YinYang Bipolar Relativity:

A Unifying Theory of Nature, Agents and Causality with Applications in Quantum Computing, Cognitive Informatics and Life Sciences

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Cover Design: Nick Newcomer

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Zhang, Wen-Ran, 1950-
Yinyang bipolar relativity : a unifying theory of nature, agents and causality with applications in quantum computing, cognitive informatics and life sciences / by Wen-Ran Zhang.
p. cm.
Summary: "This book presents real-world applications of YinYang bipolar relativity that focus on quantum computing and agent interaction. This unique work makes complex theoretical topics, such as the ubiquitous effects of quantum entanglement, logically comprehendible to a vast audience"-- Provided by publisher.
Includes bibliographical references and index.
ISBN 978-1-60960-525-4 (hardcover) -- ISBN 978-1-60960-526-1 (ebook) 1. Unified field theories. I. Title.
QC794.6.G7Z43 2011
530.14'2--dc22
2010054424

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Table of Contents

Foreword ix

Preface xiii

Acknowledgment xxx

Part 1
Introduction and Background

Chapter 1
Introduction: Beyond Spacetime **1**
Introduction 1
Einstein and YinYang Bipolar Relativity 4
General Relativity and Quantum Theory 9
Logical Axiomatization for Illogical Physics – The LAFIP Paradox 11
Observation and Postulation 13
Book Overview 23
Summary 25

Chapter 2
Background Review: Quest for Definable Causality **34**
Introduction 34
Faultline of Observability and Truth-Based Thinking 38
Bipolarity vs. Singularity 41
Quest for Definable Causality 45
Science, Social Construction and Destruction 54
Summary 56

Part 2
Set Theoretic Foundation

Chapter 3
Bipolar Sets and Yinyang Bipolar Dynamic Logic (BDL) 65
Introduction 65
Bipolar Sets and YinYang Bipolar Dynamic Logic (BDL) 67
Laws of Equilibrium and Bipolar Universal Modus Ponens 74
Bipolar Axiomatization and Computability 77
Bipolar Modality 81
Bipolar Relations and Equilibrium Relations 82
On Gödel's Incompleteness Theorem 90
Research Topics 92
Summary 93

Chapter 4
Bipolar Quantum Lattice and Dynamic Triangular Norms 97
Introduction 97
Bipolar Quantum Lattices and L-Sets 100
Bipolar Dynamic T-norms and P-norms 110
Norm-Based Bipolar Universal Modus Ponens 116
Comparison and Discussion 118
Bipolarity, Linearity, Integrity, and Recovery Theorem 121
Research Topics 122
Summary 124

Chapter 5
Bipolar Fuzzy Sets and Equilibrium Relations 129
Introduction 129
Bipolar Fuzzy Relations 131
Bipolar α-Level Sets 134
Fuzzy Equilibrium Relations 141
Bipolar Fuzzy Clustering 145
Equilibrium Energy and Stability for Multiagent Coordination and Global Regulation 153
Research Topics 154
Summary 154

Part 3
YinYang Bipolar Relativity and Bipolar Quantum Computing

Chapter 6
Agents, Causality, and Yinyang Bipolar Relativity 160
Introduction 160

Agents 162
Bipolar Agents 163
Bipolar Causality and Bipolar Causal Reasoning 168
YinYang Bipolar Relativity 170
Predictions 177
Axiomatization of Physics 186
Research Topics 188
Summary 188

Chapter 7
Yinyang Bipolar Quantum Entanglement: Toward a Logically Complete Theory for Quantum Computing and Communication 195
Introduction 196
Review on Quantum Theory 198
Toward a Logically Complete Quantum Theory 208
Bipolar Quantum Entanglement and Teleportation 211
Bipolar Quantum Computation and Communication 218
A Taxonomy for Bipolar Quantum Computing 223
Research Topics 225
Summary 225

Chapter 8
Bipolar Quantum Linear Algebra (BQLA) and Bipolar Quantum Cellular Automata (BQCA) 232
Introduction 232
Background Review 234
Bipolar Quantum Linear Algebra and Bipolar Quantum Cellular Automata 239
Equilibrium, Non-Equilibrium, and Oscillatory BQCAs 251
A Unifying Paradigm of Bipolar Relativity 253
Research Topics 260
Summary 261

Part 4
Applications

Chapter 9
YinYang Bipolar Quantum Bioeconomics for Equilibrium-Based Biosystem Simulation and Regulation 266
Introduction 266
Review on Bioeconomics 268
Bipolar Quantum Bioeconomics (BQBE) 270
BQBE in TCM Diagnostic Decision Support 272
Biosystem Simulation and Regulation with YinYang-N-Element BQCA 280
Analysis and Applications 287

Research Topics 293
Summary 293

Chapter 10
Mentalsquares: An Equilibrium-Based Bipolar Support Vector Machine for Computational Psychiatry And Neurobiological Data Mining 298
Introduction 299
Bipolar Disorder Classification 300
Equilibrium-Based Computational Neuroscience and Psychiatry 302
Equilibrium-Based Bipolar Disorder Classification and Analysis 306
Exploratory Neurobiological Data Mining 313
Stability Analysis 317
Mixed BPD Classification 318
Bipolar Scalability to Schizophrenia Classification 320
Other Potential Applications 321
Computer Operability 323
Research Topics 323
Summary 326

Chapter 11
Bipolar Cognitive Mapping and Decision Analysis: A Bridge from Bioeconomics to Socioeconomics 333
Introduction 333
Cognitive Mapping and Mind Reading 335
Bipolar Quantum Brain Dynamics 337
Simulation of Bipolar Crisp CCM Development (Adapted from Zhang, 2003a) 339
Simulation of Bipolar Fuzzy CM Development (Adapted from Zhang, 2003B) 352
Conceptual CM (CCM) vs. Visual CM (VCM) 355
Research Topics 358
Summary 358

Part 5
Discussions and Conclusions

Chapter 12
Causality is Logically Definable: An Eastern Road toward Quantum Gravity 363
Introduction 363
A Debate on Bipolarity and Isomorphism 364
Pondering and Wondering 365
Some Historical Facts 367
Causality is Logically Definable 370
Bipolar Axiomatization for Physics 371
No Ultimate Logic in an Open World 372

Logical Distinctions 373
Answers to Critics 377
On the Ubiquitous Effects of Quantum Entanglement 385
Limitations 386
Major Research Topics 387
Summary 388

About the Author 395

Index 397

Foreword

I returned to my undergraduate alma mater, Georgia Southern University, in 2000 to develop programs in biostatistics and to establish a school of public health. Subsequently, I met Wen-Ran Zhang—the author of this book—and soon learned that he was highly regarded both as a teacher and a researcher. Some colleagues remarked: "Wen-Ran is a very hard worker and a prolific contributor to the literature, but few, if any, understand his research."

Over the next few years Wen-Ran and I often met to discuss each other's research interests and some common research interests. I must say that I was taken aback when I once asked him to tell me what his research was about in a few words. He said: "Multiagent Brain Modeling and YinYang Bipolar Logic." Somewhere in my undergraduate studies I learned logic and having had many Chinese friends over the years, I had a layman's understanding of Yin and Yang. Further, having designed and analyzed clinical trials in the development of drugs to treat bipolar disorder, I had some understanding of the word bipolar. But how these concepts could be brought together in a unifying theory was indeed puzzling.

But that is what the author has done in this book. YinYang Bipolar Relativity presents a logical unification of the two complementary opposites – the negative and positive energies of nature. By bringing the two sides together the book claims to provide an equilibrium-based computing paradigm for applications in physical, social, and life sciences especially in quantum computing.

It is well said by someone that *"Real innovation has no peers."* Therefore, I will not try to judge the book as a peer. On the other hand, as a colleague and friend, I am determined to stay impartial. So I asked the author to pass me the anonymous review comments on an earlier draft of his book from a double-blind review process sponsored by the publisher together with his response. In the following I provide a summary of both the negative and the positive review comments using direct quotes. Interestingly, the negative and positive sides themselves together present, to a certain extent, a vindication of YinYang bipolar relativity in a balanced and impartial manner.

THE POSITIVE SIDE WROTE

"The strengths of this book perhaps are best described in its contribution to understanding of YinYang bipolar relativity as 'an equilibrium based unifying computing paradigm that (1) logically defines causality, (2) logically unifies gravity with quantum theory, (3) brings relativity and quantum theory to the real-world for scientific computation and exploratory knowledge discovery in microscopic and macroscopic agent interaction, coordination, decision, and global regulation in physical, social, and life sciences especially in quantum computing and communication.' The objective defined by the author(s) was clearly met in the book."

"The author(s) have perhaps under-emphasized the importance of conceptualizing the concept of the YinYang and the power of the symbol as continual movement of two energies, etc. to better explain and lead into YinYang bipolar relativity. Such emphasis is given in the manuscript for Aristotelian science and logic and also to Einstein's theories of relativity. Yet, as the author(s) state, 'the word 'YinYang' indicates that the main idea is philosophically rooted in the ancient Chinese YinYang cosmology.' Since the manuscript establishes the bipolar theory and the importance of the opposite poles, the theory is different from Einstein's theory of relativity."

