may be ultimately responsible for all the intricacies of the fine structure of the Mandelbrot set, Julia set, and other similar constructions.

Said the German mathematician Leopold Kronecker (1823–1891), "God created only the integer numbers, all the others being the work of man" (as cited by Lima de Freitas, 1992). The driving force of Chaos Theory and the theory of Fractals was their clear and multisided featuring of the world of the potentially observable phenomena.

Therefore, it is suggestive to explore the following "Conceptual Triade" formed by the following "items": *URAM*, *Numerology* and *Reality*. Here, the latter component (Reality) has, in turn, "subcomponents" of physically actual reality and virtual (physically possible) reality.

The idea of a Virtual Reality "hidden" in Numerology (and geometry) is not new. The descending (unfolding) of the Platonic World into the "actual" material reality is common to many cultural traditions. Citing Lima de Freitas (De Freitas, 1992): The circle stood, at least since the Egyptians and the Greeks, for the idea of Totality, Wholeness, as enfolding all possibilities of manifestation (space, time, matter, consciousness) past, present or "zero," conceivable and inconceivable …

These ideas, which are in the same spirit as "holographic unfolding" (Bohm and Hiley, 1993; Talbot, 1992, 2011), move us somewhat in a direction of contemplative agreement with URAM values rather than active actualization ("everything already exists within a virtual manifold").

Nevertheless, it is almost humanly impossible to surrender the ultimate importance of our deeds and personal responsibility. This implies some inherent time asymmetry and a "one-time-only" evolution. These should somehow dichotomically co-exist with all-containing virtuality in the above-described cosmic sense.

11.5 The ultimacy of experience in a context of eternal meaning

Most intelligent people do not believe in God, but they fear him just the same.
Wilhelm Reich (1897–1957, psychoanalyst, "Orgon" theory)

The two most important facets of the URAM (Ultimate Reality and Meaning) problem may be (1) the URAM of our creative efforts and (2) the problem of ultimate theodicy ("why so much evil").

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Despite their dissimilarity and seeming un-relatedness, these two aspects have multiple inter-connections, and they both are relatively common within a wide range of religious or metaphysical beliefs and concerns.

New physics makes potential contributions to these problems along several lines, including the whole matter of Virtual Reality. As was stated by the French mathematician Henri Poincare, one of the fathers of the modern chaos theory, (cited by Barrow, 1998): “A reality completely independent of the spirit that conceives it, sees it or feels it, is an impossibility. A world so external as that, even if it existed, would be forever inaccessible to us.”

In a modern context, these ideas can take the form of an experiential realization (in a quantum mechanical sense) of the reality of various forms of fiction and imagination. To that, we can relate a variety of fiction stories, as well as such sources as, “sacred books,” legends, myths, and more recently, cinematography, and imaginary and surrealistic art.

All these forms assert in them a greater (and not a lesser!) “level-of-reality” than the “real world.” A rather specific “experimental illustration” to this premise will be the well-established medical action of placebo effects and other healing techniques based on visualization (Moyers, 1993).

Here, the imagery and the “refining” of a reality in a quantum sense (Zohar, 1990) acts in an observable (and often in a medically registered) way as an enhancement (elevation) of the level of existence from a virtual level to a level of consequential realization.

The issue of the ultimate validation and eternal significance of our human experience is a common thread for most religions and contemplative metaphysical systems. The scientific world-view (at least, in a recent “new physics”) emphasizes a “trichotomic” (rather than a dichotomic) human experience. The triangle SPIRIT-MIND-BODY arises through the wave particle *dualism* if we amend this quantum dualism with an additional (“third”) *informational* dimension.

The dynamism of non-linear quantum reductions coupled with the linearity of the Schrödinger equation (Penrose, 1989a; Berezin, 1994c, 2015, 2016) can be seen as a route for the unfolding (exteriorization) of this trichotomic relationship.

What would be the place for the theodicy aspects of the URAM problem in modern physics? These are related to the problem of suffering, pain, and all other devastating aspects of existence. Within a cosmic Anthropic Principle (Wheeler, 1988, 1990), a promising foundation is provided by the principle of Maximum Diversity: the hypothesis that the universe is constructed in such a way as to optimize its possible diversity. Citing Freeman Dyson:

> The principle (of maximum diversity) operates both at the physical and at the mental level. It says that the laws of nature and the initial conditions are such as to make the universe as interesting as possible. As a result, life is possible but not too easy. Always when things are dull, something new turns up to challenge us and to stop us from settling into a rut. Examples of things which make life difficult are all around us: comet impacts, ice ages, weapons, plagues,

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> nuclear fission, computers, sex, sin and death. Not all challenges can be overcome, so we have tragedy. Maximum diversity often leads to maximum stress. In the end we survive, but only by the skin of our teeth. (Dyson, 1988)

Extending these thoughts, we can say that the range of URAM-related aspects in modern science is quite diverse. Such problems as the Eternalization of Time, Backward Causation (the future affects the past) and their relationship to teleology, multidimensionality of time (e.g., a possible introduction of a kind of quantum "Hilbert space" for time itself, if one introduces time as a variable with infinite dimensionality) – all these aspects, and many others, are awaiting further elaboration by philosophers, metaphysicians, and spiritual practitioners.

11.6 Euclidean embedding

Most scientifically literate people know that according to Modern Physics, the space-time of the Universe is curved due to the effects of General Relativity and the "real" geometry of the Universe is a Riemannian geometry, which is a version of non-Euclidean geometry. Whether the Universe is finite or infinite, or whether there are other universes (separate "soap bubbles"), and whether there are "higher dimensionalities" – these are all the questions which be better addressed by metaphysics and/or surrealistic art, than by "physics as such."

And in this regard, my personal sympathies are pretty much lean toward metaphysics and visionary contemplations rather than "hard facts" of physics (Berezin, 2004c). This is because, in my experience at least, the so-called "hard facts" in physics (as physics itself) are always in the state of flux, and our present (eclectic as it is) picture of the World, most likely, will be changing with time. At least, prior history of science provides numerous examples of that.

Yet, the ideas of curved or finite space (space-time) have never satisfied me completely. My vision still includes an infinite flat Euclidean-Cartesian space-time with dimensionality N, where N may be any integer number (will Nature make a preference for Prime Numbers as far as the dimensionality is concerned?).

Such an N-dimensional "space" serves as an "*embedding space*" in which any curved spaces with any twisted geometry can be immersed (embedded). Why I do adhere to such a picture of "*Euclidean Embedding*"? The straight answer to that is because such a flat N-dimensional space-time realm is simply a *thinkable* (and conceptually easy) abstract image to construct. A picture of an infinite flat space (or space-time) is the *simplest* one for our mental imagery and visualization. And according to the Ockham Razor Principle, the simplest explanations are usually the most likely ones, as well as they are conceptually preferable.

In an infinite Euclidean N-dimensional rectangular space, all seems simple. That is why it is usually introduced in the beginning of Calculus (mathematical) programs,

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sometime, perhaps, even in junior schools. The distance (D) between any two points is expressed through an N-dimensional Pythagoras Theorem. In our contemplations on the flat Euclidean space(s) nothing stops us from perceiving it as "infinite in all directions," as the title of the book by Freeman Dyson calls it (Dyson, 1988).

The very fact that is so easy and natural for us to mentally "visualize" infinite flat space makes it an almost irrefutable template and an irresistible image for the actual physical space. Same applies to the infinity of (flat, "Euclidean") time, never mind the "time loops" and other "beginning of time" theories (Berezin, 2004c, 2015, 2016). In fact, for our inquiring mind, it is perhaps MORE DIFFICULT (if at all possible) to envision a closed and finite space (and time), rather than perceiving them as infinite and extending indefinitely in all directions.

11.7 Isotopic randomness and omega number

Omega Number was introduced by Gregory Chaitin in the theory of randomness and (un)computable functions. It is related to halting probability of computer programs, something which was started by Alan Turing. Omega Number is a generic term and it can be defined in many ways, so it is not unique as, for example, Pi number (3.14159 ...).

Omega Number is a real transcendental number which can be defined, yet there is no algorithm which can compute it. It sounds paradoxical, and it is, it is somewhat akin to Gödel's Undecidabilty Theorem, yet, as the present author already stated, he (that is me) likes paradoxes and antinomies.

While an absolute ("true") randomness is perhaps Gödel-undecidable (undefinable in a closed form), in practice it is often measured by the information content needed to describe (explicit or implicit) pattern (e.g., Shannon entropy, S). Like stars on the sky (are they "random" or form "constellations"?), stable isotopes in crystals form patterns.

Informational patterning through CNT [short for "correlated neutron tunneling" (Berezin, 1992a)] indicates limitations of traditional statistics based on "democratic" (ergodic) counting of available configurations. Isotopic systems of finite size may be governed by informational attractor with infinite S (of countable or uncountable cardinality, in the sense of Cantor's "ALEPHS").

Furthermore, like Omega Number, the true structure of this informational attractor may even be ultimately unknowable. Such "unknowability," however, does not preclude the said attractor from pattern-forming capacity. Infinite Sets (IS) are not confined to classical probabilities, for example, IS of all integers can be split on IS of ISs, each containing IS of primes and only one composite. This visibly gives an impression that there are (infinitely) many more primes than there are composite numbers! This is the "statistical inversion," as discussed by David Lewis (Lewis, 1986) and it was described in Section 5.1).

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Thus, the fact that CNT occupies only a tiny (tower exponentially small) fraction of Hilbert space of quantum states can be overridden by some nonergodic attractor implicating Aristotelian “final causation” (*causa finalis*). Likewise, correlated radioactive decays imply possibility of strong (laser-like) departures from standard exponential decay law.

11.8 Cantor sets and eternal return paradox

Ideas of “*Eternal Return*” have a proper place in mythology, cosmology,, and mathematics. With such names as Arthur Schopenhauer, Friedrich Nietzsche, Mircea Eliade, Albert Camus, and many others (up to modern cosmologists), these ideas accumulated a significant literature presence. The myth of Sisyphus is probably the most known in this fold.

As this myth goes, the gods condemned Sisyphus to ceaselessly roll a rock to the top of a mountain, whence the stone would fall back on its own weight. They (gods) thought, with some reason, that there is no more dreadful punishment than such a futile and hopeless labor. Albert Camus (1913–1960) gave an extensive existential interpretation of this myth is his book with the same title. As Camus interpret it, the picture of such a world is pretty gloomy and leaves not much room for the hope, presenting Sisyphus as an archetype of eternal absurdity.

A more physical and philosophical tilt of these ideas are encapsulated in the theory of the “*Eternal Return*” (also known as “Eternal Recurrence”). It is a concept that the Universe, and all existence and energy, has been recurring, and will continue to recur, in a self-similar form an infinite number of times across the infinite time and space (Eliade, 1971).

Similar ideas can be found in Indian philosophy and in ancient Egypt and were subsequently taken up by the Pythagoreans and Stoics. With a decline of antiquity and the spread of Christianity, the concept of Eternal Return fell into disuse in the Western world, with the exception of Friedrich Nietzsche, who connected this idea to many of his other concepts.

In addition, the philosophical concept of eternal recurrence was addressed by Arthur Schopenhauer. It is a purely physical concept, involving no supernatural reincarnation, but the return of beings in the same bodies. Time is viewed as being not “linear” but “cyclical” (eternal repeats).

So, Eternal Return and Cyclical Time seem to be a curse imposed on us (as well as on everything else in the universe). What’s the point of life if everything (including us) returns in exactly same shape and form infinitely many times?

Infinite rat-race on a circle, we may say. Eternal Return in the above sense (everything repeats infinitely many times) seems to negate all our strives to originality and innovation, as well as render to absurdity our insights and commitment to a genuine creativity. Why bother, if it all return to the point of origin? And that’s what Albert Camus emphasized in his philosophy of universal absurdity.

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And yet, there may be an escape route from such a curse.

For that, I believe, we have to look at the ideas of *Infinite Sets* by Georg Cantor, his hierarchy of "*Alephs*." Let us recall that according Cantor, there is an infinite set of "nested" infinities and the first (lowest) infinity is ALEPH-ZERO (or "Aleph-Naught") set – a "countable" infinity (Dauben, 1977, 1979; Tiles, 1989).

The infinity of all Integer Numbers 1, 2, 3, 4, 5, ..., or Prime Numbers (2, 3, 5, 7, 11, ...), or all *rational* numbers (fractions like p/q, where both "p" and "q" are integers) have the same "cardinality," in other words, they are all of the "same size."

Infinity of all *real* numbers (such as Pi, e, etc.) have a *higher* cardinality (ALEPH-ONE) and, in a sense, it is "infinitely greater" than ALEPH-ZERO set. And that is not the end, there is an *Infinite Sequence* of *Infinite Sets*, each next one is "*infinitely greater*" than the previous one!

In view of such ideas, it is hardly surprising that some of Cantor's contemporaries saw his ideas as weird and crazy. Such highly regarded mathematician as Leopold Kronecker called Cantor a "scientific charlatan," "renegade," and the "corrupter of youth." Not all people were ready for the ideas of "infinity of infinities"!