"Yes, the information in this manuscript does illustrate the issues, problems, and trends related to the theme or argument according to the author(s) is 'that equilibrium or non-equilibrium, as a physical state of any dynamic agent or universe at the system, molecular, genomic, particle, or sub-atomic level, forms a philosophical chicken and egg paradox with the universe because no one knows which one created the other in the very beginning.' This analogy serves as a guide to understanding the major point or argument in the manuscript. This analogy is further expanded in the YinYang concept when the author(s) argue that 'it is undoubtedly necessary to bridge the gap between the Western positivist thinking and the Eastern balanced thinking for solving unsolved scientific problems.' It is strongly supported in the literature (Ebrey, 1993, et al) in that the symbol YinYang represents an understanding of how things work in the universe. In fact, Ebrey noted in Chinese Civilization: A Sourcebook, 2nd ed. (New York: Free Press, 1993, pp. 77-79) that the concepts of Yin and Yang and the Five Agents 'provided intellectual framework of much of Chinese scientific thinking especially in the fields of biology and medicine.' This adds further credence to the argument made in the manuscript. In addition, it supports the contention that YinYang bipolar relativity has, in fact, opened an eastern road toward quantum gravity which, as noted, is Einstein's unfinished scientific unification of general relativity and quantum mechanics."

"As I have noted earlier, the target audience was defined in the Preface of the text. ... Given the nature of the subject, it might be a valuable research in other areas particularly in medicine and biology."

"The organization and/or flow of the book is a strength of this text. The chapters are well-illustrated for better understanding of major concepts. The chapters contain both a summary of important ideas and separate references for each chapter. Finally and perhaps most importantly, the chapters follow a logical sequence of ideas in the manuscript."

THE NEGATIVE SIDE WROTE

"The book is easy to read, except for extensive logic derivations and proofs which are too great for the reviewer to validate during a short review process and are considered by the reviewer to be secondary for this review purpose."

"The strength of this book is the mathematic work for bipolar logic. The reviewer believes that some models (not all though) might be useful for cases where bipolar agents do exist."

"As a researcher in the areas of information sciences, management science, and computer science, the reviewer would like to comment on modeling which is actually the theme of the book."

"The fatal mistake of this book is over-claiming. In reviewer's view, the bipolar theory proposed by the author(s) is nothing more than a modeling technique. The reviewer does not want to argue whether bipolar agents exist in the real world which is not important at all, but want to see the evidence to support your claims."

"This book over-emphasizes the following issues which do not add values to the research community.

1 Debate on philosophies. YinYang or not does not really matter - bipolar matters.
2 Unifying theory. Do not over-claim your theory for the fields you do not really know much.
3 Parallel with Einstein. 'Relativity' for your book is unnecessary."

"This book under-emphasizes the following problems which are important to the research community.

1 Practical problem solving.
2 Objective evidences beyond ideas and mathematics derivations.
3 Comparison of your models and other existing commonly used models in the fields."

"A sustainable theory must be supported by evidences of problem solving. Subjective modeling and interpretation of phenomena or events are not good enough. People do not really mind whether YinYang is in their body, but they do care whether the theory helps medical doctors cure the patients."
"'The author(s)' term 'application' means 'to apply the bipolar theory to explain the world.' To the reviewer, 'application' means 'to apply the model to solve a real problem.'"
"The book over-claims the target audience in the Preface."
"The reviewer does (not) find any problem with the organization of the book. The presentation flow is quite smooth, and easy to follow, except for lengthy mathematical derivations and proofs. Literally, the manuscript is well written."

After I finished reading the last draft of the book and the anonymous reviews with the author's response, it is quite clear to me which side of the above review comments is more objective. But, as I promised earlier, I shall not divulge in order to stay impartial. Instead, I leave it to readers of the book to make their own judgment. Of course, reviewer concerns have helped the author to improve his book.

In any case, I can positively say that the author is an outstanding research scientist. The breadth and depth of his knowledge in many areas, particularly in the computer, mathematical and physical sciences, and his capacity for original thinking and advancing knowledge are awe-inspiring. He is to be commended for his efforts in writing this book and his efforts to venture into uncharted, if not controversial scientific territories.

I am honored and flattered to have the opportunity to write the foreword of this remarkable book.

Karl E. Peace

Karl E. Peace *is the Georgia Cancer Coalition (GCC) Distinguished Cancer Scholar, Senior Research Scientist and Professor of Biostatistics in the Jiann-Ping Hsu College of Public Health (JPHCOPH) at Georgia Southern University. He is the architect of the MPH in Biostatistics and Founding Director of the Karl E. Peace Center for Biostatistics in the JPHCOPH. Dr. Peace holds the Ph.D. in Biostatistics from the Medical College of Virginia, the M.S. in Mathematics from Clemson University, the B.S. in Chemistry from Georgia Southern College, and a Health Science Certificate from Vanderbilt University. Dr. Peace's first career was academic teaching and research. He previously taught Mathematics at Georgia Southern College, Clemson University, Virginia Commonwealth University, and Randolph-Macon College, where he was a tenured professor. He also holds or has held numerous adjunct professorships at the Medical College of Virginia, the University of Michigan, Temple University, the University of North Carolina, and Duke University. Dr. Peace's second career was in research, technical support and management in the pharmaceutical industry. He held the positions of Senior Statistician at Burroughs-Wellcome, Manager of Clinical Statistics at A.H. Robins, Director of Research Statistics at SmithKline and French Labs, Senior Director of GI Clinical Studies, Data Management and Analysis at G.D. Searle, and Vice President of World-Wide Technical Operations at Warner Lambert/Parke-Davis. He then founded Biopharmaceutical Research Consultants, Inc. (BRCI), where he held the positions of President, Chief Executive Officer, and Chief Scientific Officer. Dr. Peace has made pivotal contributions in the development and approval of drugs to treat Alzheimer's disease, to prevent and treat gastrointestinal ulcers, to reduce the risk of myocardial infarction, to treat anxiety, depression and panic attacks, to treat hypertension and arthritis, and several antibiotics. Dr. Peace is or has been a member of several professional and honorary societies, including the Drug Information Association (DIA), the Biometric Society, Technometrics, the American Society for Quality Control (ASQC), the American Statistical Association (ASA), and Kappa Phi Kappa (KPK). He is a past member of the Committee on Applied and Theoretical Statistics, National Research Council, National Academy of Science. He is the recipient of numerous citations and awards: (1) Georgia Cancer Coalition Distinguished Cancer Scholar, (2) Fellow of the ASA, (3) the Distinguished Service Award of the DIA, (4) Star and Featured Alumnus, School of Basic Sciences, and Founder's Society Medal from the Medical College of Virginia, (5) College of Science and Technology Alumnus of the year, Alumnus of the year in private enterprise, Presidential Fellowship Award, Researcher of the year awards, and the First Recipient of the prestigious President's Medal for outstanding service and extraordinary contributions, all from Georgia Southern University, (6) 2007 APHA Statistics Section Award, (7) 2008 Shining Star and HR #2118 recognition by GA House of Representatives, (8) US Congress Citation for contributions to drug research and development and to Public Health, (9) the Tito Mijares Lifetime Achievement Award, (10) the Deen Day Smith Humanitarian Award and (11) several meritorious service awards from the ASQC, BASS and the Georgia Cancer Coalition. He is or has been Chair of: the Biostatistics Subsection of the Pharmaceutical Manufacturers Association (BSPMA), the Training Committee of the BSPMA, the Biopharmaceutical Section of the ASA, the Statistics Section of the APHA, and is Founder of the Biopharmaceutical Applied Statistics Symposium (BASS) in 1994. Dr. Peace is the author or editor of nine books and the author or co-author of 200 articles. His primary research interests are in drug research and development, clinical trial methodology, time-to-event methodology, and public health applications of biostatistics. Dr. Peace is a renowned philanthropist. He has created 21 scholarship endowments across 5 educational and public health institutions. Further details of Dr. Peace's accomplishments and contributions may be found in his autobiography entitled Paid In Full available at www.plowboy-press.com.*

Preface

A few years away from the centennial celebration of general relativity, the author of this monograph feels blessed for having the opportunity to present *YinYang Bipolar Relativity* to readers of the world. It seems surreal but, hopefully, the book can serve three purposes: (1) to add a piece of firework to the centennial celebration; (2) to introduce a deeper theory that transcends spacetime; (3) to reveal the ubiquitous effects of quantum entanglement in simple, logically comprehendible terms. Certainly, whether it is indeed an applicable deeper theory or just a piece of firework is ultimately up to the readers to make a judgment. As pointed out by Einstein: *"Experience remains, of course, the sole criterion of the physical utility of a mathematical construction. But the creative principle resides in mathematics."* (Einstein, 1934)

In this book we refer to relativity theories defined in spacetime as *spacetime relativity*. Thus, all previous relativity theories by Galileo, Newton, Lorenz, and Einstein are classified as spacetime relativity. This terminological treatment is for distinguishing *YinYang bipolar geometry* from *spacetime geometry*.

Regarding judgment, believe it or not, in the world-wide scientific community there may be more Chinese who emotionally resent the word "YinYang" due to misinformation or misunderstanding than Westerners who scientifically oppose the YinYang cosmology. This may sound ironic but is actually a historical phenomenon with socioeconomic reasons. First, most modern day Chinese want China to be integrated into the modern world and don't care much about YinYang, deemed an unscientific concept of the old school. Secondly, some overseas Chinese are concerned that the word "YinYang" might offend Western colleagues.