But inspite that some opposition to Cantor's ideas continued even after his death (in 1918), it gradually run out of steam. In the subsequent decades (the Cantor's theory is over 100 years old), thanks to the work of several generations of mathematicians, the Cantor's Set Theory was elevated to the level of the most important foundation of mathematics. Even if it still has some open problems, like the famous "*Continuum Problem*" – a quest if there is a set with cardinality that lies strictly between ALEPH-ZERO and ALEPH-ONE.

However, this does not affect the capacity of Set Theory to provide a "metaphysical solution" to the Eternal Return conundrum. Thus, the meditations on Infinite Sets remain one of the most powerful and uplifting intellectual exercises for many spiritually oriented people of all ages and backgrounds.

So, what the "solution" can be offered here?

To begin, let us presume (provisionally, at least) that the Planck's length, which is 10^(–35) m (35 orders of magnitude smaller than "our" human length), is the smallest possible length. Of course, physically it may not be so (there may not be the "smallest" length scale), but for the sake of an argument, let us consider this as just an "ad-hoc" assumption.

All BBU can be divided on many "Planck boxed" filling the entire universe. The Planck box is cube with a side of Planck length. How many such "cubes" will fill the whole BBU? Well, the presumed size of the BBU is some 100 billion light years (we take an upper estimate). That is (approximately) 10^27 m [one light year is about 10^16 m]. So, the "size" of the BBU comes to about 10^62 Planck's lengths (35+27 = 62), and hence, to "fill" the BBU, we need a cube of this number, that is 10^186 Planck's boxes [(10^62)^3 = 10^186].

So, it is "only" 10^186 Planck's boxes? Recalling our "Tower Exponential" notations and "*Superfactorials,*" this number (10^186) looks ridiculously small ("1" followed by 186 zeros – can be written on a small card!).

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It is even less than T(3) = 10^10^10 of which we talked above (in Chapter 3), not to mention the four-level Skewes Number (10^10^10^34). And we can talk about Tower Exponents and Superfactorials whose mere HEIGHT is much higher than the size of the Universe [such as, e.g., T(1000) – a vertical stack of 1000 "tens"]. And the "Prime Number Gaps" can be longer [actually, infinitely longer!] than any of T-like numbers, even if the height of stack of "10s" can be higher that the size of the Universe!

But we need to go a bit further. Our goal is to find some escape route from the curse of Eternal Return.

Let us presume that all our "experience" in "this" Universe is coded by some two huge Prime Numbers, say, they both are about T(1000) long. Or, take, a million, or a billion, or anything, instead of just "1000." There will be enough digits in them to code not just "our" experience, but the "experience" of the entire BBU. Call these primes, say, P and Q.

Now form the *ratio* of them, r(1) = P/Q. This is a *rational* number. Rational number is the ratio of two integers. As we know, Rational Numbers form *countable* set (ALEPH-ZERO) and between any two rational numbers there is an infinity of other rational numbers. As mathematicians say, the "rational numbers form a dense set."

Now take some other "r(2)" arbitrary close to r(1), that is also a ratio of two (other) Prime Numbers. These Prime Numbers may code completely different "universal experience." Consequently, the "enfolding" such experience gives us an alternative scenario to escape the Eternal Return dilemma. Thus, an "Eternal Return" is rendered to a pseudo-curse and we can safely keep going with our lives not being bothered by the whole issue of the Eternal Returns of any kind.

If only Friedrich Nietzsche could figure this out ...

11.9 Logarithmic spiral: Path of infinity

On a somewhat easier note, we can illustrate the above thoughts with an image of the Logarithmic Spiral (LS) that is often used in various designs and artifacts like pendants or ear rings. The mathematical expression for LS is given by the exponential equation that in polar coordinates (r, θ) can be written as

$$r = a^{\star}\exp(b^{\star}\theta), \tag{11.2}$$

where "r" is the radius-vector, "a" and "b" are arbitrary positive constants, and θ is an angle that can go from minus infinity to plus infinity. For one full rotation around, the origin θ changes by $2^{\star}\pi$.

The most amazing thing about LS is that although it looks as it "starts" at the center of the coordinate system (that is point x = 0 and y=0), it really never gets there. When we move along LS trying to approach to the center, the spiral makes INFINITELY

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MANY turns around the center. So, we are closer and closer to the center at every next turn, yet we never get there exactly. In this way, the LS serves as a "metaphysical connecter" between the "Infinitely Large" and "Infinitely Small" realms. That likely explains both the "conscious" and "unconscious" esthetic appeal of LS for various artifacts and jewelry.

Interesting, that if we move along the LS from any starting point on it, in the *inward* direction (that is, toward the center), the *length* of the path that we have to go will be *finite*. That can be easily calculated by integrating the equation (11.2). Thus, it may seem (since the path is finite) that we can reach the Origin (the Center) in a finite time. And yet, it is hard (or perhaps, impossible) to do because we have to make *infinitely many turns* while approaching the center closer and closer, yet never actually reaching it! This is because the Origin (the point x = y = 0 in the rectangular coordinates) does not belong to the LS. This is another illustration of the Paradox of Infinity.

Infinite fractal structure of the Mandelbrot Sets is another image of such connection between infinitely small and infinitely large.

11.10 Living in the matrix – Physics reloaded

> *There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.*
> Donald Rumsfeld (b 1932, former US Secretary of Defense)

In-line with the "digital information" tone of this book, I would like to inject here a spirit of radical thinking and futurology by discussing the so-called "Simulation Argument." While it lies at the boundary of science fiction and the "real" computer science, it is gaining some momentum along the lines of the Transhumanism and Posthumanism discourse (Berezin, 2006).

The rapid evolution of computers and the exponential growth of computing power have triggered some interesting philosophical speculations. These speculations and ideas can, actually, be traced back to even earlier times. Recently, the philosopher and futurologist Nick Bostrom in an article with the provocative title "*Are you living in a computer simulation?*" (Bostrom, 2003, 2016; Berezin, 2006) presented a modern version of the argument for solipsism and subjective idealism.

Earlier proponents of similar idea, known largely under the term "*solipsism,*" include Ancient Stoics, and the philosopher and bishop George Berkeley (1685–1753) by whom the city of Berkeley, California is named. There are various grades of solipsism, but the central point is that the "outside world" is indistinguishable from "illusion."

This simulation argument resonates with several recent developments and global trends. One key point is the observation that there is a (super)-fast (exponential)

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advancement of information processing technologies. The so-called "Moore's Law" (doubling of processing power every two years) still runs its course for several decades (Berezin and Ibrahim, 2004).

So, the open discourse here is whether future computer and/or robotic systems will be able to emulate human consciousness (artificial intelligence, AI) at the level equal (or exceeding) our own. In other words, the standing quest here whether future humans will reach a biological symbiosis with computers (the stage of *transhumanism,* or *posthumanism*, as defined below), or (in more radical predictions), whether humans will actually be replaced by artificial self-replicating life-forms (e.g., "silicon life").

These philosophical themes have even attained some notorious visibility in mass culture and entertainment (e.g., the recent blockbuster movies *Matrix* and *Matrix Reloaded*). An earlier reflection on these issues was presented by Frank Tipler in his 1994 book, *The Physics of Immortality* (Tipler, 1994). His argument of the "*Omega Point*" was akin to the earlier ideas of universal convergence that were developed by the French Jesuit and paleontologist Pierre Teilhard de Chardin (1881–1955). Although Teilhard did not talk explicitly about the simulation hypothesis, the extrapolation of his ideas potentially points in this direction.

Somewhat similar ideas were spelled out over hundred years ago by (now almost forgotten) Russian philosopher Nikolai Feodorov (1828–1903). In his book "The philosophy of the Common Deed" (Feodorov, 1913), he discussed the idea of the universal resurrection on the bases of some future-advanced technologies. Such recent concepts as "Biocentrism" (Lanza and Berman, 2009) follow the same line of discourse using the ideas of quantum physics and parallel universes.

Even before Bostrom's publications, simulation ideas were well represented in the science fiction literature. Without going into a detailed discussion of much of this work (it could easily take many pages), I will mention here two dystopian novels by Greg Egan: *Permutation City* (Egan, 1994) and *Diaspora* (Egan, 1997). They address anticipated events in the middle of the twenty-first century. Computing power has increased enormously, to the extent that it is possible to run very detailed simulations of human brains and human bodies.

Also, scanning technology has improved to the point where it is possible to scan existing brains at the atomic level. In *Permutation City* Egan describes a community of simulated humans (Copies) with multiple copies of the "same" individuals. But it is not all good news: many Copies cannot tolerate this state of affairs and attempt to "bail out" into "reality." The Copies who do continue as simulations are worried about their rights and about maintaining access to the computing power on which their very "existence" depends.

In *Diaspora* humanity is divided into three types: "polis citizens" (downloaded minds running on software in virtual reality), "Gleisner robots" (software people living embodied lives in robot bodies), and "fleshers," people still embodied in good old-fashioned meat. The novels deal with many existential, philosophical, and math-

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ematical issues that would likely arise in the realm of grand computer simulations (such as, e.g., what would we experience if our brains were computer-upgraded to perceive a 12-dimensional world?).

Partly because of the success of the *Matrix* movie series, many aspects of the simulation argument have been discussed recently from a variety of philosophical positions. David Chalmers in his work *The Matrix as Metaphysics* (Chalmers, 2005) posited that the "Matrix" presents a version of an old-philosophical fable: "The Brain in a Vat." The brain is stimulated with the same sort of inputs that a normal embodied brain receives. To do this, the brain is connected to a giant computer simulation of a world. The simulation determines which inputs the brain receives.

When the brain produces outputs, these are fed back into the simulation. The internal state of the brain is just like that of a normal brain, despite the fact that it lacks a body. From the brain's point of view, things seem very much as they seem to all of us. The brain is massively deluded, it seems. It has all sorts of false beliefs about the world. It believes that it has a body, but it has no body. It believes that it is walking outside in the sunlight, but in fact it is inside a dark laboratory.

Furthermore, even the existence of the "real" (biological) brain is not essential – the entire simulation can proceed as a chain of bits (0s and 1s) in some supercomputer. As Nick Bostrom suggested (Bostrom, 2003), it is not out of the question that in the history of the Universe, technology will evolve to the point that will allow beings to create computer simulations of entire worlds.

There may well be vast numbers of such computer simulations, compared to just one real world. If so, there may well be many more beings who are in a matrix than beings who are not. Given all of this, one might even infer that it is more likely that we are in a matrix than that we are not. Whether this is right or wrong, it certainly seems that we cannot be certain that we are not in a matrix.

As Chalmers points out (Chalmers, 2005), the question of "reality" is a tricky one. We should not necessarily see a simulated world as being "unreal" – it just exists on the basis of a different metaphysical substrate, computer "bits" instead of atoms and molecules. Therefore, according to Chalmers, the situation (even if we live in the Matrix) may not be that worrisome – the simulated world just has a more fundamental metaphysical substrate (digital bits and information) than ordinary physical matter (electrons, atoms, and molecules). In short, whereas the "ordinary" physical world is based on the dynamics of material particles, the simulated world has its foundation in an unstoppable play of computer digits. In a metaphorical way, one could say that such a simulated world would be a direct projection of the IPW of Numbers.

It is interesting to note that notwithstanding the speculativeness of the simulation argument, we do have an obvious (and "real") analogy to it in our everyday life. Most (all?) people have dreams during their sleep, and sometimes these dreams are very vivid. Assuming that we can envision our brain as a (biological) computer, can we say that it actually creates a simulated reality during our dreams? In our dreams do "we" remain our "real selves," or do we emanate our simulated twins? Amazingly,

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analysis of the nature of our dreams leads to almost the same questions as are raised by the simulation argument.

Physicist Paul Davies puts it this way: "We are fascinated by dreams. Those people who, like myself, dream very vividly, often have the experience of being "trapped" in a dream that we believe is real (...). Can we be absolutely sure that the "dream world" is illusory and the "awake world" real? Could it be the other way about, or that both are real, or neither?" (Davies, 1993, p. 117).

Similar dream-or-reality ideas are plentiful in science fiction. While not attempting to review this truly impressive body of literature, I will mention here the novel *Solaris* (1961) by the renowned Polish writer Stanislaw Lem (Lem, 1981: English translation). This novel has been adapted for the screen several times, the best-known blockbuster movie was made by the Russian director Andrei Tarkovsky.

The novel talks about the discovery of a gigantic sentient colloidal ocean on the planet Solaris. The planet-scale brain is capable of incredible self-regulation, governing its macro-processes by controlling its orbit around two suns, and also its micro-processes by the manipulation of neutrino fields to create phantasmic simulacra of human beings.

When the novel's protagonist, psychologist Kris Kelvin, arrives at the Solaris research station orbiting the planet, he, to his amazement and horror, encounters a visitor – Rheya, a simulacrum of his dead wife, for whose suicide back on Earth he has blamed himself for many years. The scientists on the Solaris station come to realize that the sentient ocean is capable of producing materialized forms of their own unconscious thoughts.

Thus, the simulated Rheya is, actually, a materialized projection of what Kelvin's memory contained about the actual Rheya back on Earth. But physically the new Rheya is different: as Kelvin discovers through the atomic analysis of her blood, she does not consist of regular atoms but is actually made up of a system of stabilized neutrinos organized by a quantum field which is apparently under the planet's control. However, her behavioral autonomy is isomorphic with human behavior.

Thus, neutrino beings created by the ocean Solaris can be seen as intermediate between "real" people (made of atoms and molecules) and "true" computer simulations, which "exist" in the form of electronic bits in a running computer program. And this brings us to the following question: what grounds (if any) do we have to say that beings made of atoms are "real" while beings in the form of electronic bits are "fictional"? While not pretending to give a definite answer to this question (and I am not sure if anyone can!), I believe that this opens up a new and fascinating avenue to ponder on the ultimate issues of human and universal existence.

There are many other examples of items of mass entertainment that deal with the interface between what is "real" and what is "simulated." Such popular television series as *The Outer Limits* or *The Twilight Zone* and the impressive success of such books as the *Harry Potter* series and *The Lord of the Rings* trilogy – all evidence the

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actuality and importance of the theme of "reality versus dream world" for people in general. In fact, many of these fictional books and movies address questions of Ultimate Reality and Meaning (URAM) directly. Some of the typical questions are given below.

– Does it really matter if we are simulated reality or not?
– Do simulated beings (if there are any) belong to the same moral Universe as us, presumably "real," beings?
– To what extent can our dreams and imaginary worlds be considered to be simulated realities?
– Do the quality aspects of simulation affect the ethical values we assign to them?
– Is it morally prohibited to simulate "anti-reality," meaning by that some ultimately evil Universes of discourse? (It is almost certain that if a "positive" reality can be simulated, a "negative" one can also be simulated).
– If a strong ethical component in the simulated acts can be indicated, what are the criteria or guiding principles there?
– By whose moral authority are these presumed criteria and principles to be imposed?

By their very nature, most of these questions are open-ended. It is very difficult, if not impossible, to provide an unambiguous single answer to most of them, unless we are willing to confine ourselves to a stringent and limited philosophical frame. At the same time, there are some areas where the interface between the real and the simulated can be (to a degree, of course) explored at the experiential level. Numerous observations (and even some in-depth studies) on drug-induced hallucinations, enlightenment, and meditation practices, and Eastern and Western mysticism and spiritual awareness, although diverse in quality, intentions and results – all point to the expectation that our understanding of the interface between the real and the imaginary (or simulated) is likely to attain new levels.

Perhaps, a useful connection to explore in the context of these questions can be provided by the notion of the co-existence of Parallel Universes and Multiple Realities – ideas that are currently gaining strength at the advanced frontier of quantum physics and cosmology (Berezin, 2004c; Randall, 2005).

Or, in other words, is it, even in principle, possible to tell whether we are in a simulated reality or in a "real" one? Is there any difference between the two? Does it matter? And how should we behave if we know that we were living in a simulated reality?

Recently, the idea that "the Universe is a huge computer" has become popular in the mainstream physics (Lloyd, 2006). This view entails that all physical processes (atomic dynamics, biology, cosmological events, etc.) are elements of a single computational process. In this vein, the Simulation Argument (whether it uses the image of the Matrix or another relevant metaphor) would become an organic part of the underlying metaphysics rather than an odd addition to it.

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In a theological interpretation, the same, in essence, can be stated, as if physical reality is represented in the mind of God, and our own thoughts and perceptions depend on God's mind. In such a view, the simulation of the world is implemented in the mind of God. If this is right, we should say that physical processes really exist: it is just that at the most fundamental level they are constituted by processes in the mind of God.

In splitting his arguments into several alternative scenarios, Bostrom posits that with a very high likelihood at least one of the following three propositions is true:

(1) the human species is very likely to become extinct before reaching the post-human stage;
(2) any post-human civilization is extremely unlikely to run a significant number of simulations of their evolutionary history (or variations thereof); and
(3) we are almost certainly living in a computer simulation.

The first of these propositions is another form of "Doomsday Argument," according to which there is a very high probability that human civilization (and humanity itself) will be destroyed within a historically short time frame. While the Doomsday Argument has an implicit (sometimes explicit) presence in most key religions (say, the Book of Revelation in the Bible), in recent years it also has become a visible and powerful component of broad public discussion.

The published literature and numerous internet discussions show an exponential growth and intensification of this subject in recent years. Current political instability, nuclear proliferation, the growth of terrorism and intolerance, as well as demographic, economic and environmental uncertainties and tensions, are contributing to these gloomy predictions. If we add to this scenario various possible technological threats, such as self-replicating nanoscale systems which may quickly consume "ordinary" biological entities (the "grey goo" scenario), or the possibility of an uncontrollable genetically engineered pandemic, the overall picture becomes very scary indeed.

In fact, in recent years, the Doomsday Argument has evolved from a somewhat fringe and a "conspiracy theory" subject into a vocal issue of mainstream philosophical and futurological discourse. Such serious authors as, for example, the Canadian philosopher John Leslie (Leslie, 1996) and the renowned British cosmologist and astrophysicist Martin Rees (Rees, 2003) have summarized numerous arguments about why, more likely than not, our luck may soon be running out.

Without going into a detailed review of all the various possible (competing and/or concurrent) scenarios for our possible extinction, it is sufficient to mention one, probably the most serious, threat. There is an unstoppable and ever-growing capability for small but dedicated groups of people (and even single individuals) to inflict large-scale damage, to which events like the Oklahoma bombing of 1995 and the horrors of September 11, 2001 bear ominous testimony. Due to unstoppable advances in nuclear engineering and technology, the sheer amount of physically destructive power potentially available to small clandestine groups is becoming increasingly frightening.

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While some may downplay the above as conspiracy theories, the unfortunate reality is that the destruction of life on Earth through the explosion of a super-powerful nuclear device ("the doomsday machine") is not an unthinkable possibility. On the contrary, it is fully within the technological means existing today to construct such a device. Apart from nuclear threats, there are ongoing discussions about bio-terrorism, cyber-terrorism, and other sinister means of mass destruction. Even such crazy scenarios as an attempt to deflect a large asteroid to hit the Earth, are not within the realm of the impossible (e.g., the recent blockbuster movies *Deep Impact* and *Armageddon* depict technologically plausible means of deflecting asteroids).

On top of all this, it is becoming increasingly clear that no functionally sensible social system can fully control all the fringe individuals who may be nourishing such megalomaniac suicidal plans for all humankind. It is not uncommon for single individuals to commit suicide (some available statistics suggest that, on average, as many as 1% of all people die by suicide, and most likely not all suicide deaths are reported as such), why not take the rest of humankind with you?

[Note the recent case when a suicidal pilot deliberately crashed a passenger jet, killing not just himself but over a hundred others]

It is, of course, impossible to predict with full certainty whether the Doomsday Scenario (in whatever fashion) will indeed come to pass, or whether humanity will find a safe route to avoid it and keep progressing indefinitely. The most optimistic scenario foresees the future proliferation of humankind beyond this planet, perhaps even to galactic and cosmic levels, as some scientists are proposing (e.g., Dyson, 1979a, 1979b, 1988).

This does not necessarily limit future cosmic humanity to our present biological form; in fact, some authors propose a human–computer symbiosis ("cyber-humans"), or even a complete transfer of consciousness to robots (Kurzweil, 1999, 2005; Moravec, 1999). Marvin Minsky, one of the pioneers of Artificial Intelligence, has expressed a thoroughly optimistic view: "*Yes, we will engineer replacement bodies and brains using nanotechnology. We will then live longer, possess greater wisdom and enjoy capabilities as yet unimagined*" (Minsky, 1994). This future will show whether such optimism was warranted.

The ideas of *Transhumanism* and *Posthumanism* have their vocal enthusiasts as well as skeptics. These ideas are certainly unorthodox and controversial. Some critics fiercely oppose the very idea that human nature can or should be changed or tampered with in any way. The popular social philosopher and bestselling writer Francis Fukuyama went as far as to list Transhumanism among the most dangerous ideas the world is presently facing. He dismissed Transhumanism as: "a strange liberation movement whose crusaders aim much higher than civil rights campaigners, feminists, or gay-rights activists (…) This movement wants nothing less than to liberate the human race from its biological constraints" (Fukuyama, 2004). It remains to be seen if humanity will be able to work out more balanced and constructive views on these issues, or whether the clashes and divisions will continue, at least for the foreseeable future.

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When I myself contemplate these issues (especially in the context of the *isotopicity* ideas discussed in this book), I tend to reconcile these two "opposites" in myself: to see our world and our existence in it as "real" reality (what a tautology!) and a "simulated" matrix Universe. Maybe, there is some kind of antinomy (unity of opposites) in these two ways of looking at the world and ourselves. Everything rests on polarities: day and night, life and death, love and hate, positive and negative – everything: from our feelings and emotions to positive and negative electric charges. And the quantum Uncertainly Principle speaks of a similar duality: position and momentum, energy and time, particles and waves, discrete and continuous, order and chaos. Likewise, a duality of information (both "ideal" and "physical") comes into play here as well.

From ancient times until the present day, there has been an interesting (and often uneven) relationship between the "twin sisters": the "real" physics and "ideal" mathematics. And we most certainly need both of them as they need each other. Thus, perhaps, in some synthetic modality, we are both "real" and "simulated" in the overall infinite Platonic world of numbers and forms. And this is especially the case, if our contemplations in this regard go along the lines of such ideas as digital information, algorithms, binary strings (provided by isotopes and anything else), or the universal "Library of Babel" of all possible books and all possible knowledge.

Chapter summary

Quantum physics distinguishes between stable and unstable systems. The best-known unstable systems are radioactive isotopes that decay with a specific rate. For example, radioactive carbon, 14C, has a half-lifetime of 5,730 years which means that half of all 14C atoms will decay within the said period. The fact that this lifetime is relatively short, makes carbon-14 a useful tool for the dating of historical objects ("Shroud of Turin" is one of the best-known examples). Yet, the notion of absolutely stable particles (atoms, electrons, protons, etc.) is an idealization and, in fact, even so-called stable atoms (stable isotopes) have a finite life-time, never mind sometime their lifetimes are orders of magnitude higher than the presumed age of the BBU (about 14 billion years). Decaying states in quantum physics are called "quasi-stationary states" and, strictly speaking all states and atoms are quasi-stationary.

A peculiar feature of quantum states (quasi-stationary states) is that they are not confined to a particular location, but extend indefinitely. Their quantum wave functions have "tails" going to infinity. That relates even to the macroscopic objects and systems like ourselves. Strange as it may seem, this means that we do not just exist "here and now," but have presence at the remote galaxies. That opens up a discourse on the ultimacy of (our) experience and eternal meaning. The issue of "Eternal Return" raised by Friedrich Nietzsche, Albert Camus and others, comes into the focus of such a discussion. If taken as face value, "Eternal Return" can be interpreted as

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indication of the meaninglessness of all our efforts and universal absurdity of life. Yet, the suggested "metaphysical escape" from this conundrum can be sought in the Theory of Infinite Sets of Georg Cantor and its reflection in such images as the infinite pattern of Prime Numbers and Logarithmic Spiral that connects infinitely large and infinitely small scales. Ideas of simulated realities ("Matrix") and Transhumanism are discussed in this context.

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12 Neutronicity: A twin paradigm to isotopicity

This chapter suggests some ideas on the key role of the neutron in the cosmic informatics and digital universe. The ideas discussed in this chapter were formulated jointly with Dr. Vladimir V. Gridin of the Israel Institute of Technology (Technion, Haifa, Israel).

The concept of "neuronicity" is, in our view, a "twin concept" to "isotopicity" and, to our best knowledge, is an original concept in terms of the terminology and actual content. This chapter is written by two senior physicists, and it offers new and original views on cosmic and creative functions of the particle that we call *neutron*. These ideas are at the radical departure from the commonly accepted "mainstream" science of today.

Here, we advance the idea that neutron as a quantum particle is the *prime* dynamical carrier of the information in the universe. As was just said, we are unaware if there was any prior discussion of such an idea in any media, be it published literature (books, articles, and conference abstracts), or any other type of public communications. However, if there were any similar ideas spelled out previously, we in no way lay any priority claims; on the contrary, we will consider such prior discussions as a confirmation that we are on the right track. This chapter was prepared as a separate article by two authors; hence the use of "we" instead of "I." It may have some overlaps with previous discussions of "isotopicity paradigm" (or "isotopicity principle").

12.1 Centrality of informatics

This chapter unfolds the idea that elementary particle called *neutron* is the prime informational agent in the universe. We offer our views on this matter as an original concept that is ready to be picked up for further development by scholars in physics, informatics, biology, philosophy, mathematics, cosmology, and, perhaps, even in psychology and social sciences.