Subsequently, while the word "YinYang" has appeared in numerous Western publications spanning almost the whole spectrum of arts and sciences including but not limited to the prestigious journals *Science, Nature,* and *Cell*, some Chinese scholars including some researchers in traditional Chinese medicine (TCM) tend to shun YinYang. For instance, a few years ago a well-established Chinese American friend strongly advised (or demanded) the author to drop the word "YinYang" from titles of future submissions to avoid *"hurting the others' feelings."*

Western scholars, on the other hand, are free from carrying the above historical or socioeconomical baggage and are curious about YinYang. While many Westerners regard "YinYang" objectively as a philosophical word related to nature, society, and TCM, some Western scientists expect YinYang to play a critical or even unifying role in modern science. Here are a few examples:

1. Regarding the *"hurting the others' feelings"* matter, the author consulted a few "Westerner" colleagues and was given exactly the opposite advice: YinYang symbolizes the two energies of dynamic equilibrium, harmony, and complementarity; bipolarity without YinYang is often used in the West to indicate disorder, chaos, and dichotomy. (Note: Bipolarity is used in this book as YinYang bipolarity.)

2. Legendary German mathematician Leibniz – co-founder of calculus – invented the modern binary numeral system in the 17th century and attributed his invention to YinYang hexagrams recorded in the oldest *Chinese Book of Change – I Ching* (Leibniz 1703) (Karcher 2002).
3. Legendary Danish physicist Niels Bohr, father figure of quantum mechanics, brought YinYang into quantum theory for his particle-wave complementarity principle. When he was awarded the Order of the Elephant by the Danish government in 1947, he designed his own coat of arms which featured in the center a YinYang logo (or Taiji symbol) with the Latin motto *"contraria sunt complementa"* or *"opposites are complementary."*
4. Following Einstein's lead that history and philosophy provide the context for science and should be a significant part of physics education (Smolin 2006 p310-311), a group of renowned scientists and linguists noticed that different philosophies and cosmologies could result in different cultures and linguistic terms which in turn could make a major difference in the interpretation and understanding of space, time, and the quantum world (Alford 1993). Specifically, the word *"YinYang"* is deemed a most suitable noun for characterizing quantum interaction. As stated by linguist Alford (Alford 1993), YinYang *"represents a higher level of formal operations" "which lies beyond normal Western Indo-European development."*
5. A widely referenced genetic agent (protein) discovered at Harvard Medical School is named YinYang 1 (YY1) (Shi *et al.* 1991) due to its ubiquitous repressor-activator (YinYang) functionalities in gene expression regulation in all cell types of living species (Jacobsen & Skalnik 1999).
6. A YinYang Pavilion created by American artist Dan Graham is dedicated to MIT and housed in Simmons Hall on the MIT campus (MIT News 2004).
7. A New York Times science report (Overbye 2006) described a subatomic particle discovered at the Fermi National Accelerator Laboratory as a *"YinYang dance"* that can change polarity three trillion times per second (Fermilab 2006).

While Western science and media don't seem to have problem with the word "YinYang", the word is, nevertheless, largely mysterious, albeit extremely pervasive. Its pervasive and mysterious nature can be characterized with a famous quote from Einstein: *"After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well."*

Evidently, a resolution to the *"science and art"* YinYang mystery bears great significance and has become imperative for the advancement of science and humanity. Unfortunately, such a resolution has been deemed scientifically impossible by many. This monograph is intended to accomplish the mission impossible based on the following observations and assertions:

1. The *"science and art"* YinYang paradox is similar to particle-wave quantum duality in Niels Bohr's complementarity principle. However, quantum mechanics has so far only recognized YinYang complementarity but failed to identify the essence of YinYang bipolarity. Without bipolarity, any complementarity is less fundamental due to the missing "opposites." In one word, the negative and positive poles such as action-reaction forces and particle-antiparticle pairs are the most fundamental opposites of Mother Nature but science-art, particle-wave, and truth-falsity are not exactly YinYang bipolar opposites.
2. Resolving the YinYang mystery is essentially the same as logically defining Aristotle's causality principle, axiomatizing all of physics (Hilbert 1901), resolving the EPR paradox (Einstein, Podolsky

& Rosen 1935), or providing a logical foundation for the grand unification of general relativity and quantum mechanics.

3. The *"higher level" "post-formal"* YinYang operation entails a philosophically different logical foundation that does indeed lie *"beyond normal Western Indo-European development"* and such a logical foundation is attainable in formal mathematical terms.

OBJECTIVE

The objective of this monograph is to present YinYang bipolar relativity as an equilibrium-based unifying computing paradigm with a minimal but most general axiomatization of physics that (1) logically defines bipolar quantum causality; (2) logically unifies gravity with quantum theory; (3) brings relativity and quantum entanglement to the real-world of microscopic and macroscopic agent interaction, coordination, decision, and global regulation in physical, social, and life sciences especially in quantum computing and exploratory knowledge discovery.

INTENDED AUDIENCE

The intended audience of the book includes, but is not limited to,

1. Students, professors, and researchers in mathematics, computer science, artificial intelligence, information science, information technology, data mining and knowledge discovery. These readers may find bipolar mathematical abstraction, bipolar sets, bipolar dynamic logic, bipolar quantum linear algebra, bipolar quantum cellular automata and their applications useful in their fields of teaching, learning, and research.
2. Students, professors, and researchers in quantum computing, physical sciences, nanotechnology, and engineering. These readers may find both of the theoretical and application aspects useful in their field of teaching, learning, and research. It is expected that quantum computing will be a major interest to these readers.
3. Students, professors, and researchers in bioinformatics, computational biology, genomics, bioeconomics, psychiatry, neuroscience, traditional Chinese medicine, and biomedical engineering. These readers may use the book material as an alternative holistic approach to problem solving in their fields of teaching, learning, research, and development.
4. Students, professors, and researchers in socioeconomics, bioeconomics, cognitive science, and decision science. These readers may find the mathematical tools and the quantum computing view useful in their fields of teaching, learning, research, and development.
5. Industrial researcher/developers in all fields who are interested in equilibrium-based modeling, analysis, and exploratory knowledge discovery in quantum computing, cognitive informatics, and life sciences. These readers may actually apply the theory of bipolar relativity for dealing with uncertainties and resolving unsolved problems in uncharted territories.

Limited logical and mathematical proofs of related theorems are included in Chapters 3-8. The proofs are for the convenience of logicians and mathematicians. They can be skipped by non-mathematical readers who are only interested in using the mathematical results for practical applications.

ORIGIN

While YinYang bipolar relativity can trace its philosophical origin back to ancient Chinese YinYang cosmology which claimed that everything has two sides or two opposite but reciprocal poles or energies, the formal theory presented in this monograph, however, is not the result of experimentation or elaboration of ancient Chinese YinYang but the result of free invention in the following spirit:

1. According to Einstein logical axiomatization of physics is possible: *"Physics constitutes a logical system of thought which is in a state of evolution, whose basis (principles) cannot be distilled, as it were, from experience by an inductive method, but can only be arrived at by free invention."* (Einstein 1916).
2. According to Einstein: *"Evolution is proceeding in the direction of increasing simplicity of the logical basis (principles)." "We must always be ready to change these notions – that is to say, the axiomatic basis of physics – in order to do justice to perceived facts in the most perfect way logically."* (Einstein 1916)
3. According to Einstein: *"... pure thought can grasp reality, as the ancients dreamed"* and *"nature is the realization of the simplest conceivable mathematical ideas."* (Einstein 1934)
4. According to Einstein the grand unification of general relativity and quantum mechanics needs a new logical foundation: *"For the time being we have to admit that we do not possess any general theoretical basis for physics which can be regarded as its logical foundation."* (Einstein 1940)
5. According to Einstein: *"Put your hand on a hot stove for a minute, and it seems like an hour. Sit with a pretty girl for an hour, and it seems like a minute. That's relativity."*

In the last quote, Einstein used sorrow and joy to hint the two sides of YinYang in general. Symbolically, the two sides can be paired up as a bipolar variable and generalized to action-reaction forces denoted *(-f, +f)*, negative-positive electromagnetic charges denoted *(-q, +q)*, matter-antimatter particles *(-p, +p)* or the equilibrium-based bipolar variable (e^-, e^+) in a YinYang bipolar dynamic logic (BDL) for the theory of YinYang bipolar relativity (Zhang 2009a,b,c,d).

While space and time are not symmetrical to each other, not quantum entangled with each other, and not bipolar interactive, the concept of YinYang bipolarity is symmetrical and applicable in both microscopic and macroscopic worlds of physical and social sciences for characterizing agent interaction and bipolar quantum entanglement. Arguably, if space is expanding, spacetime has to be caused by something more fundamental; if YinYang bipolarity can survive a black hole due to particle-antiparticle emission or Hawking radiation, the logical foundation of physics has to be bipolar in nature; if particle-antiparticle pairs and nature's basic action-reaction forces are the most fundamental components of our universe, YinYang bipolar relativity has to be more fundamental than spacetime relativity. These arguments provide a basis for the transcending and unifying property of YinYang bipolar relativity beyond spacetime geometry.

Historically, even though YinYang has been the philosophical basis in the actual practice of TCM for thousands of years in China, it has failed to enter the arena of modern science until recent decades. It is a living proof to Einstein's assertion that *"Physics constitutes a logical system of thought which is in a state of evolution, whose basis (principles) cannot be distilled, as it were, from experience by an inductive method, but can only be arrived at by free invention."* (Einstein 1916).

Here are a few major modern developments in YinYang research:

1. **Biological YinYang.** The most noticeable result in this category is the discovery of the genetic regulator protein Yin Yang 1 (YY1) in 1991 at Harvard Medical School (Shi *et al.* 1991). YY1 exhibits ubiquitous repressor-activator functionalities in gene expression regulation in all types of cells of living species. The discovery of YY1 marks the formal entry of the ancient YinYang into genomics – a core area of bioinformatics. Since then, YY1 has been widely referenced by the top research institutions in the US and the world.
2. **Bayesian YinYang (BYY)**. BYY harmony learning **(**Xu 2007) has been widely cited and has become a well-established area in neural networks.
3. **Binary or Boolean YinYang**. Boolean YinYang (Zhang 1992; Kandel & Zhang 1998) follows Leibniz binary interpretation of YinYang. The binary interpretation provides a basis for all digital technologies.
4. **Bipolar YinYang.** Bipolar YinYang consists of YinYang bipolar sets, bipolar dynamic logic, bipolar quantum linear algebra, YinYang-N-Element quantum cellular automata, bipolar quantum entanglement, and the theory of YinYang bipolar relativity for applications in quantum computing, socioeconomics, and brain and life sciences (Zhang and coauthors, 1989-2009) (Zhang 1996-2010). Bipolar YinYang follows the YinYang cosmology that claims everything in the universe including the universe itself has two opposite reciprocal poles or energies.

This book follows the direction of bipolar YinYang. However, it should be remarked that the above different approaches to YinYang are interrelated or overlapped with each other. The repression and activation regulatory properties of Yin Yang 1 are bipolar in nature; YinYang equilibrium is essential in YinYang harmony; the two poles of YinYang are truth objects plus reciprocal bipolarity. From a physical science perspective, (-,+) bipolarity and symmetry in particle physics can also be considered evidence that supports the YinYang bipolar cosmology. From a decision science perspective, YinYang has been an influential philosophy in business management, socioeconomics, and international relations especially in Eastern countries. Noticeably, the national flag of South Korea is featured with a YinYang logo.

Indeed, YinYang has entered every aspect of the Western as well as the Eastern societies. Due to its lack of a unique formal logical basis, however, YinYang theory has remained largely mysterious. This book is to fill this gap. Although the technical ideas have been partially reported in refereed journal and conference articles, they have never been systematically presented as a coherent relativity theory in a monograph.

CENTRAL THEME

It is well-known that microscopic and macroscopic agents and agent interactions are essential in physics, socioeconomics, and life sciences. Unifying logical and mathematical axiomatization of agent interaction in microscopic and macroscopic worlds including but not limited to quantum, molecular, genetic, and neurobiological worlds is needed for scientific discoveries and for the coordination and global regulation of both non-autonomous and autonomous agents. Since agent interactions are governed by physical and social dynamics, the difficulty of axiomatizing agent interactions can be traced back to Hilbert's effort in axiomatizing physics, Aristotle's causality principle, the concept of singularity, and bipolar equilibrium.

English mathematical physicist Roger Penrose described two mysteries of quantum entanglement (Penrose 2005, p591). The first mystery is identified as the phenomenon itself. The second one, accord-

ing to Penrose, is *"How are we to come to terms with quantum entanglement and to make sense of it in terms of ideas that we can comprehend, so that we can manage to accept it as something that forms an important part of the workings of our actual universe? .. The second mystery is somewhat complementary to the first. Since according to quantum mechanics, entanglement is such a ubiquitous phenomenon – and we recall that the stupendous majority of quantum states are actually entangled ones – why is it something that we barely notice in our direct experience of the world? Why do these ubiquitous effects of entanglement not confront us at every turn? I do not believe that this second mystery has received nearly the attention that it deserves, people's puzzlement having been almost entirely concentrated on the first."*

A major argument of this monograph is that equilibrium or non-equilibrium, as a physical state of any dynamic agent or universe at the system, molecular, genomic, particle, or subatomic level, forms a philosophical chicken and egg paradox with the universe because no one knows exactly which one created the other in the very beginning. Since bipolar equilibrium (or non-equilibrium) is a generic form of equilibrium (or non-equilibrium), any multidimensional model in spacetime geometry is not fundamental. *It is postulated that the most fundamental property of the universe is YinYang bipolarity.* Based on this postulate, bipolar relativity is presented that extends YinYang cosmology from *"Everything has two reciprocal poles"* to a formal logical foundation for physical and social sciences which claims that *"Everything has two reciprocal poles and nature is the realization of YinYang bipolar relativity or bipolar quantum entanglement."*

The main idea of the book starts with the paradox *"logical axiomatization for illogical physics" (LAFIP)* (Zhang 2009a) on Hilbert's Problem 6. It is observed that without bipolarity the bivalent truth values 0 for false and 1 for true are incapable of carrying any shred of direct physical syntax and semantics, let alone illogical physical phenomena such as chaos, particle-wave duality, bipolar disorder, equilibrium, non-equilibrium, and quantum entanglement. Therefore, truth-based (unipolar) mathematical abstraction as a basis for positivist thinking cannot avoid the LAFIP paradox. It is suggested that this is the fundamental reason why there is so far no truth-based logically definable causality, no truth-based axiomatization of all physics, no decisive battleground in the quest for quantum gravity, and no logic for particle-wave duality, bipolar disorder, economic depression, big bang, black hole, and quantum entanglement.

Furthermore, it is pointed out that, while no physicist would say *"electron is isomorphic to positron"*, it is widely considered in logic and mathematics that "-1 is isomorphic to +1" and (-,+) bipolar symmetry, equilibrium, or non-equilibrium is not observable. If we check the history of *negative numbers*, we would find that the ancient Chinese and Indians started to use negative numbers thousands of years ago but European mathematicians resisted the concept of negative numbers until the 18th centuries (Temple 1986, pp.141) (Bourbaki 1998) (Martinez 2006).

Regardless of the great achievement of Western science and technology, it is undoubtedly necessary to bridge the gap between the Western positivist thinking and the Eastern balanced thinking for solving unsolved scientific problems. As *"passion for symmetry"* can *"permeate the Standard Model of elementary particle physics"* and can unify *"the smallest building blocks of all matter and three of nature's four forces in one single theory"* (The Royal Swedish Academy of Sciences 2008), it is not only reasonable but also inevitable to explore the bipolar equilibrium-based computing paradigm (Note: Equilibrium-based is to equilibrium and non-equilibrium as truth-based is to truth and falsity with fundamentally different syntax and semantics).

SYNOPSIS

YinYang bipolar relativity is intended to be a logical unification of general relativity and quantum mechanics. The monograph can be considered the first step to address the gigantic topic with real-world applications in both natural and social sciences focused on quantum computing and agent interaction in socioeconomics, cognitive informatics and life sciences. Subjects opened in the book can be further addressed in succeeding volumes in depth.

The main body of the book starts with a new set-theoretic logical foundation. To avoid LAFIP, bipolar set theory is introduced with a holistic equilibrium-based approach to mathematical abstraction. Bipolar sets lead to YinYang bipolar dynamic logic (BDL). A key element of BDL is bipolar universal modus ponens (BUMP) that provides, for the first time, logically definable causality. It is shown that BDL is a non-linear bipolar dynamic fusion of Boolean logic and quantum entanglement. The non-linearity, however, does not compromise the basic law of excluded middle (LEM) and bipolar computability. Soundness and completeness of a bipolar axiomatization are asserted. Bipolar sets and BDL are extended to bipolar fuzzy sets, bipolar dynamic fuzzy logic (BDFL) and equilibrium relations.

With the emergence of space, time, and bipolar agents, a completely background independent theory of bipolar relativity, the central theme of the book, is formally introduced based on bipolar sets and BDL. It is shown that, with bipolar agents and bipolar relativity, causality is logically definable; a real-world bipolar string theory is scalable, and an equilibrium-based minimal but most general axiomatization of physics, socioeconomics, and life sciences, as a partial solution to Hilbert's Problem 6, is logically provable.

It is shown that YinYang bipolar relativity is rich in predictions. Predictions are presented, some of which are expected to be falsifiable in the foreseeable future. In particular, it is shown that bipolar relativity provides the unified logical form for both gravity and quantum entanglement. It is conjectured that all forces in the universe are bipolar quantum entanglement in nature in large or small scales and in symmetrical or asymmetrical forms; the speed of gravity is not necessarily limited by the speed of light as it could well be limited by the speed of quantum entanglement.

Due to bipolar quantum entanglement, YinYang bipolar relativity leads to a logically complete theory for quantum computing with digital compatibility. The bipolar quantum computing paradigm is ideal for modeling non-linear bipolar dynamic oscillation and interaction such as non-local connection and particle-wave duality in quantum mechanics as well as self-negation/self-assertion abilities in cognitive informatics and competition-cooperation in socioeconomics. In particular, it is shown that bipolar quantum entanglement makes quantum teleportation theoretically possible without conventional communication between Bob and Alice. Furthermore, it is shown that bipolar quantum-digital compatibility and bitwise cryptography have the potential to make obsolete both prime number based encryption and quantum factorization.