We are living in the age of digital informatics. Information is the major commodity of our entire civilization (Du Bravac, 2016). And we extend the ideas of information and "informatics" to areas well beyond of "informational electronics" as such.

We talk about the informational content of human speech and music, we calculate the informational capacity of human genomes and genetic codes, and we discuss the dynamics of information at cosmological scales (Lloyd, 2002, 2006).

Such active areas of intellectual and technological pursuits as robotics, AI (artificial intelligence), virtual and simulated realities (Bostrom, 2003, 2016; Kurzweil, 1999, 2005; Johnson, 1994) – all, in different ways, have "information" and "informatics" as a key *modus operandi* of the ongoing discourse.

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So far, practically all informational systems that are in use today are based on "electronics." This means that the processes with electrons (like operating of transistors in computers and memory chips) are the major (and, for all practical purposes, the only) players in all these technologies.

In this chapter, which we believe is highly thought-provoking, we propose to deepen this discussion to the level of elementary particles, in particular, neutron, for which we envision numerous aspects than what traditional physics presumes. Specifically, we present neutron as a key item for the universal informatics and informational connections at all levels – from the sub-atomic scales to cosmological and super-cosmic.

In the comments that follow, we unfold the hypotheses, that is, presenting neutron as a prime creative factor in the physical universe.

At the cosmological scales, the formation of the black holes and the collapse of stars to the neutron stars determine the dynamics of cosmos in real time and provide a physical platform for evolution and informational ascending. By the latter we mean *negentropic* ("anti-entropic") processes of self-organization and biological morphogenesis, as well as the emergence of self-aware structures and consciousness (Berezin and Nakhmanson, 1990; Leff and Rex, 1990; Lloyd, 2002, 2006).

We argue that such "capacities" embedded in neutron are largely due to it being a "tri-united" particle. The latter means that in a virtual (potential) sense, neutron is a quantum superposition of three other "components" *(proton*, *electron*, and *antineutrino*) that are "actualizing" themselves (becoming "real" particles) at the radioactive decay of neutron (a free neutron spontaneously decays on the three said particles with characteristic decay time of 15 min).

In what follows, we point to neutron as a prime particle responsible for the informational connectivity of the universe. We extend the ideas of the "paradigm of isotopicity" (Berezin and Gridin, 2017 and references therein) to a generically similar notion of the "paradigm of neutronicity." In this regard, we propose to look at this logistically connected tandem of two "paradigms" as a key foundation of the material world at all scales – from microscopic to cosmological.

12.2 Creativity of nature

The starting point of our discussion here is the principle of the creativity of nature. A look at the world around us leaves no doubt that nature unceasingly is busy in devising all kinds of systems and structures in all realms. At cosmic mega scales, we observe stars, galaxies, and galactical clusters millions of light years across.

As for the biological level (as it is known to us), it extends over some 15 orders of magnitude from the smallest bacteria to the entire planetary ecosystem (Gaia), with an enormous variety of ever-evolving organisms and symbiotic structures of all varieties (Cairns-Smith, 1982). We can mention here such system as, say, correlated

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flocks of birds and schools of fish, or multiple forms of social organizations in human societies. At the so-called non-organic (physical) level, we have various self-organized structures and processes.

From crystals and macroscopic phase transitions, the correlated phenomena with high degree of coherency (such as superconductivity, superfluidity, and other cooperative phenomena) exist on many scales and take many forms. Our main interests in this discourse lie at the level of atomic self-organization with a focus on atomic nuclei, dynamics of protons and neutrons, and, specifically, the key role of the neutron as a particle that is primarily responsible for the formation of isotopes, chemical elements, and cosmogenesis at all scales.

Our ideas of "isotopicity" and "neutronicity" are based on the *Parsimony Principle* as applied to the whole nature. This principle (also known as "Occam's [Ockham's] Razor") is basic to all sciences. It tells us to choose the simplest scientific explanation that fits the evidence. In terms of conceptual tree-building, this means that, all other things being equal, the best hypothesis is the one that requires the fewest evolutionary changes.

In view of the highly diverse biological world around us, we can conclude that the nature is highly creative in using all available tools for its own ends. So, the following question arises: Why nature has created (or chosen) neutron as a key particle in the first place? And the very existence of isotopes (as a "corollary" to the existence of neutron) raises the same quest as well – what goal (or goals) does Mother Nature have in its wisdom in making the material universe so "isotopic"?

There are likely some biological functions for practically all chemical elements of the periodical table (never mind, we may not know them all yet). Nature does not seem to miss any opportunity to use chemical diversity to the best possibilities. So, question can be raised about isotopic diversity. Does nature efficiently use it in biology or consciousness? Our answer to this is that nature does indeed use it (isotopic diversity), but we are yet to discover how exactly nature does that (how nature uses isotopes). All we have so far are just plausible suggestions (Berezin and Gridin, 2017), but targeted experimental studies are still awaiting their future.

12.3 Making sense of the world

To re-state some thoughts from the introduction section, it can be said that this "smartness of nature" is reflected in our constant strive for understanding. People are eager to make sense of the world around them. Sources and tools for this (presumed or real) understanding are many. On one end, we find religious texts and practices, spiritual enlightenments, and metaphysical meditations; on the other end, we have scientific theories and models (like big bang or self-organization theory and chaos theory). People are looking for the "big synthesis" in many modes and forms.

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Sometimes, it comes to using mixed metaphors combining religious (or spiritual) and scientific terminology. Naming a recently discovered "Higgs boson" a "God Particle" is just one example (as we argue below, in our view, the nomination of the Higgs boson to this "divine" status is misplaced).

Likewise, the ideas along the line "Mathematics as a God" are discussed by many authors in a great variety of the discourse modes (Carloye, 1992; Davies, 1993; Tipler, 1994; Dauben, 1977, 1979; Wolf, 1996; Plichta, 1997; Aczel, 2000; Livio, 2009).

Of particular interest is the intersection of the theory of infinite sets with theology and the idea of the infinity of God. Georg Cantor, founder of the theory of infinite sets, has identified some central points in this discourse in his correspondence with the key theologians of the time:

> … he [Cantor] summarized the position commonly encountered in the seventeenth century: that the number could only be predicated of the finite. The infinite, or Absolute, in this view belonged uniquely to God. Uniquely predicated, it was also beyond determination, since once determined, the Absolute could no longer be regarded as infinite, but was necessarily finite by definition. Cantor's inquisitive 'how infinite' was an impossible question. To minds like Spinoza and Leibnitz, the infinite in this absolute sense was incomprehensible, as was God, and therefore any attempt to assign a basis for determining magnitudes other than merely potential ones was predestined to fail. (Dauben, 1979, p. 123)

Thus, we express the view that the inquiry into the nature of physical foundations of the universe has a strong theological dimension. Here, we focus on the unique position of the neutron in this regard. Specifically, we view the neutron as a prime creative unit of the material universe –truly a "God Particle" in all possible aspects of this term.

12.4 Periodical table and isotopes

Almost 150 years ago, Dmitry Mendeleev had organized chemical elements in the periodical table – one of the cornerstones of the physical, chemical, and biological sciences of today. At that time, isotopes have not yet been discovered, but in the subsequent decades it was found that for 100-plus chemical elements there are some 3,000 isotopes – stable and radioactive.

So, in a somewhat rhetorical sense we can pose a question: Why Mother Nature needed so many isotopes for just a handful of chemical elements? (in average, over 30 isotopes for some 80 or so stable chemical elements).

This fact, which the present author (Alexander Berezin) has coded under a singular term *isotopicity*, has numerous implications and applications for virtually all areas of science, technology, and economics (Berezin, 2015, 2016; Berezin and Gridin, 2017). Isotopes differ in the number of neutrons in their atomic nuclei and this makes neutron a key player in everything related to isotopes and the effects coming from isotopic diversity and isotopic randomness.

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To provide some visual image, we can say that while the traditional periodic table is "2-dimensional" (each element occupies one box), the addition of isotopes can make it "quasi-3-dimensional," with all isotopes of every element plotted against *z*-axis and ordered according to the number of neutrons in each isotope.

Our prior publications (Berezin and Gridin, 2017 and references therein) discuss the *informational* dimension of the *isotopicity* concept. This, in the opinion of these authors, can lead to such ideas as an *alternative genetic code* based on isotopic combinations and the concept of "isotopic biology." The inclusion of isotopes as distinguishable quantum particles can greatly (exponentially) increase the informational capacity of DNA structures with possible consequences for biology, genetics, evolution, psychology, and biomedicine along the lines of ideas of emergence, informatics, and self-organization (Nicolis and Prigogine, 1977; Haken, 1978; Dyson, 1979a, 1979b, 1988; Hopfield, 1982).

We have also indicated (Berezin, 2015, 2016; Berezin and Gridin, 2017) some reasons why, in our view, these aspects were largely overlooked and underappreciated by the science community, apart from some sporadic ideas that potentially were pointing in this direction (e.g., Mann and Primakoff, 1981).

12.5 From isotopicity to neutronicity

In this chapter we deepen the concept of *isotopicity* to the very core of this phenomenon of isotopic diversity – the central role of the neutron in the universe, bioinformatics, and the origin of life.

We advance the view that neutron is a well-known elementary particle responsible for the existence of isotopes and radioactivity. We also propose that the neutron is a lot more – an entity that plays an active role as the information connector for the dynamics of emergence, origin of life, consciousness, and biodiversity.

In other words, we offer for the general circulation an idea that the neutron, due to its properties, is the *main* informational and creative actor in the universe (hence the reason for using capital "N" for neutron).

Neutron is not just another "elementary" particle that is used in nuclear reactors and neutron scattering experiments, but it is an entity that bears a prime responsibility for the information transfer and self-organization in the universe in the most direct way. And in such a context to call neutron an "elementary" particle is a disrespectful misnomer, or just a remnant of an obsolete terminology (like an "atom" – *a-tom*: mean un-divisible in Greek, although we know that atom is pretty much a "divisible" thing).

Of course, neutron is one of the main household items in modern physics. Everybody in the science community (and almost everybody with at least some basic education) knows what the neutron is. And yet, according to the authors of this

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chapter, there is a major gap in the realization of the role of neutron as a prime information-loaded actor in the self-organizational dynamics of the universe.

Previously, the concept of "isotopicity" was introduced to present isotopic diversity as a singular phenomenon of its own right (Berezin, 2015, 2016; Berezin and Gridin, 2017). As an umbrella term for many phenomena related to isotopes, "isotoipicity paradigm" works in a way of interdisciplinary integration (physics, chemistry, material science and engineering, nanotechnology, quantum computing, biology, biotechnology, etc).

Likewise, we can offer a new term "neutronicity" to encode all the variety of the effects and facets of Nature that are related to neutrons. In this way, we present *isotopicity* as a conceptual sub-set of *neutronicity*.

12.6 Neutron: Some prime facts

The first step in getting to our arguments is to realize the obvious *fact* that everything around us (including ourselves) is largely neutrons.

In fact, "we are all neutrons." And despite this fact being largely a trivia, in our experience, almost nobody appreciates, and even less so dwells at length, upon this straightforward fact!

Indeed, atomic nuclei, as we know, are made of protons and neutrons. A look at the periodic table (compare the atomic weight A and atomic number Z) shows that almost all atoms have more neutrons (N) than protons (Z), for example, Uranium-238 has Z = 92 and N = 146. Thus, *most* matter is, actually, neutrons. So, roughly, about 60% of the total weight of anything is made of neutrons. Speaking allegorically, we are all large walking bags of neutrons!

Moreover, almost everything we see around (including ourselves) is, actually, an empty space. Almost all mass of an atom is in atomic nucleus that takes a negligibly small fraction of the total volume of an atom. The diameter of an atom itself (nucleus + electron cloud) is by a factor from 23,000 (uranium) to 145,000 (hydrogen) larger that the diameter of the nucleus. If we imagine the nucleus of a size of a blueberry (1 cm), the uranium atom will be the size of a large cathedral (230 m) and the hydrogen atom will amount to the sphere with a diameter of five Eiffel Towers (1,450 m)!

Another fact is the radioactive decay of a *free* neutron. It is a well-known experimental fact that the free neutron decays within 15 min (in average) on three other particles, namely, *proton*, *electron*, and *(anti)neutrino*.

We note that 15 min is a typical time for many human endeavors (like a typical duration of a conversation, length of the attention span). In other words, it is in "our" human timescale of events. That is another reason to see neutron as "our" particle!

Of course, we can further wonder if this is a mere coincidence or, maybe, there are some "fundamental reasons" why nature has chosen 15 min, and not any other

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time, for the [average] life-span of a [free] neutron (decay times of radioactive isotopes range over some 40 orders of magnitude).

Furthermore, can we draw some unexpected conclusions from this fact that neutron decays on three of the above-mentioned entities (proton, electron, and antineutrino)? Whether it appears an odd suggestion or not, maybe, there is something more in this trio (Trinity?) of particles, something that points to the informational foundation of the world, or, perhaps, even to some "universal spiritual background"?

12.7 Neutrons and negentropy

> *A living organism continually increases its entropy – or, as you may say, produces positive entropy – and thus tends to approach the dangerous state of maximum entropy, which is of death. It can only keep aloof from it, i.e. alive, by continually drawing from its environment negative entropy. What an organism feeds upon is negative entropy … the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive.*
> Erwin Schrödinger (1887–1961), "What is Life?"

Neutron, by definition, is an electrically neutral particle. It makes it (almost) immune to long-range Coulomb forces. We say "almost" because it (neutron) still has an electric dipole moment, as well as a magnetic moment, and that makes it capable for a variety of weaker interactions such as the dipole–dipole (Van der Waals) interaction.

The prime quest we can raise about the neutron is "why nature needed neutron in the first place." Thinking over this quest has let us to suggest that Mother Nature has assigned to the neutron some global functions of which we hardly were thinking so far. There are a number of scenarios along this line of contemplations, and one is the least action principle in its thermodynamic and self-organizational context (Nicolis and Prigogine, 1977; Haken, 1978; Hopfield, 1982).

Recalling thermodynamic interpretation of the *least action principle*, we can view the decay of a free neutron on proton, electron and antineutrino in terms of elementary "quasi Carnot cycle." By this we mean that some order (negentropy) can emerge with a simultaneous increase of disorder (entropy) in a form of the increased level of chaos generated by the interactions of the flying antineutrino with the surrounding particles and electromagnetic fields (photons).

While energetically these effects may be quite weak, we can refer here to the so-called Butterfly effect from the chaos theory (energetically small causes can lead to major consequences).

As we know, there is an innate relationship between entropy and information. That is often explained by the metaphor of the "Maxwell's demon." This metaphor has numerous and impressive illustrations and generated intensive discussions in physics that keep going for well over a century (Berezin and Nakhmanson, 1990; Leff and Rex, 1990).

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The above-mentioned "tri-united" nature of the neutron makes it uniquely suitable to be the key "informational particle" of the universe. In particular, the functions of the "original creation" of information and its propagation can be comfortably separated in the case of the neutron. By the "original creation" we can presume the extraction of information from the infinite informational resources of the "ideal platonic world" of numbers and forms (Dauben, 1979; Penrose, 1994; Aczel, 2000; Berezin, 2015, 2016).

The "propagation" function is accomplished by an all-penetrating (anti)neutrino that is capable of traveling light years without causing considerable troubles of interactions with other particles. We do not know in what form the antineutrino carries this information, but can guess that this information may be coded in the form of digital strings.

The latter (digital strings) may be specific for each individual antineutrino that carries the information about a particular neutron that generated the said (anti)neutrino in the first place. In this view, the "decay" of each neutron is actually its "transformation" (or "metamorphosis") into the set of three particles (proton, electron, and antineutrino). For those readers who like vivid analogies, we can compare such a process (at least, at the aesthetic or "impressionistic" level) with a metamorphosis of a caterpillar to a butterfly, with the latter (butterfly) being a "reincarnation" of a caterpillar in its next life.

Thus, the decay of each individual neutron becomes an event of a cosmic significance with the antineutrino carrying a message (a "top news") of this event across the universe.

12.8 Neutron and H atom: Generic relatives

When we say that a free neutron spontaneously decays on Proton, electron, and antineutrino, we, metaphorically at least, imply that these particles somehow "dwell" inside the neutron, perhaps in some kind of a "virtual" (potential) sense. Nonetheless "they are there." Time of a half-decay of a free neutron is about 15 min (900 s), so at any instance, these three particles may pop up from the neutron as a proverbial jinni from the bottle.

Thus, in terms of its "content," we can see the hydrogen atom (H-atom) as a neutron that is blown up by several orders of magnitude. In the center of H-atom it is a proton, outside of it is an orbiting electron (actually, a quantum standing wave) and, altogether, this system is confined by electromagnetic interaction (in a trivial model – by electrostatic force). In a quantum mechanical sense, a hydrogen atom is an (over) excited state of a neutron.

Since the wave function of an electron has a small (but finite) probability to be localized inside the proton, H-atom can, at times, be a *virtual neutron*. In addition, correspondingly, by the law of reciprocity, an electron that, quantumly speaking, "sits" inside the neutron, can be found to be "out," to form (though instantaneously) a (virtual) H-atom.

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The above scenario is one of the fundamental dichotomies of the physical world. This back and forth metamorphosis (“quantum oscillation”) of a neutron to an H-atom and vice versa is, we suggest, one of the key processes in the universe. We can view the neutron as a metastable state of the latent hydrogen (as if the neutron “wants” to become hydrogen). We can further wonder if such an “oscillation dynamics” can be a critical catalyzing step in the self-organization and the origin of life?

In other words, we can view protons as “latent hydrogen atoms” that generically are the “descendants” of neutrons. Thus, such a buildup (by adding neutrons one after another) of the table of elements reorients (deepens) the periodical table to its *real* foundation at the nuclear level rather than leaving it at a purely chemical level of electronic structures and electronic bonds.

In the formation of chemical elements and isotopes by adding neutrons, nature uses the main “advantage” of the neutron as (“by definition”) a neutral particle. Hence, in approaching the nucleus, the neutron does not experience Coulomb repulsion (as a proton would) and can freely coalesce with the nucleus, adding to its atomic weight (A) by one. In this case, adding a neutron produces the next isotope of the same chemical element.

However, if a “new neutron” (that just came in), will “decide” (quantum randomness!) to “decay” inside the nucleus by ejecting an electron (and antineutrino), and thus converting to a proton, then the said nucleus becomes a nucleus of the next element in the periodical table (“Z” increases by one at the ejection of a negatively charged electron).

In either of the above scenarios (formation of the “next” isotope, or the “next” chemical element), neutron acts as key player in the process. In short, nothing can be done in nature without the neutron!

So, what is the difference between Mendeleev’s approach to the building up of his periodical table and our version of it? Mendeleev added by protons (in his time – by atomic numbers), while we are adding by neutrons. For us, the existence of isotopes is not some secondary fact of chemistry (as many people see it), but the *central* fact of nature, a key way to build up atoms in all the richness of their diversity.

This is another idea for further interdisciplinary exploration at the interface of physics, chemistry, informatics, and cognitive sciences.

12.9 Neutron as a basis for the digital universal coding

In a straightforward physical picture, atomic nuclei consist of two types of particles: protons and neutrons (we are not talking here about the details of nuclear forces, mesons, gluons, and so on – we remain in the realm of the “straightforward” picture of atomic nuclei). The only exception is a hydrogen atom (H atom) whose nucleus is a sole proton, without an accompanying neutron. Hydrogen isotope deuterium has both proton and neutron in its nucleus. All other nuclei have at least one neutron and usually many more.

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As we just mentioned, hydrogen atom (H atom) can be seen as a highly excited state of a neutron. But contrary to other electronically excited atoms, H atom does not decay in a standard way (that is, an electron does not "fall" back on a proton to form again a neutron – except in a quantum sense as an instantaneous virtual state).

Both proton and neutron have almost the same mass and in a number of other ways look pretty much "alike," almost like twin siblings. This quasi-similarity allows us to consider proton and neutron as two base units for a binary digital code. We can designate neutron (N) as binary "zero" (0) and proton as binary "one" (1).

During its lifetime as a free particle (decay time 15 min), the neutron as a quantum particle can instantaneously dissociate from proton and electron. This can be interpreted as a quantum superposition (*S*) in Hilbert space:

$$S = A\cdot(0) + B\cdot(1),$$

where the coefficients *A* and *B* can be any real numbers (or complex numbers – in quantum superpositions complex coefficients are often used).

In any plausible theory of digital sets, we have to define two base elements as "zero" and "one." Thus, using a somewhat allegorical language, we can call (or view) the neutron as a (potential) "parent" of the proton. Hence in our designation the neutron works as a digital "zero" (prime source) and the proton serves as a digital "one." And the fact that all atomic nuclei (except hydrogen) are all made of protons and neutrons, opens the way for the establishing a natural (spontaneous) binary coding at the nuclear level.

A nucleus having *Z* protons and *N* neutrons ($N = A - Z$) can be viewed as a binary digital string of *Z* "ones" and N "zeros." Say, a string like "01001011101001110001...101." Quantum mechanically, the states of the nucleus is described by a superposition of all such strings with all possible order of "0s" and "1s."

As we know, real numbers form a continuous (*uncountable*) set. It is "*Aleph-One*" set in the terminology of Cantor's set theory (Dauben, 1979; Aczel, 2000). Such a set, by definition, contains any possible information. The latter is often popularly explained by the metaphor of the "Babylonian Library of All Possible Books" (a well-known novella by Jorge Luis Borges) discussed above in this book (Sections 8.5, 8.6, and 8.7). More complicated nuclei with many "*P*" and "*N*" can form even greater variety (in principle, unlimited) of quantum superpositions with, correspondingly, almost unlimited information content.

Consequently, the neutron as a quantum particle of a dualistic nature (superposition of two states in "*S*") can carry any information in a digitally coded form.

Thus, the internal digitization of the universe can open up at the nuclear level. We believe that the idea of digital coding and informational content at the nuclear level deserves further contemplations and, perhaps, some more involved theoretical (and experimental?) studies.

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12.10 Neutron as a "particle of creation"

In this chapter, we advance the view of a neutron as a prime informational particle in the universe – so to say, the "particle of creation." By its physical nature, the neutron is an informationally loaded entity that is capable to accept, store, and transfer all kinds of information. Thus, it can be said that the neutron is the basis for nuclear coding of information.

Furthermore, informational capabilities of the neutron go well beyond storing and transferring the information. In regard to information, the neutron is an *active* actor that is capable of processing and amplifying informational inputs and, so to say, raising the information at the next level of non-local informational field, the informational field that potentially encompasses the whole Cosmos. In this way, the neutron as a particle is an "elementary quantum computer" that works on a principle of quantum superpositions of alternative states.

So far, coding of biological information was attributed exclusively to the chemical level. In this "chemical paradigm," all the information (genetic, neurological, psychological) is located in the molecular structures and no special role is assigned to the possibility of informational content at the nuclear level. We suggest that much more of this dynamical information may be "hidden" at scales of atomic nuclei, with the neutron being a key actor of this universal information coding.

More specifically, in our "Gedanken experiment," we view the neutron as a key element that is capable of massive binary digital coding well in excess of what the chemical (molecular) level can provide.

To understand the working of quantum binary digital coding, let us consider the deuteron.

Deuteron is a nucleus of the hydrogen isotope deuterium (the basis of the "heavy water") and is a bound state of a proton (P) and neutron (N). There are various spin states for this system and taking "P" and "N" as basic quantum vectors (eigenvectors) in the Hilbert space, we can form a superposition, $a(P) + b(N)$, where the ratio a/b can be any real (or complex) number.

From this we can go to other elements and their isotopes (e.g., tritium, helium-3 and helium-4, and Lithium). And in each case the interplay of virtual oscillations between the neutron and proton can form a basis for digital coding of informational binary strings. Thus, any message, of any length, can be stored and transmitted this way.

In the reality of digital communications and modern information technology, continuous messages are truncated to digital strings of real numbers, in particular prime numbers (Knuth, 1976; Plichta, 1997; Lloyd, 2002, 2006; Berezin, 2015, 2016). Prime numbers, as we know, form an infinite (but *countable*) set ("Aleph-zero" set).

From that we can go to our next quest: how all these digitally coded pieces of information can be transported from the nuclear level to the realm of biological processes? Our hypothesis is that the decisive role in this process belongs to this elusive particle – *Antineutrino* (the third "member" of a "tri-united" neutron).

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Atomic nuclei consist of protons and neutrons. However, nuclei are not static systems. There is a constant non-ceasing exchange of other particles (mesons and gluons) between protons and neutrons with a characteristic time scale of this "basketball" of the order of 1/10^22 to 1/10^23 s (size of nucleus divided by the speed of light). For comparison, the estimated time from the Big Bang is 10^17 to 10^18 s. In other words, there is about 40 orders of magnitude difference between the nuclear time scale and the (presumed) age of the (big bang) universe.

Thus, an enormous frequency of internal nuclear dynamics (23 orders shorter than a second) makes every nucleus a super-fast elementary *quantum computer* capable of processing the fantastic volumes of information. And each and every atom (nucleus) in the universe (apart from hydrogen, which has only a single proton and hence no meson exchange) can do this quantum computer job! We can only guess how all these nuclear-scale quantum computers are connected to each other to form a unified "field of consciousness" of the entire universe.

In this context, we note the central importance and a special role of the notion of "zero" in a set theory. Everything unfolds out of zero (Seife, 2000; Weatherall, 2016).

As a watershed between the infinities of negative and positive numbers, zero (0) acts as a guardian and "reconciliatory manager" of both wings of the infinity (positive and negative). And on the physical plane, this role is played by the neutron. Since protons (and hence all chemical elements with their isotopes) are generic derivatives of the neutron, we can say that the neutron is the true particle of creation of the material world. Everything comes out of the neutron.