Based on the logical foundation, limited mathematical construction is presented. Specifically, bipolar quantum linear algebra (BQLA) and YinYang-N-Element bipolar quantum cellular automata (BQCA) are introduced with illustrations in biosystem simulation and equilibrium-based global regulation. It is shown that the dimensional view, bipolar logical view, and YinYang-N-Element BQCA view are logically consistent. Therefore, bipolar set theory, bipolar dynamic logic, BQLA, bipolar agents, bipolar causality, and BQCA are all unified under YinYang bipolar relativity.

It is contended that YinYang bipolar relativity is an Eastern road toward quantum gravity. It is argued that it would be hard to imagine that quantum gravity as the grand unification of gravity and quantum

mechanics would not be the governing theory for all sciences. This argument leads to five sub-theories of quantum gravity: *physical quantum gravity, logical quantum gravity, social quantum gravity, biological quantum gravity, and mental quantum gravity that form a Q5 quantum computing paradigm*. The Q5 paradigm is then used as a vehicle to illustrate the ubiquitous effects of bipolar quantum entanglement that confronts us at every turn of our lives in comprehendible logical terms.

LIMITATIONS

Mathematically, the theory of YinYang bipolar relativity as a pure invention is not derived from general relativity or quantum theory. Instead, it presents a fundamentally different approach to quantum gravity. As a first step, the monograph is focused on the logical level of the theory and its applications in physical, social, brain, biological, and computing sciences with limited mathematical or algebraic extensions. Thus, equilibrium-based bipolar logical unification of gravity and quantum mechanics is within the scope of the book; the quantization of YinYang bipolar relativity and the mathematical unification of Einstein's equations of general relativity and that of quantum mechanics have to be left for future research efforts because *"For the time being we have to admit that we do not possess any general theoretical basis for physics which can be regarded as its logical foundation"* (Einstein 1940).

Theoretically, YinYang bipolar relativity presents an open-world and open-ended approach to science that is not *"a theory of everything."* In this approach, the author doesn't attempt to define the smallest fundamental element such as strings in string theory. Instead, it is postulated that YinYang bipolarity is the most fundamental property of the universe based on well-established observations in physical and social sciences. With the basic hypothesis, equilibrium-based logical constructions are developed with a number of predictions for experimental verification or falsification. This approach actually follows the principle of exploratory scientific knowledge discovery.

Practically, YinYang bipolar relativity is expected to be applicable wherever bipolar equilibrium or non-equilibrium is central (e.g. Zhang 2003a,b; Zhang 2006; Zhang, Pandurangi & Peace 2007; Zhang *et al.* 2010). As a quantum logic theory it is recoverable to Boolean logic and, therefore, is computational. As a relativity theory, its major role is to provide predictions and interpretations about nature, agents, and causality. Since it is not *"a theory of everything"*, it does not claim universal applicability. Simulated application examples are presented in quantum computing, cognitive informatics, and life sciences to illustrate the utility of the theory. The examples, however, are not intended to be systematic and comprehensive applications but only sufficient illustrations. While the theory is logically proven sound, predictions or interpretations made in the book can be either verified or falsified in the future, as usual.

CITING

References to others in this monograph are focused on important relevant works related to the logical foundation of this work. Since the formal system presented in the book is a free invention, not a philosophical elaboration of YinYang or an extension of other quantum gravity theories, references to YinYang literature are limited to the well-known basic concepts related to the logical foundation and references to relativity and quantum theory are limited to the basic concepts of spacetime geometry, particle physics, quantum entanglement, and teleportation. Selected references are mostly published scientific works in

peer reviewed books, journals, or conference proceedings. Non-peer reviewed Web articles cited are strictly limited to well-known historical facts or philosophical non-technical viewpoints. This treatment ensures that all technical references are from peer-reviewed scientific sources but undisputed well-known historical facts available online, and freely expressed, non-peer reviewed philosophical viewpoints published in the Web by related experts could be taken into account for readers' convenience.

SIGNIFICANCE

To the author's knowledge, this is the first monograph of its kind to introduce logically definable causality into physical and social sciences and to make the ubiquitous effects of quantum entanglement logically comprehendible. While Leibniz binary YinYang provided a technological basis for digital technologies, YinYang bipolar relativity is expected to bring quantum gravity into logical, physical, social, biological, and mental worlds for quantum computing.

The significance of YinYang bipolar relativity lies in its four equilibrium-based logical unifications: (1) the unification of unipolar positivist truth with bipolar holistic truth, (2) the unification of classical logic with quantum logic, (3) the unification of quantum entanglement with microscopic and macroscopic agent interaction in simple logical terms, and (4) the unification of general relativity with quantum mechanics under bipolar equilibrium and symmetry. Despite its limited mathematical depth, it is shown that YinYang bipolar relativity constitutes a deeper theory beyond spacetime geometry tailored for open-world open-ended exploratory knowledge discovery in all scientific fields where equilibrium and symmetry are central.

ORGANIZATION

The book consists of twelve chapters which can be roughly divided into the following five sections:

Part 1. Introduction and Background. This part consists of Chapter 1 and Chapter 2. Chapter 1 is an introduction; Chapter 2 is a background review.

Part 2. Set Theoretic Logical Foundation. This part consists of Chapters 3-5. This part lays out the set-theoretic logical foundation for bipolar relativity including YinYang bipolar sets, bipolar dynamic logic, bipolar quantum lattices, bipolar dynamic fuzzy logic, bipolar fuzzy sets and equilibrium relations.

Part 3. YinYang Bipolar Relativity and Quantum Computing. This part consists of Chapters 6-8 which are focused on the central theme of the book. Chapter 6 presents the theory of agents, causality, and YinYang bipolar relativity with a number of predictions. Chapter 7 presents bipolar quantum entanglement for quantum computing. Chapter 8 presents YinYang bipolar quantum linear algebra (BQLA), bipolar quantum cellular automata (BQCA), and a unifying view of YinYang bipolar relativity in logical, geometrical, algebraic, and physical terms.

Part 4. Applications. This part consists of Chapters 9-11. Chapter 9 is focused on biosystem simulation with BQLA and BQCA. Chapter 10 is focused on bipolar computational neuroscience and psychiatry. Chapter 11 is focused on bipolar cognitive mapping and decision analysis.

Part 5. Discussions and Conclusions. This part consists of the last chapter (Chapter 12) in which discussions and conclusions are presented.

CHAPTER OUTLINE

Chapter 1. Introduction: Beyond Spacetime

This chapter serves as an introduction to bring readers from spacetime relativity to YinYang bipolar relativity. Einstein's assertions regarding physics, logic, and theoretical invention are reviewed and his hint of YinYang bipolar relativity is identified. The limitations of general relativity and quantum mechanics are briefly discussed. It is concluded that logically definable causality, axiomatization of physics, axiomatization of agent interaction, and the grand unification of general relativity and quantum theory are essentially the same problem at the fundamental level. A paradox on Hilbert's Problem 6 – Logical Axiomatization for Illogical Physics (LAFIP) – is introduced. Bipolarity is postulated as the most fundamental property of nature transcending spacetime. The theoretical basis of agents, causality and YinYang bipolar relativity is highlighted and distinguished from established theories. The main ideas of the book are outlined.

Chapter 2. Background Review: Quest for Definable Causality

This chapter presents a review on the quest for logically definable causality. The limitation of observability and truth-based cognition is discussed. The student-teacher philosophical dispute between Aristotle and Plato is revisited. Aristotle's causality principle, David Hume's challenge, Lotfi Zadeh's *"Causality Is Undefinable"* conclusion, and Judea Pearl's probabilistic definability are reviewed. Niels Bohr's particle-wave complementarity principle, David Bohm's causal interpretation of quantum mechanics, and Sorkin's causal set program are discussed. Cognitive-map-based causal reasoning is briefly visited. YinYang bipolar logic and bipolar causality are previewed. Social construction and destruction in science are examined. It is asserted that, in order to continue its role as the doctrine of science, the logical definability of Aristotle's causality principle has become an ultimate dilemma of science. It is concluded that, in order to resolve the dilemma, a formal system with logically definable causality has to be developed, which has to be logical, physical, relativistic, and quantum in nature. The formal system has to be applicable in the microscopic world as well as in the macroscopic world, in the physical world as well as in the social world, in cognitive informatics as well as in life sciences, and, above all, it has to reveal the ubiquitous effects of quantum entanglement in simple comprehendible terms.

Chapter 3. Bipolar Sets and YinYang Bipolar Dynamic Logic (BDL)

In this chapter an equilibrium-based set-theoretic approach to mathematical abstraction and axiomatization is presented for resolving the LAFIP paradox (Ch. 1) and for enabling logically definable causality (Ch. 2). Bipolar set theory is formally presented, which leads to YinYang bipolar dynamic logic (BDL). BDL in zeroth-order, 1st-order, and modal forms are presented with four pairs of dynamic DeMorgan's laws and a bipolar universal modus ponens (BUMP). BUMP as a key element of BDL enables logically definable causality and quantum computing. Soundness and completeness of a bipolar axiomatization are asserted; computability is proved; computational complexity is analyzed. BDL can be considered a non-linear bipolar dynamic generalization of Boolean logic plus quantum entanglement. Despite its non-linear bipolar dynamic quantum property, it does not compromise the basic law of excluded middle. The recovery of BDL to Boolean logic is axiomatically proved through depolarization and the computability

of BDL is asserted. A redress on the ancient paradox of the liar is presented with a few observations on Gödel's incompleteness theorem. Based on BDL, bipolar relations, bipolar transitivity, and equilibrium relations are introduced. It is shown that a bipolar equilibrium relation can be a non-linear bipolar fusion of many equivalence relations. Thus, BDL provides a logical basis for YinYang bipolar relativity – an equilibrium-based axiomatization of social and physical sciences.