As was mentioned above, self-organizational and morphogenetic processes are "anti-entropic" (*negentropic* , Leff and Rex, 1990) and can lead to the spontaneous emergence of complexity. The latter is the basis of evolution and the origin of self-aware systems (e.g., humans; however, some skeptics may question that). In this realm, the physical properties and the "informational" aspects of the neutron (electroneutrality, digital coding capacities, neutron–proton quantum oscillations) make it uniquely suitable to be a prime particle of cosmogenesis and ontogenesis. All these can be further "assisted" by the one of the products of neutron's decay, namely, antineutrino that is "serving" as an "informational messenger" at a cosmic scale.

12.11 Antineutriono: A universal cosmic messenger

Neutrinos (and/or antineutrinos) as particles of (almost) zero mass, moving with (almost) the speed of light, can travel galactic distances with the information about the particular neutron that generated them in the first place. This information may be digitally coded in them as a super-large (tower-exponentially large) prime number.

Because there are infinitely many prime numbers, there is potentially an unlimited resource of possible messages that can be carried by this-or-that (anti)neutrino.

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The above non-local connection may be of the same nature as quantum entanglement (Selleri, 1990; Albert, 1992). This is often discussed in the context of Bell theorem and the capacity of quantum communication channels to transmit information in a form of digital strings with a conservation of total entropy of the signal (Shannon, 1951; Leff and Rex, 1990; Jaynes, 1992; Wilczek, 1999).

In this way, we can view (anti)neutrino as a messenger of information about the individual (specific) neutron that generated (was a "parent" of) this particular (anti) neutrino in the first place. And such a message can fly undistorted many light years from the place it was born!

Thus, the information about some particular micro event (like a decay of a particular neutron) can be propagated to the galactic scales. That establishes a true connection between micro and macro (cosmic) worlds.

This is another premise that we leave for further contemplations.

12.12 Neutron stars and black holes

Our nomination of the neutron for the title of "God Particle" is, we believe, strongly supported by the unique and superb cosmological role of the neutrons. Here we can primarily refer to the neutron stars that (as astrophysical science of today claims) are precursors of the "black holes." The latter (black holes) may, in turn, be the "portals" to parallel universes according to now-popular speculations.

The very idea of neutron stars came from the alleged mechanisms of energy generation by stars. The catalytic chain reaction known as Bethe -von Weizsacker isotopic loop (Berezin, 2015, 2016; Berezin and Gridin, 2017), as well as hydrogen–helium cycle, are critically depended of the role of neutrons that are amply generated in these processes. This can explain the abundance of neutrons in the universe, which we had discussed earlier using a metaphor "we are all neutrons."

For illustration, we can make the following calculation. Density of a neutron matter (neutron star) is about 7·10^17 kg/m^3. This is a billion tons per cm^3! (billion tons is a weight of 1 km^3 of water!). This is about the same as the density of the actual neutron as a "particle" (considering a somewhat fuzzy definition of the "size" of quantum particles). Yet, if we divide the mass of neutron 1.674·10^–27 kg by its "volume" as a classical "ball" of radius of about 1 fermi (10^–15 m), we obtain the neutron density as 4·10^17 kg/m^3, about ·the same as the above quoted density of neutron matter.

As a further illustration of these orders of magnitude numbers let us imagine a small ball of 1 cm in diameter (size of a blueberry) made of neutron matter. If, using the equations of the classical (Newtonian) physics, we calculate the strength of the field of GRAVITY on the surface of this ball, we obtain 1.4·10^6 m/sec2, that is about 140,000 (140 thousand) times stronger than "our" normal "g" of 9.8 m/s^2.

Thus, we can envision neutrons as making the "cosmic bullion" of the zero-cycle – a real Particle of Creation. Neutron is a "neutral" particle, and it is much easier

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for it (we can almost say “for Him”!) to be everywhere without being bothered by strong Coulomb interactions.

Neutron allows itself to be packed to (almost) any density. Hence it can act as a “particle of creation” on virtually all scales – microscopic, mesoscopic, and macroscopic alike. This makes neutron a prime (“number one”) particle for the creation of material objects and systems of all types and scales.

Thus, in neutron we face the dichotomy of stability and de-stabilization as well as some “exploratory” (“investigative”) capacities. The latter aspect is well suited for the likely key role of neutron in the origin of life and biological evolution at large.

12.13 Neutrons and origin of oil

A broadly accepted view is that the oil (petroleum) is a “non-renewable resource” that originated from the remnants of the ancient plants and animals. Hence, the supply of oil is limited and we may soon be running out of it. There are multiple political and economic interests vested in the supporting this dominant paradigm.

Yet, there are some dissenting views questioning this scenario. For example, astrophysicist Thomas Gold (1920–2004) proposed the idea that oil is constantly regenerated inside Earth’s mantle by microorganisms adapted to live at high temperatures (Gold, 1999). There are also other ideas in circulation proposing various mechanisms of abiogenic origin of oil.

We can add to this another hypothesis that the formation of liquid oil is due to the neutron flux that is coming from nuclear reactions in the Earth’s core or in the mantle. Neutrons interacting with carbon-containing materials can form quasi-bound states with carbon atoms. Then, at their decay on protons and electrons, neutrons turn into Hydrogen atoms that, in turn, can form hydrocarbons, including such structures as benzene rings (C_6H_6).

Russian petroleum geologist Nikolai Kudryavtsev (1893–1971) came up with an observation that any region in which hydrocarbons are found at one level will also have hydrocarbons in large or small quantities at all levels down to and into the basement rock. Thus, where oil and gas deposits are found, there will often be coal seams above them. Gas is usually the deepest in the pattern and can alternate with oil. All petroleum deposits have a capstone, which is generally impermeable to the upward migration of hydrocarbons. This capstone leads to the accumulation of the hydrocarbon (Kudryavtsev, 1973).

According to the view that we present in this chapter, neutron can be envisioned as a metastable state of a latent (virtual) hydrogen. Consequently, the entrapment of the decaying neutrons by the coal seams leads to the synthesis of liquid hydrocarbons that form oil deposits.

Such a process seems to us as akin to the so-called “cold fusion” of which there were numerous claims in the past decades. While the details of such an oil generation

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process (like the estimation of the neutron fluxes) need to be worked out, this scenario suggests a mechanism of oil formation that is an alternative to the conventionally held views on the origin of oil. The extent to which such a mechanism (if confirmed) still makes oil a “non-renewable resource” can be further debated. We live it as an open quest at this point.

Likewise (and on the similar grounds), we can suggest that neutrons can be responsible for the formation of diamonds. It is known that diamond clusters are usually found in kimberlite pipes that form at high temperatures and pressures in the vicinity of volcanoes. We notice that the energy released at the decay of the neutron can contribute to this process.

12.14 Neutron: A real “God particle”?

For those who may feel some sympathy with a view of God as a “universal cosmic quantum field of consciousness,” we can propose that in such a picture, the neutron plays a role of a quantum (or elementary excitation) of such a “field,” in a similar way as Photons are quanta of the electromagnetic field.

So, can we call neutron a REAL “God Particle”?

Recently the title of “God Particle” was “awarded” to the so-called “Higgs boson.” As a subject for the popular talk-shows and best-selling books (there are many around), this metaphor (moniker) as applied to the Higgs boson may well serve the purpose.

Yet, we can wonder how seriously we can take such a title to a “particle” that (according to CERN Hadron Collider experiments) has a mass of 130 protons (really, a “Higgs BISON”!) and a mean lifetime of 10^−22 s (10 to −22 s). Such a time frame is totally beyond anything comparable to time scales relevant to us. In contrast to that, neutron that has a lifetime (as a free particle) of 15 min is comfortably in “our” time scale of events.

Let “esteemed high-energy physicists” accuse us of being cranks or mavericks, but we laugh at the awarding to such a grossly overweight and ephemeral particle as “Higgs boson” the “God’s” status.

Thus, in our view, all the above “theological analogies” make neutron a *real* (and most important) “God Particle,” leaving the Higgs boson at the rank of (at best) a “vice God particle.”

Taking that neutrons make about 60% of all visible matter, that fact *alone* is sufficient to name neutron as a *true* “God Particle.” Contrary to the (somewhat mythical and elusive) “Higgs Boson,” neutron is a *real* particle, “here and for all” – in fact, in a number of ways it is a *real* foundation (foundational particle) of the world – and not just, “here on Earth.” We can point, for example, on the physics of energy production in the sun, which is an energy source that is absolutely critical for our existence.

Out of all chemical elements, only four are absolutely critical for all (so far known) Earth’s biology. These are hydrogen, carbon, oxygen, and nitrogen. Let us call this

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bunch of elements the “HCON” group. What is interesting (and perhaps, peculiar) is that HCON elements are also thought to be responsible for the energy production cycle in the sun. In this way, humans and the sun are may be said to be “relatives.” In 1938 Hans Bethe (1906–2005) and Carl von Weizsacker (1912–2007) have suggested (independently) the so-called CNO-cycle as a catalytic mechanism by which sun fuses hydrogen into helium, which is the source of energy generated by the sun. This reaction goes through the chain (a loop) of isotopes of oxygen, carbon, nitrogen, as well as hydrogen (prime “food”) and helium (end “product”). The heavier nuclei (C, N, or O) serve as reaction sites for the hydrogen atoms (protons) to turn into helium. This isotopic reaction looks like this:

$$12C \rightarrow 13N \rightarrow 13C \rightarrow 14N \rightarrow 15O \rightarrow 15N \rightarrow (12C) \ldots$$

In this isotopic chain loop reaction neutrons play a critical (catalytical) role.

By-products of this loop of isotopic nuclear reactions are positrons, gamma rays, and neutrinos, and a total energy yield of one loop cycle is 26.8 MeV. After six stages of nuclear reactions we arrive back to the original 12C nucleus and the loop repeats over again. In this scenario the carbon, nitrogen, and oxygen isotopes are, actually, one nucleus that goes through a number of transformations in a repetitive catalytic loop.

It should be noted that at the time of this writing (2018), it is thought that CNO cycle is responsible for only about 1.7% of the energy output of the sun, and the rest is the proton–proton fusion reaction. In this reaction four protons transform into helium-4 isotope and neutrons, again, are critical participants of this process. This, again, gives us another reason to see ourselves as “isotopic relatives” of the sun.

12.15 Neutron – Three in one (Neutron and holy trinity)

The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies were made in the interiors of collapsing stars. We are made of starstuff.
Carl Sagan (1934–1996)

Here we would like to talk about some nontrivial aspects of the neutron that are usually omitted (or ignored) within the scope of “mainstream physics.”

By its very linguistic definition, a “neutron” means an electrically neutral particle having zero net electrical charge. Yet, strangely enough, the neutron has nonzero magnetic moment (just slightly less than that of a proton).

This tells us that there is some electrical activity (or “quantum dynamics”) going on inside the neutron (magnetism is produced by the motion of electrical charges, in other words, by some inside electrical currents). And as was mentioned earlier, the bare observable fact is that a free neutron spontaneously decays with a mean lifetime of about 15 min to *three* particles, namely proton, electron, and (anti)neutrino. So,

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neutral neutron splits itself on positive and negative charges – proton and electron, respectively (plus antineutrino that takes away an extra energy in a form of radiation).

Normally, the neutron decay reaction can be written as follows:

$$N \text{ --> } P + e + \text{(antineutrino)}$$

So, how it comes possible? Does this mean that proton and electron "sit" inside the neutron waiting to escape from it and to start their "independent" existence as "free particles"?

Yes and no – depends how to look at this and what philosophical platform to adopt for the interpretation of the above decay reaction.

Here (God forgive us!) we want to suggest a "theological" interpretation based on a "tri-united" nature of the neutron. Without any attempt of an undue "proselytizing," we believe that some readers may find our analogies both interesting and philosophically teasing.

The idea of God as Holy Trinity is among the prime ideas of Christianity. Here we are not going to extensive theological discussions on this matter, but mention a few analogies that we see as related to the nature of neutron as a particle. An elementary particle, we can say, that also has a tri-united nature.

Since early Christian theology was mostly written in Greek language, we can refer to some terminology used by early church fathers. In their discussion of Holy Trinity, one of the key terms they used was "Perichoresis," which can be translated as "permeation without confusion." This is the idea that each of the persons of the Trinity shares completely in the life of the other two. Theologians say that each of the persons of the Holy Trinity "interpenetrates" the others, so that the distinctions between the persons are preserved, and the substance of God is not divided into three. In other words, *perichoresis* can be described as "the intimate and perfect inhabitation of one Person in the other," meaning that the three persons of the Trinity live in and relate to each other perfectly.

Many modern writers prefer to use the word "indwelling" to express the idea of *perichoresis*. They say that there is a mutual indwelling of the persons of the Trinity. Latin equivalent of perichoresis is the term *circuminsessio*. And Russian (Slavonic) language expresses the idea of Trinity by saying that the Father, the Son, and the Holy Spirit present in the Trinity "*nerazdelno–neslijanno*" (without separation and without merging).

Now, turning our attention to the neutron, we observe pretty much the same. Neutron (at least before it decays) has "inside" it in a potential (virtual) way three "components" – proton ("the Father"), electron ("the Son"), and antineutrino ("the Holy Spirit"). The first "person" (proton – the Father) represents the prime source (the ultimate creator). The second "person" (electron – the Son) acts as a messenger conveying most of the information in the universe (is it not providential that in our "information age" most of the information is carried by *electron*-ics!). And the third "person" (antineutrino – the Holy Spirit) is linked to the radiation and energy.

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In other words, we present the neutron as a "*Physical Paradigm*" (or an "*Image*," or "*Egregore*," or "*Avatar*") of the Holy Trinity. It should be noted that we do not necessarily limit this analogy to just a traditional Christian Trinity. The "Trinities" of other religions and traditions can also be included in such a hypothetical imagery. In particular, the Trinity of Hinduism (*Brahma* – Father, *Vishnu* – Son, and *Shiva* – Spirit [or Cosmos]) has a generic similarity with the Christian Trinity – an analogy that is discussed in numerous scholarly sources.

Another point for contemplation along the "Trinity" line can be a tri-unity of (our) Spirit–Mind–Body that was mentioned in Section 11.5. We can identify (speculatively, of course) "body" with proton, "mind" with electron, and "spirit" with (anti)neutrino (a universal cosmic connector).

Taking that neutrons make about 60% of all visible matter, this fact *alone* is sufficient to name neutron as a *true* "God Particle." Contrary to the (somewhat mythical and elusive) "Higgs Boson," neutron is a *real* particle, "here and for all" – in fact, in a number of ways it is a *real* foundation (foundational particle) of the world. And not just, "here on Earth." We can point (see previous section), for example, on the physics of the energy production in the sun – an energy source that is absolutely critical for our existence.

Summary on neutron and "neutronicity"

This chapter extends the earlier idea of "*isotopicity*" toward indicating the key role of neutron as a particle responsible for the existence of isotopes and playing a central role as an informational connector in the universe. These ideas can be conveniently molded in a new concept of "*neutronicity*" – a "twin concept" to *isotopicity*.

Out of all three components of a *tri-united neutron*, we have pointed a special role of *antineutrino* as a truly cosmic carrier of information.

The philosophical quests we are facing here is "Why Nature has chosen neutron in the first place?" What is the "ultimate reason" behind the existence of neutron? How neutron can be accountable for the origin of life and for consciousness? And what are other, not yet discovered or appreciated, functions of the neutron in the universe?

And what all the above quests have to do with such major cosmic phenomena as the formation of neutron stars and the (alleged) formation of black holes? And how neutrons are related to the ideas of infinite sets and prime numbers (Dauben, 1979; Penrose, 1994; Aczel, 2000). Could a targeted manipulation of slow neutron fluxes finally provide a trigger for the so desperately sought "cold fusion" as a global alternative to our dependence on oil? Or could neutrons, packed to enormous densities at the neutron stars, form portals to the parallel universes through the quantum wormholes and relativistic twisting of space–time matrix? And what about such puzzles and mysteries as superstrings, teleportation, time loops, and time travel that are now creeping

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(with a varying success) from science fiction to "real science." Perhaps, readers of this book can add some more items to this list.

And finally, we can look even deeper than neutron as such, and go to the Planck scale of effects. Or, perhaps, even beyond it, taking as guide the image of the *logarithmic spiral* (Fibonacci Spiral) that ultimately connects *infinitely large* with *infinitely small* realms?

To conclude, we believe we have made the case for the neutron as a prime particle for the creation of the material universe in all its manifestations. Nature has created a universal binary information code on the basis of neutron. Nature has built chemical elements by adding neutrons one by one using its "reciprocity" aspects with (virtual) hydrogen atom. While inside nucleus neutron lives "forever" (does not decay), as a free particle it quickly decays on proton (responsible for the solid matter), electron (responsible for chemistry and chemical bonds), and antineutrino (responsible for the universal information traffic). This "tri-united" nature of neutron makes it a true "God Particle" that was originally put into a "grand design" of the universe.

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13 Cosmic horizons

Among all the services that can be rendered to science, the most important is the injection of novel ideas.
Joseph John Thomson (1856–1940, discoverer of electron, Nobel Prize (1906))

Throughout this book, we talked about many ideas at the interfaces of science, philosophy, and metaphysics. Some of the issues this book puts up can be perhaps broadly labeled as "esoterica." If so, the author does not mind. Yet, there are *two* main lines that likely will be seen by a "scrupulous" reader (and as an author, I hope that there will be at least one like this, although I will not mind if there will be dozens, or hundreds, or thousands [etc.] such readers!) as the central themes of this book.

These two are the *infinity of prime numbers* and *isotopic randomness* as an informational factor in biology and other processes of self-organization. In these concluding words, I would like to restate what was said in the end of introduction about these two "items" as "metaphysical relatives." First of all, I have to say a few words how it all fits in the context of "akashic record" and "morphogenetic field" as quantum information-carrying entities that are postulated at the global (cosmic) and local scales, respectively. Some of these connections were mentioned earlier in my paper A.A.Berezin, "Isotopic Diversity as an Unexplored Mind-Matter Dimension," Science Progress (Oxford), 1990 (also books: Berezin, 2015, 2016). In this regard, isotopic randomness (*isotopicity*) works as a universal connector between localized ("our") and delocalized ("cosmic") consciousness.

13.1 Ideas on life and consciousness

The more I examine the Universe and study the details of its architecture, the more evidence I find that the Universein some sense must have known that we were coming.
Freeman Dyson (1979, p. 250)

An example of how the mainstream topic can be conveniently turned into a "fringe" can be provided by the paraphrasing of a parable of "are automobiles alive?" (Tipler, 1994) The (more or less mainstream conceptual) definition of life will be "a system is alive if it interacts with the environment, capable of reproducing itself and are preserved by a natural selection." The automobiles precisely do this: they do reproduce on factories using human mechanics as their "environmental arrangement." The form of automobiles in their environment is preserved by natural selection: there is a fierce struggle for existence between various "races" (brands) of automobiles and various car manufacturers. By this definition of life, not only automobiles but all machines – in particular computers – are alive (Tipler, 1994).

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Furthermore, according to Roger Penrose (Penrose, 1994), the phenomenon of (human) consciousness may be fundamentally related to (sub) quantum physics. Penrose proposes that consciousness can be fundamentally non-computable, that is, it cannot be adequately modelled on any (digital) computer.

At the same time, recent (and often, fascinating) speculations of the "world as simulated reality," ideas such as "matrix," and artificial (machine-based) consciousness have stirred a high-level philosophical discourse (Dyson, 1979a, 1979b, 1988; Vinge, 1993; Minsky, 1994; Kurzweil, 1999, 2005; Moravec, 1999; Crawford, 2000; Bostrom, 2003, 2016; Chalmers, 2005; Berezin, 2006), which sometime projects itself into a metaphysical and eschatological realm (e.g., Lewis, 1986; Tipler, 1989; Drogalina-Nalimov, 1990Leslie, 1996; Webb, 2002; Rees, 2003; Fukuyama, 2004), as well as to the score of science-fiction literature (e.g., Egan, 1994, 1997) and even to some earlier writings of now-almost-forgotten authors (e.g., Feodorov, 1913; Condorcet, 1955 [original: 1795]).

13.2 Akashic record and morphogenetic field: Further explorations

Ideas of "akashic record(s)" and "morphogenetic field(s)" (sometime these concepts are written in plurals) are broadly talked about nowadays. While the idea of akashic record (and the term akasha) goes to Indian philosophy, in recent times it was picked up by many philosophers and metaphysicians, in particular, Edgar Cayce (1877–1945) and Ervin Laszlo (b. 1932).

In Laszlo's interpretation, the akashic record is seen as a metaphysical depository of all experience of the universe. This is pretty much a global concept of all-encompassing information at the cosmological scale. In terms of its dynamics, Laszlo primarily discusses it in the context of the universal informational self-organization.

As for the morphogenetic fields, it is a more recent concept. The prime modern author here is Rupert Sheldrake. This idea refers to a more focused and specifically targeted dynamics of gaining and transmitting the experience of living beings (humans and animals) through some nonlocal physical connections. The specific "mechanisms" of these effects (akashic record and morphogenetic field) are still debatable and not quite clearly understood. So, in terms of their exploration this is still a "work in progress."

Now, I propose some suggestions about the physical and metaphysical foundations of these effects along the two prime lines of this book: prime numbers and isotopes. In both cases, I stress the coding of information by the digital strings of prime numbers and isotopes, respectively, as it was already mentioned in the introduction.

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14 Epilogue

In my concluding words, I want to tell my reader (virtual or real) what I have learned thinking and writing on *isotopicity*, infinity, Platonic world of numbers, ultimate realities, arts, and other big and small things.

I am a native Russian speaker. Till the age of 34 (for me it was 1978), I have always lived in Russia (then USSR), not a single time I was out of this country, even for a day. Only once I applied for a permission to go to some conference to Hungary (at that time still a socialist country inside Soviet-controlled block!) and even for such a trip to the "friendly, socialist country" (!) that I did not get *ok* to go (apparently, because of some reports to Komitet Gosudarstvennoj Bezopasnosty (KGB) on my "dissident views").

So, when I and my family got our permission to immigrate and leave USSR on March 31, 1978 for Vienna, it was my first ever trip outside Soviet Union.

Yes, I learned English at school and at the university. My mother used to hire private English language tutors for me while I was at school, yet my real command in English came only a few years after we had immigrated to Canada (in November 1978) and I started my academic career in Canada, becoming (from September 1980) a university lecturer, associate professor of engineering physics at McMaster University. In this capacity and on the same position, I served for exactly 30 years till my official retirement in June 2010 with a lifetime title "professor emeritus." At halfway of my McMaster carrier (in 1996), I was promoted to a full professor rank, after two appeals to deny me that rank. My first appeal (in 1989–90) was unsuccessful; my second appeal (in 1996) had finally succeeded.

Needless to add, the resistance of my colleagues (the "academic establishment") to my promotion was fueled not by any "deficiencies" in my teaching duties (here I was, at least as good as most), but exclusively and entirely by my publications on "fringe" and "crazy" topics. What person with a "normal" ("mainstream") and "generally accepted" vision can quietly stand topics such as "intelligent microparticles," or "physics of homeopathy" or "neural networks in healing crystals?" This is not to mention the key (and probably, the most important) of my hypotheses reviewed in this book – "alternative genetic code based on isotopic permutations." Yet, in the end, I am satisfied that my ideas on *isotopicity* are spreading around, thanks to my numerous publications.

(As a matter of curiosity, I always take a fun from the fact that in English language "full professor" and "fool professor" sound the same. Anyone has the full right ("fool right?") to apply either spelling toward me (I don't mind), as I have the same right to apply either of these spellings to many full professors I happen to know over my long carrier).

At the time of this writing (2018), I was for 40 years in Canada, feeling myself truly bilingual in Russian and English. I do my best to always remain on a keen alert about the peculiarities in either of these languages. I can read and write in both languages, of course, feeling myself in the same boat with Vladimir Nabokov on this issue (and no, contrary to him, I don't speak French, only marginal).

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To repeat, the prime (and, actually, *the only*) reason for denying me a promotion to a full professor level by the departmental and faculty committees was a controversial and interdisciplinary nature of much of my work – something that should be evident from this book to anyone who will read it, or at least browse through it.

The hardly deniable *fact* (that can be supported by massive evidence from all around) *is* that a large segment of academic community (probably, its majority) maintains high level (sometime, obsessively high) of intolerance to *any* idea that looks unusual, or too speculative, or too "metaphysical" for an average functioning academic brain to digest and accept. Mediocrity and pressure of standardization ("do-as-all-other-do") are a ground rule in academia, as, practically, is almost any other "big" system in the world (never mind some exceptions here and there).

And for some academics, this intolerance to anything that looks like falling "outside the box" rises to the level of paranoiac mania and unstoppable desire to suppress unorthodox ideas and disdain those who voice them (enough to recall here that once *Nature* magazine (issue of September 24, 1981) proposed that books by Rupert Sheldrake on morphic resonance "must be burned"). Fortunately, however, these suppressors are not always successful in the end, and "off-line" ideas sometime win – Nikola Tesla is just one great example.

Whatever scale of importance can be assigned to my work in science, it, to a large degree, falls into the above-mentioned category. Such is much of my work on various aspects of isotopic randomness, on pattern formation in electrostatic systems, or some unusual vistas of physics of hopping conductivity and quantum tunneling, or my paper coauthored with Raoul Nakhmanson (Berezin and Nakhmanson, 1990) that suggests a possibility of a consciousness at the level of electrons, as well as my thoughts on Platonic reality, prime numbers, cosmology, and so on.