This chapter is based on ideas presented in (Zhang & Zhang 2003, 2004) (Zhang 2003a,b; 2005a,b; 2007; 2009a,b,c,d). Early works of this line of research can be found in (Zhang, Chen & Bezdek 1989) (Zhang *et al.* 1992) (Zhang, Wang & King 1994)

Chapter 4. Bipolar Quantum Lattices and Dynamic Triangular Norms

Bipolar quantum lattice (BQL) and dynamic triangular norms (t-norms) are presented in this chapter. BQLs are defined as special types of bipolar partially ordered sets or posets. It is shown that bipolar quantum entanglement is definable on BQLs. With the addition of fuzziness, BDL is extended to a bipolar dynamic fuzzy logic (BDFL). The essential part of BDFL consists of bipolar dynamic triangular norms (t-norms) and their co-norms which extend their truth-based counterparts from a static unipolar fuzzy lattice to a bipolar dynamic quantum lattice. BDFL has the advantage in dealing with uncertainties in bipolar dynamic environments. With bipolar quantum lattices (crisp or fuzzy), the concepts of bipolar symmetry and quasi-symmetry are defined which form a basis toward a logically complete quantum theory. The concepts of strict bipolarity, linearity, and integrity of BQLs are introduced. A recovery theorem is presented for the depolarization of any strict BQL to Boolean logic. The recovery theorem reinforces the computability of BDL or BDFL.

This chapter is based on the ideas presented in (Zhang & Zhang 2004) (Zhang 1996, 1998, 2003, 2005a,b, 2006a,b, 2007, 2009b). Early works of this line of research can be found in (Zhang, Chen & Bezdek 1989) (Zhang *et al.* 1992) (Zhang, Wang & King 1994)

Chapter 5. Bipolar Fuzzy Sets and Equilibrium Relations

Based on bipolar sets and quantum lattices, the concepts of bipolar fuzzy sets and equilibrium relations are presented in this chapter for bipolar fuzzy clustering, coordination, and global regulation. Related theorems are proved. Simulated application examples in multiagent macroeconomics are illustrated. Bipolar fuzzy sets and equilibrium relations provide a theoretical basis for cognitive-map-based bipolar decision, coordination, and global regulation.

This chapter is based on the ideas presented in (Zhang 2003a,b, 2005a,b, 2006a). Early works of this line of research can be found in (Zhang, Chen & Bezdek 1989) (Zhang *et al.* 1992) (Zhang, Wang & King 1994)

Chapter 6. Agents, Causality, and YinYang Bipolar Relativity

This chapter presents the theory of bipolar relativity – a central theme of this book. The concepts of YinYang bipolar agents, bipolar adaptivity, bipolar causality, bipolar strings, bipolar geometry, and bipolar relativity are logically defined. The unifying property of bipolar relativity is examined. Space and time emergence from YinYang bipolar geometry is proposed. Bipolar relativity provides a number of predictions. Some of them are domain dependent and some are domain independent. In particular, it

is conjectured that spacetime relativity, singularity, gravitation, electromagnetism, quantum mechanics, bioinformatics, neurodynamics, and socioeconomics are different phenomena of YinYang bipolar relativity; microscopic and macroscopic agent interactions in physics, socioeconomics, and life science are directly or indirectly caused by bipolar causality and regulated by bipolar relativity; all physical, social, mental, and biological action-reaction forces are fundamentally different forms of bipolar quantum entanglement in large or small scales; gravity is not necessarily limited by the speed of light; graviton does not necessarily exist.

This chapter is based on the ideas presented in (Zhang 2009a,b,c,d; Zhang 2010).

Chapter 7. YinYang Bipolar Quantum Entanglement: Toward a Logically Complete Theory for Quantum Computing and Communication

YinYang bipolar relativity leads to an equilibrium-based logically complete quantum theory which is presented and discussed in this chapter. It is shown that bipolar quantum entanglement and bipolar quantum computing bring bipolar relativity deeper into microscopic worlds. The concepts of bipolar qubit and YinYang bipolar complementarity are proposed and compared with Niels Bohr's particle-wave complementarity. Bipolar qubit box is compared with Schrödinger's cat box. Since bipolar quantum entanglement is fundamentally different from classical quantum theory (which is referred to as unipolar quantum theory in this book), the new approach provides bipolar quantum computing with the unique features: (1) it forms a key for equilibrium-based quantum controllability and quantum-digital compatibility; (2) it makes bipolar quantum teleportation theoretically possible for the first time without conventional communication between Alice and Bob; (3) it enables bitwise encryption without a large prime number that points to a different research direction of cryptography aimed at making prime-number-based cryptography and quantum factoring algorithm both obsolete; (4) it shows potential to bring quantum computing and communication closer to deterministic reality; (5) it leads to a unifying Q5 paradigm aimed at revealing the ubiquitous effects of bipolar quantum entanglement with the sub theories of logical, physical, mental, social, and biological quantum gravities and quantum computing.

This chapter is based on ideas presented in (Zhang 2003a, 2005a, Zhang 2009a,b,c,d; 2010).

Chapter 8. YinYang Bipolar Quantum Linear Algebra (BQLA) and Bipolar Quantum Cellular Automata (BQCA)

This chapter brings bipolar relativity from the logical and relational levels to the algebraic level. Following a brief review on traditional cellular automata and linear algebra, bipolar quantum linear algebra (BQLA) and bipolar quantum cellular automata (BQCA) are presented. Three families of YinYang-N-Element bipolar cellular networks (BCNs) are developed, compared, and analyzed; YinYang bipolar dynamic equations are derived for YinYang-N-Element BQCA. Global (system level) and local (element level) energy equilibrium and non-equilibrium conditions are established and axiomatically proved for all three families of cellular structures that lead to the concept of collective bipolar equilibrium-based adaptivity. The unifying nature of bipolar relativity in the context of BQCA is illustrated. The background independence nature of YinYang bipolar geometry is demonstrated with BQLA and BQCA. Under the unifying theory, it is shown that the bipolar dimensional view, cellular view, and bipolar interactive view are logically consistent. The algebraic trajectories of bipolar agents in YinYang bipolar geometry are illustrated with simulations. Bipolar cellular processes in cosmology, brain and life sciences are hypothesized and discussed.

This chapter is based on earlier chapters and the ideas presented in (Zhang 1996, 2005a, 200ba, Zhang 2009a,b,c,d, 2010; Zhang & Chen 2009; Zhang *et al.* 2009).

Chapter 9. Bipolar Quantum Bioeconomics for Biosystem Simulation and Regulation

As a continuation of Chapter 8, this chapter presents a theory of bipolar quantum bioeconomics (BQBE) with a focus on computer simulation and visualization of equilibrium, non-equilibrium, and oscillatory properties of YinYang-N-Element cellular network models for growing and degenerating biological processes. From a modern bioinformatics perspective, it provides a scientific basis for simulation and regulation in genomics, bioeconomics, metabolism, computational biology, aging, artificial intelligence, and biomedical engineering. It is also expected to serve as a mathematical basis for biosystem inspired socioeconomics, market analysis, business decision support, multiagent coordination and global regulation. From a holistic natural medicine perspective, diagnostic decision support in TCM is illustrated with the YinYang-5-Element bipolar cellular network; the potential of YinYang-N-Element BQCA in qigong, Chinese meridian system, and innate immunology is briefly discussed.

This chapter is based on earlier chapters and the ideas presented in (Zhang 1996, 2005a, 2006a, Zhang 2009a,b,c,d, 2010; Zhang & Chen 2009; Zhang *et al.* 2009).

Chapter 10. MentalSquares: An Equilibrium-Based Bipolar Support Vector Machine for Computational Psychiatry and Neurobiological Data Mining

While earlier chapters have focused on the logical, physical, and biological aspects of the Q5 paradigm, this chapter shifts focus to the mental aspect. MentalSquares (MSQs) − an equilibrium-based dimensional approach is presented for pattern classification and diagnostic analysis of bipolar disorders. While a support vector machine is defined in Hilbert space, MSQs can be considered a generic dimensional approach to support vector machinery for modeling mental balance and imbalance of two opposite but bipolar interactive poles. A MSQ is dimensional because its two opposite poles form a 2-dimensional background independent YinYang bipolar geometry from which a third dimension – equilibrium or non-equilibrium – is transcendental with mental fusion or mental separation measures. It is generic because any multidimensional mental equilibrium or non-equilibrium can be deconstructed into one or more bipolar equilibria which can then be represented as a mental square. Different MSQs are illustrated for bipolar disorder (BPD) classification and diagnostic analysis based on the concept of mental fusion and separation. It is shown that MSQs extend the traditional categorical standard classification of BPDs to a non-linear dynamic logical model while preserving all the properties of the standard; it supports both classification and visualization with qualitative and quantitative features; it serves as a scalable generic dimensional model in computational neuroscience for broader scientific discoveries; it has the cognitive simplicity for clinical and computer operability. From a broader perspective, the agent-oriented nature of MSQs provides a basis for multiagent data mining (Zhang & Zhang 2004) and cognitive informatics of brain and behaviors (Wang 2004).