The idea of isotopic biology was presented in my earlier work (Berezin, 1984h, 1986c, 2015, 2016). In its essence, it is an observation that the placements of isotopes of prime chemical elements of biology (hydrogen, oxygen, carbon, and nitrogen) in genetic structures (DNA chains, etc.) can form a digital code over-and-above the "normal" genetic code. Thus, "isotopic biology" works as a next level of "ordinary" biology and can significantly (exponentially) increase the informational capacity of genetic structures. This can affect (and expand) horizons of our creativity, spirituality, and enhance our connections to higher levels of cosmic consciousness.

Similar "isotopic digitization" can happen in other systems including liquids and solids. This can account for the effects of "water memory" (basis of homeopathy) and healing action of quartz and other crystals through the formation of "isotopic neural networks" (Berezin, 1990b, 2015, 2016; Berezin and Gridin, 2017).

In these effects, isotopic combinations act as digital strings, similar to digital coding of information in computer systems. Thus, considering the capacity of isotopic combinations and isotopic digital strings to form digitally coded information arrays raises the biology at a new level.

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Talking about prime numbers as a "digital code in the Platonic world," we can concisely summarize this idea in the following words:

Infinite set of prime numbers presents a somewhat similar "miracle of nature" as the above-mentioned isotopic digital strings. As we know, prime numbers keep appearing like beads on the infinite number of line of integers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 ... (to infinity). While the proportion of prime numbers decreases with N (in a logarithmic fashion), they never "run out" and keep forever popping-up even after enormously long "gaps" that are the intervals between two consecutive primes.

Stressing this analogy, we can say that prime numbers act as "digital milestones" in the infinite Platonic world of numbers. And that is what makes prime numbers and isotopes "generic relatives" in some "metaphysical sense." Allegorically, we can call the infinite set of prime numbers a "genetic code" of the ideal Platonic world (IPW) and the entire universe. Thus, the concepts of *isotopicity*, *prime number code of the universe* (as well as the concept of *neutronicity*) are the key offerings unfolded in this book.

In a nutshell, prime numbers and isotopes are the two "twin concepts" on which we can base our metaphysical meditations on the infinity and eternity.

In my concluding words, I want specifically to address to the "young reader" of this book, assuming, of course, that I do not put here any specific age cutoffs in this regard.

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15 Message to the young reader

Be fearless in the pursuit of what sets your soul on fire.
Sarah Kitt Vollmer (b. 1984, physicist, artist, and philosopher)

Do not fear to be eccentric in opinion, for every opinion now accepted was once eccentric.
Bertrand Russell (1872–1970)

The title of this conclusion as a "Message to the Young Reader" right away needs some clarification. Yes, I have a few words below this that are addressed specifically to young(er) scientists and explorers who may still be in search for their big quest: what to do with their lives and the research lines they may be undertaking. And the choices and possibilities in this regard in our modern world are enormous, both in quantity and quality. But the "young reader" in my view can also include persons (whether they are scientists or not) of any age who retain their passionate curiosity about the world and are, so to speak, "young at heart and in mind" as, I humbly hope, the author of these lines is.

And I can say here (hoping that I will not be accused of vanity or bragging – or, even if I am, I can stand it) that being now in my mid-70s (I was born in 1944, one year before the end of World War II), my curiosity and questions about the world and our place in it have steadily increased (and not decreased) from my early days through all my path in science and they are still on the upswing as of today. And I am more than sure that there are many (yes, thousands upon thousands) people in my age group, and even older, who can state exactly the same about themselves. So, "young people of all ages, unite".

So, what is the prime message of this book? Let us recall how Richard Feynman was able to capture the most important cumulative result of science in one sentence (quoted in the first paragraph of the introduction of this book). The essence was that the world is made up of atoms and the rest can be unfolded from this primary fact. Likewise, what kind of sentence could summarize the main message of this book in the most concise way? At the risk of being accused of imitating Feynman, I suggest that the key idea of this book is that "the diversity of stable isotopies (*isotopicity*) may act as an additional informational factor in physical, self-organizational, and biological dynamics and manifestations." This book attempts to unfold this primary idea along several directions, as discussed in the previous chapters.

And, of course, the primary "devil's advocate" argument objecting the above-mentioned statement will be: "if everything is as this author claims, why has nobody else put similar ideas into circulation until now?" Actually, this is the question that I was asked a number of times when presenting these ideas at various seminars and conferences.

While my short answer to this could be the story about the Mobius strip (Section 4.8), my more detailed answer would be to go over several key points about big

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science, peer review, social and economic factors, competition for funds, and other factors that I have detailed in this book and in my prior publications. How convincing my argument is up to the reader to decide. In any case, I humbly believe that my book offers several lines of contemplation for enthusiasts and skeptics alike (and all grades in-between).

Repeating a few words from Chapter 5, if nature is smart enough to use the diversity of chemical elements for biology (almost all the elements from the periodic table have some biological functions including microelements), then it may look somewhat odd that nature would omit to use such a mighty additional informationally rich resource as the diversity of stable isotopes for structuring and functioning of biological systems at all levels of evolution and complexity.

The likely “answer” to such a “puzzle” is that, yes. Nature most likely uses it (isotopic diversity) but we have so far failed to detect this and have even (largely) failed to look at it even at the level of hypothesis, not to mention any targeted experimentation. One of the primary aims of this book is to draw the attention of the world’s research community to this incipient research area of stable isotopicity and isotopic engineering – a direction that (with some luck) may turn out to be a newly found gold mine for physics, biology, biomedicine, material science, cognitive sciences, and informational technology in a broader sense.

As the author of this book, I realize that some readers will consider the ideas and suggestions presented here to be mere fantasies and speculations that never can or will be implemented at the practical level. Yes, I am familiar with such attitudes from my numerous seminars and coffee conversations. However, I have actually taken them as (unintended, perhaps) compliments as they, paradoxically, put me in a good company. When Jules Verne published *De la Terre a la Lune (From Earth to the Moon)* in 1865, who really believed that travel to the Moon one day would become a reality? Well, it did, 104 years later. And when in 1903, Konstantin Tsiolkovsky suggested that a hydrogen–oxygen rocket (rather than the huge cannon of Jules Verne) could do the job, he was much closer to the target, but he was still largely seen as a visionary and a dreamer. Yet these people (H.G. Wells and a few others can be added here) planted seeds in the public perception that eventually stimulated technological and engineering developments toward successful implementations of these ideas.

Turning to the potential of isotopic informatics in physics, engineering, nanotechnology, or biology and biomedicine (as described at length in this book), we can state that, yes, at the present stage we do not yet have all the technology needed for practical testing of the ideas of stable isotopicity. Yes, we have technology for isotope separation, but to handle isotopes atom by atom (as some of the potential applications treated in this book call for), we need further advancement of tools such as atomic force microscopy, molecular beam epitaxy, micro- and nano-laser instrumentation, and perhaps some other methods that this author is presently unaware of (but some others may well be). If this book stimulates further thinking and contemplation

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about all these isotopic opportunities, the author will see it as an indication that his efforts brought some worthy result.

However, there are a few words that I would like to address specifically to young people who may still be university or college students (be it at the undergraduate or graduate levels), or who may be postdocs and research fellows at academic or industrial facilities, or working at start-up business enterprises, or perhaps in some other niche. Since I myself was in most of the above-mentioned categories, I hope I can reliably attest to the typical aspirations, ambitions, and frustrations that usually come along at these stages of life and career.

Yes, many of you have dreams and desires to really make a difference in this world, but you are not in a pure vacuum but always within some structure (academic or whatnot) that brings some constraints and rules of conduct with it. If you are actively involved in a research project, you are most likely a part of some team (research group, industrial R&D lab, or whatnot) and you have some supervisors and/or superiors ("bosses") with ongoing research programs and you have to find your "freedom within this matrix." While I certainly cannot give an exhaustive "one size fits all" algorithm on how to best navigate in such an environment, I would still like to give you some tips based largely on my 50+ years of working in science. Take them not as preaching of some guru sitting somewhere on a mountain top, but simply as helpful hints from someone who traveled similar routes before you.

(1) First of all, form as clearly as you can your own vision of your interests and goals. Put them in writing in a special notebook. You do not need to do this all at once, but be sure that you keep all the records in a well-organized and dated way. You can have several directions and levels for your interests and it is okay to add to the list of your interests and goals and revise your priorities. (And one more comment from me: in spite of the fact that nowadays most of our recording and writing goes on electronically on laptops, USB sticks, and so on, I strongly recommend for practical and emotional reasons that you keep the habit of paper notebooks for your most important ideas and plans. Printouts are okay too, if you keep them organized and stored in binders.)

(2) If you have some specific idea or hypothesis, no matter how far-fetched and speculative it may appear to you, try to shape it up in the form of a short draft of an article – the chances are that it may indeed be a seed for publishable material. If you have some trustworthy friends and/or colleagues who may be interested in your idea, it is all right to collaborate (and perhaps later to coauthor), but be sure that your idea is in no way compromised by such collaboration. This is a fine art, of course, and not all scenarios can be predicted here, but it is important that you maintain full control over the spelling out of your ideas.

(3) If you are a part of a research group (e.g., if you are a graduate student or postdoc) and your idea "does not fit" the research program you are in (or, to put it flatly, your supervisor ["boss"] does not share or support your ideas), then you are in a situation that I was in more than once during my career (as, I am sure, many

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others have been too). If this is currently what you have, you should figure out what the best way for you to navigate in such a situation is. If your idea has already shaped up to the level of a research paper, you may consider publishing it over the head of your supervisor. In the university environment and in groups that are not involved in any classified or proprietary projects, such a practice is rather common – at least, I used it a number of times and never had regrets for doing this. A good share of my earlier papers (which are included in the references of this book) were like this – concerning work that I did and published on my own initiative and that was outside of the formal work that I was paid to do. Of course, I did the latter work too, otherwise I would not have received my paycheck (or rather, cash – there were no checks in the USSR at that time and all wages and transactions were in actual cash). Remember that your ideas are far more important than being a "good boy/girl" in the eyes of this-or-that boss. And if you have to choose, always be sure that your choice comes from your heart. Fortunately, the above-mentioned situation becomes much easier for people who obtain a teaching position at a college or university. In this case, there are virtually no restrictions on what people can do for their research, especially if it is theoretical or a conceptual work. If the teaching for which you are paid goes well, the university is unlikely to care too much what you research and publish (although, like any bureaucracy, they practice "paper counting" for promotional and other administrative reasons).

(4) Do not be upset or put down by people who disagree with you and may be voicing their disagreement to you, sometimes quite aggressively. Such reactions are typical and quite common. As Robert Kennedy put it, "One-fifth of the people are against everything all the time." Whether we like it or not, this urge for confrontation and putting others down (those who dare to have their own views and – god forbid – ideas) is pretty much a common trait of our biological species. This does not mean that you should see yourself as a saint, immune to the above (none of us can safely make such a claim), but the best you can do is to take it calmly and politely, on a "let us agree to disagree" note. And even if you are angry by what your opponents say, never show any aggressiveness or scorn in return.

(5) Also look carefully to see if there may be some real substance in the arguments and criticism of your opponents. If so, consider their comments in a creative and constructive way. This may happen, not very often in my own experience, but occasionally it does. And as for Kennedy's "one fifth", my own experience in academia and in dealing with peer review many dozens of times makes me to upgrade his estimate to a far higher level, perhaps 4/5 at least. But never mind, if you are persistent, consistent, and stubborn (it is all right to be stubborn about good ideas), you will make it through. Remember what Winston Churchill used to repeat: "Never, never, never give up!"

(6) Do not be scared by the peer-review system. Read more about it (many sources) and also look at what numerous posters on the web have said about it. You will

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find a lot of criticism of it, as well as some ideas about how to get around it. Yes, it is possible to “cheat” the peer-review system (as many authors have before) and get your most important ideas published. In fact, in the electronic age, we are currently (web pages, blogs, YouTube, etc. – and the list is growing) implementing many alternative ways to circulate your ideas outside the formal system of science publications. You can even start your own online journal or self-publish a book. The latter option (self-publishing) needs to be studied carefully in each particular case, because this industry contains numerous predators and scams, yet many people go along this route with various degrees of success.

(7) And finally, have your own list of role models – people whose lives and work encourage and uplift you. People who came through struggles, frustrations, and misunderstandings before they made their difference in history. People like Nikola Tesla, Marie Curie, Alfred Wegener (continental drift), Georg Cantor (the theory of infinite sets), or great martyrs of science and ideas such as Giordano Bruno or Hypatia (an ancient female mathematician, astronomer, and philosopher, who was brutally killed by a mob in Alexandria in 415 A.D., Hypathia murder). You do not necessarily need to be an expert to join this list, but the lives of these people (and you can find many more to make your own list) can inspire and offer insights for your own ideas and endeavors.

These are my short hints to you, the reader, and in traveling along your own path in science, you will most likely be able to add your own thoughts and ideas to the above-mentioned reflections. Good luck!

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Index

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