This chapter is based on earlier chapters and the ideas presented in (Zhang 2007; Zhang, Pandurangi & Peace 2007; Zhang & Peace 2007)

Chapter 11. Bipolar Cognitive Mapping and Decision Analysis: A Bridge from Bioeconomics to Socioeconomics

The focus of this chapter is on cognitive mapping and cognitive-map-based (CM-based) decision analysis. This chapter builds a bridge from mental quantum gravity to social quantum gravity. It is shown that bipolar relativity, as an equilibrium-based unification of nature, agent and causality, is naturally the unification of quantum bioeconomics, brain dynamics, and socioeconomics as well. Simulated examples are used to illustrate the unification with cognitive mapping and CM-based multiagent decision, coordination, and global regulation in international relations.

This chapter is based on earlier chapters and the ideas presented in (Zhang, Chen & Bezdek 1989) (Zhang *et al.* 1992) (Zhang, Wang & King 1994) (Zhang & Zhang 2004) (Zhang 1996, 1998, 2003, 2005a,b, 2006a,b).

Chapter 12. Causality is Logically Definable: An Eastern Road toward Quantum Gravity

This is the conclusion chapter. Bertrand Russell's view on logic and mathematics is briefly reviewed. An enjoyable debate on bipolarity and isomorphism is presented. Some historical facts related to YinYang are discussed. Distinctions are drawn between BDL from established logical paradigms including Boolean logic, fuzzy logic, multiple-valued logic, truth-based dynamic logic, intuitionist logic, paraconsistent logic, and other systems. Some major comments from critics on related works are answered. A list of major research topics is enumerated. The ubiquitous effects of YinYang bipolar quantum entanglement are summarized. Limitations of this work are discussed. Some conclusions are drawn.

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Acknowledgment

Special thanks go to the anonymous reviewers who provided critical and/or constructive review comments on the first draft of this monograph. In particular, I acknowledge an expert reviewer in the field of quantum gravity who made authoritative and decisive judgment on the central theme of this book.

Special thanks go to Development Editor Joel Gamon at IGI Global for his effective and timely double-blind review and decision process.

I acknowledge all my co-authors of published or accepted article(s) in more than 20 years for their contributions in different aspects related to the chapters of this monograph. In particular, I acknowledge Professor Anand K. Pandurangi (MD), Professor Karl E. Peace, Professor Yan-Qing Zhang, Professor Zhongming Zhao, Professor Su-Shing Chen, Professor Yong Shi, Dr. Stefan Jaeger, Ms. Jane H. Zhang, Mr. Hongzhao Zang, Professor Paul P. Wang, and Professor Justin Zhan, who have been my co-authors of recent journal or conference article(s).

I acknowledge all anonymous reviewers who have been critical and/or constructive on accepted or unaccepted submissions related to this monograph in more than 20 years. Special thanks go to one authoritative anonymous reviewer who was antagonistic toward this line of research but unwilling to reveal his name for a public debate. The antagonistic attitude provided a surviving environment for this work to grow stronger and hopefully healthier.

I acknowledge all journal Editors who handled my submissions and provided review comments in the last 20+ years. In particular, I acknowledge Professor Roger Jean, Professor Lawrence O. Hall, Professor Toshiyo Tamura, Professor Yong Shi, Professor Henri Prade, Professor Hao Ying, Professor Anew P. Sage, Professor Andrew B. Whinston, Professor Petre Dini, Professor Ivan Stojmenovic, Professor Tao Yang, Professor Robert Kozma, Professor Guo-Zheng Li, Professor Mingyu You, Professor Dan Xi, Professor Xiaohua (Tony) Hu, Professor Paul P. Wang, and Professor Feiyue Wang for their positive review decisions on my related submissions. The accepted publications laid the groundwork for this monograph.

I acknowledge my former students in the College of Information Technology, Georgia Southern University, who took the computer science course CSCI 5436/5436G – Web Programming and Design in the summer of 2007. They helped me in the design and development of a software prototype for the illustrations in Chapter 10. Special thanks go to Mr. Wisley Howard, *2007 Student of the Year in Computer Science*, for his remarkable contribution to the coding and installation of the prototype.

I acknowledge my employer Georgia Southern University for my tenure and professorship that enabled me to conduct related research work and to write this monograph in addition to regular teaching. If one day YinYang bipolar relativity is accepted by the world scientific community, it should be alternatively called *A Georgia Southern University Interpretation of Nature, Agents, and Causality*.

Part 1
Introduction and Background

Chapter 1
Introduction:
Beyond Spacetime

ABSTRACT

This chapter serves as an introduction to bring readers from spacetime relativity to YinYang bipolar relativity. Einstein's assertions regarding physics, logic, and theoretical invention are reviewed and his hint of YinYang bipolar relativity is identified. The limitations of general relativity and quantum mechanics are briefly discussed. It is concluded that logically definable causality, axiomatization of physics, axiomatization of agent interaction, and the grand unification of general relativity and quantum theory are essentially the same problem at the fundamental level. A paradox on Hilbert's Problem 6—Logical Axiomatization for Illogical Physics (LAFIP)—is introduced. Bipolarity is postulated as the most fundamental property of nature transcending spacetime. The theoretical basis of agents, causality and YinYang bipolar relativity is highlighted and distinguished from established theories. The main ideas of the book are outlined.

(Note: In this book we refer to relativity theories defined in spacetime geometry as spacetime relativity. Thus, all previous relativity theories by Galileo, Newton, Lorenz, and Einstein belong to spacetime relativity. This terminological treatment is for distinguishing YinYang bipolar geometry from spacetime.)

INTRODUCTION

Ever since Aristotelian science was established together with Aristotelian bivalent truth-based syllogistic (or classical) logic 2300 years ago, scientists have been devoting their lifetime efforts to the noble cause of seeking truths from the universe. Boolean logic (Boole, 1854) reinforced the truth-based tradition and

DOI: 10.4018/978-1-60960-525-4.ch001

eventually led to modern digital computer technologies that, in turn, significantly extended the reach of scientific explorations by mankind into both macroscopic and microscopic *agent* worlds.

Scientific explorations, unfortunately, have not been able to escape the delicate balance of Mother Nature. In the microscopic agent world, the painstaking quest for *quantum gravity*—Einstein's unfinished unification of general relativity and quantum mechanics—has so far failed to find a decisive battleground (Smolin, 2006; Woit, 2006); quantum entanglement remains a mystery (Penrose, 2005, p. 591) that is hindering the development of quantum computers; mental equilibrium and disorders are unexplained at the neurobiological and neurophysiologic levels; and, despite one insightful surprise after another that the genome has yielded to biologists, the primary goal of the Human Genome Project—to ferret out the genetic roots of common diseases like cancer and Alzheimer's and then generate treatments—has been largely elusive (Wade, 2010). In the macroscopic agent world, "big bang" so far came from nowhere and was caused by nothing to our knowledge; economic recession has been a recurring problem; and global warming is threatening the very existence of human civilization including the scientific establishment itself.

Conceivably, truth is subjected to observability and limited to certain spacetime but equilibrium or non-equilibrium, as a central concept of thermodynamics—the ultimate physical source of existence, energy, life, and information, is ubiquitous and ruthless. Despite the proven incompleteness of truth-based reasoning (Gödel, 1930) and the mounting evidence for action-reaction forces, negative-positive electromagnetic charges, matter-antimatter particles, mental depression and mania, economic recession and expansion, genomic repression and activation, social competition and cooperation, global cooling and global warming, big bang and black holes, or Yin and Yang of nature in general that overwhelmingly suggest a *bipolar equilibrium-based universe* (including equilibrium and non-equilibrium states), few scientists have asked the difficult question: *Whether the universe is actually truthful and whether the truth-based tradition is adequate for furthering scientific explorations?*

A central theme of this book is that the universe is not truthful but bipolar. This theme leads to a paradox on Hilbert's Problem 6—*"Axiomatize all of Physics"* (Hilbert, 1901). The paradox states: *"Logical Axiomatization for Illogical Physics"* (*LAFIB* or *LAFIP*) (Zhang, 2009a, 2009b, 2009c, 2009d). LAFIP manifests the inconvenient truth that truth-based logical reasoning is inadequate for axiomatizing the illogical aspects of physics. This monograph is, therefore, not for seeking truth from the universe but for resolving the LAFIP paradox in modern science. The resolution to be presented is *YinYang bipolar relativity* which is shown to be a deeper unifying logical foundation transcending spacetime and *spacetime relativity* including relativity theories by Galileo, Newton, Lorenz, and Einstein.

In front of the historical giants of science and philosophy, every living scientist or philosopher is entitled to feel humble and respectfully follow the established scientific tenet. No wonder the editor of an influential logic journal once posted a slogan on his website that read *"Never Question the Logic of Aristotle."* Evidently, this editor became "too humble" to realize that at Aristotle's time air and water were deemed the most fundamental elements and the Earth was believed the center of the universe; Copernicus would have not been able to discover the solar system had he not questioned Aristotle's cosmology and Einstein would have not been able to develop his general theory of relativity had he not questioned Aristotle's ether theory.

Despite his great contribution to science and philosophy, Aristotle's logic as well as his philosophy was inevitably subjected to the scientific and technological limitations at his time. For instance, while Aristotle's causality principle has been widely considered the doctrine of all sciences for more than two thousand years, the principle, however, is irreducible to regularity as asserted by 18th century Scottish

- **General Relativity and Quantum Theory.** This section discusses the incomplete nature of general relativity and quantum theory.
- **Logical Axiomatization for Illogical Physics (LAFIP).** This section identifies the limitation of truth-based cognition and characterizes it with the LAFIP paradox.
- **Observation and Postulation.** This section introduces equilibrium-based cognition and bipolar agents, identifies *nature's most fundamental property*, and introduces the basic concept of YinYang bipolar geometry *beyond spacetime*.
- **Book Overview.** This section presents an outline of the monograph.
- **Summary.** This section summarizes the major points in the chapter and draws a few conclusions.

EINSTEIN AND YINYANG BIPOLAR RELATIVITY

Regardless of the great achievement of Western science, without logically definable causality, it can be argued that Western science is an incomplete and evolving science. Actually, the incomplete and evolving nature was already elaborated by Einstein. According to him:

Physics constitutes a logical system of thought which is in a state of evolution, whose basis (principles) cannot be distilled, as it were, from experience by an inductive method, but can only be arrived at by free invention. The justification (truth content) of the system rests in the verification of the derived propositions (a priori/logical truths) by sense experiences (a posteriori/empirical truths). ... Evolution is proceeding in the direction of increasing simplicity of the logical basis (principles). .. We must always be ready to change these notions – that is to say, the axiomatic basis of physics – in order to do justice to perceived facts in the most perfect way logically. (Einstein, 1916)

Regarding reality, experience, and human thought, Einstein pointed out that

If, then, it is true that the axiomatic basis of theoretical physics cannot be extracted from experience but must be freely invented, can we ever hope to find the right way? Nay, more, has this right way any existence outside our illusions? Can we hope to be guided safely by experience at all when there exist theories (such as classical mechanics) which to a large extent do justice to experience, without getting to the root of the matter? I answer without hesitation that there is, in my opinion, a right way, and that we are capable of finding it. Our experience hitherto justifies us in believing that nature is the realization of the simplest conceivable mathematical ideas. I am convinced that we can discover by means of pure mathematical constructions the concepts and the laws connecting them with each other, which furnish the key to the understanding of natural phenomena. Experience may suggest the appropriate mathematical concepts, but they most certainly cannot be deduced from it. Experience remains, of course, the sole criterion of the physical utility of a mathematical construction. But the creative principle resides in mathematics. In a certain sense, therefore I hold it true that pure thought can grasp reality, as the ancients dreamed. (Einstein, 1934)

Regarding the next unification Einstein stated:

There is an old saying: *"Difference in profession makes one feel world apart."* That is still true in modern days. As a computer scientist, the author didn't pay much attention to the advances in physics until late 2008 and early 2009.

There were two remarkable events in 2008. One was the Nobel Prize in Physics. Japanese American physicist Yoichiro Nambu shared the Prize with Japanese physicists Makoto Kobayashi and Toshihide Maskawa *"for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics"* (The Royal Swedish Academy of Sciences, 2008). According to the press release, it was their *"passion for symmetry"* that permeated *"the Standard Model of elementary particle physics"* and unified *"the smallest building blocks of all matter and three of natures four forces in one single theory"* (The Royal Swedish Academy of Sciences, 2008).

The impact of the 2008 Nobel Prize is far reaching because bipolar dynamic equilibrium and non-equilibrium or symmetry and broken-symmetry form the theoretical basis of the oldest Eastern YinYang philosophy that is well-known to the world and has been extremely pervasive in all fields of physical and social science in the West as well as in the East especially in Japan. In this regard, 1949 Nobel Laureate Japanese Physicist Hideki Yukawa once said: *"You see, we in Japan have not been corrupted by Aristotle"* (Rosenfeld, 1963).

Another remarkable event in 2008 was a report on the speed of quantum entanglement. A quantum physics experiment performed in Geneva, Switzerland, determined that the *"speed" of the quantum non-local connection* or *quantum entanglement* what Einstein called *"spooky action at a distance"* has a minimum lower bound of 10,000 times the speed of light (Salart et al., 2008). Thus, the geometry of a logical foundation for physics has to transcend spacetime because spacetime has been based on the hypothesis that no speed could go beyond the speed of light.

With well-observed space expansion and quantum entanglement, it is easy to assert that space and time cannot serve as the most fundamental properties of a quantum universe. Instead, the most fundamental property has yet to be determined that would cause space expansion and the minimum lower bound of 10,000 times the speed of light. Consequently, in order to achieve the grand unification of general relativity and quantum mechanics, spacetime relativity has to be superseded and science has to advance beyond spacetime geometry.

Since strong and weak forces have been unified with electromagnetic force per 2008 Nobel Prize in Physics, gravitational and electromagnetic forces can be considered nature's two basic forces that can be denoted as action-reaction forces *(-f,+f)* and negative-positive electromagnetic forces *(-q, +q)*, respectively. On the other hand, particles and antiparticles are the only known tangible stuff in the universe that form a broken symmetry or quasi-equilibrium denoted *(-p, +p)*. Evidently, all nature's basic forces and subatomic particles are bipolar in nature. Consequently, it is natural to ask the question: *If nature cannot be the realization of space and time could the universe including spacetime be the realization of YinYang bipolar relativity?*

Understandably, the road to YinYang bipolar relativity has been and has to be "an odd path." The author did not select the path intentionally but was destined to "hit" the road accidentally and to stumble upon the uncharted territory. He has no choice but to face the challenges in writing this monograph with a trembling heart yearning for falsifiability and fear of humiliation.

The title *"YinYang Bipolar Relativity"* tells readers that the book is about the relativity of the two poles or the interactive energies of nature that are conceptualized as the Yin and Yang in general. The word *"YinYang"* indicates that the main idea is philosophically rooted in the ancient Chinese cosmology. On the one hand, it symbolizes the holistic reciprocal interactive nature of the two poles of an agent to

nature and inadequate for axiomatizing physics. The bivalent limitation could be the fundamental reason why there is so far no truth-based logical axiomatization for physics, no logically definable causality, and no grand unification.

From a set-theoretic perspective, the truth-based limitation can be attributed to the principle of mathematical abstraction in classical set theory. The principle states that the concept of element in a set is self-evident without the need for proof. In addition, it is commonly interpreted that the properties of a set are independent of the nature of its elements. This principle is so fundamental in information and computation that it is rarely challenged and commonly considered *"unquestionable."* It can be argued, however, that:

1. If an element is a bipolar equilibrium-based agent, it can be particle or wave, static or dynamic, linear or non-linear, orderly or disorderly, generous or greedy, and logical or illogical that can't be simply characterized as true or false.
2. The property of a set of bipolar equilibria could be physically dependent on the property of its elements.

For instances, with quantum entanglement a split photon can be in two places at the same time; a subatomic particle can change polarity trillion times per second (Fermilab, 2006); some genetic agent exhibits YinYang bipolar repression-activation abilities in gene expression regulation (Shi *et al.,* 1991); the bipolar interactive cellular nature of Yin and Yang are essential in synthetic biology (Gore & van Oudenaarden, 2009); a bipolar disorder can be oscillatory or mixed (American Psychiatric Association, 2000); two competitor agents can also be cooperative. We need syntactic and semantic representations for these seemingly "illogical" but nevertheless physical or natural phenomena for scientific logical solutions such as medicine for mental disorders, particle-wave duality for quantum mechanics, gene expression regulation for genomics, agent emotion modeling for mental health, and axiomatization of agent interactions or axiomatization of physics.

With classical mathematical abstraction and truth-based logic, however, we have the 3-fold dilemma:

1. If we treat each pole of a bipolar equilibrium or non-equilibrium as a self-evident element we will lose holistic bipolar fusion, binding, coupling, or quantum entanglement.
2. If we treat a bipolar equilibrium or non-equilibrium as a self-evident element its membership in a set can only be true or false where polarity cannot be represented.
3. If we preserve the independence rule between a set of equilibria and its elements we will not be able to link the global equilibrium/non-equilibrium to local ones.

Due to the 3-fold dilemma, classical set theory and truth-based logic provide no operation for equilibrium-based bipolar fusion, interaction, oscillation, symmetry, and quantum entanglement. This can be further illustrated with some intuitive examples.

Example 1. (a) How can depression, mania, mental equilibrium, and eternal equilibrium (or brain death) be directly characterized with logical values? How can the negative effect, positive effect, balancing effect, and deadly side effect of a bipolar disorder medicine be characterized with logical expressions? *(b)* A depressed patient took a positive antidepressant drug and regained mental equilibrium; a second patient took the same drug but became manic; a third patient took the drug and died of side effect; patients in deep depression tend to become suicidal. How to characterize the neurobiological reactions

Index

A

agent emotion modeling 118, 124
agitated depression 332
Alzheimer's 2
Aristotelian science 45, 62
Aristotle 2, 3, 6, 8, 9, 11, 13, 16, 17, 18, 34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 53, 54, 56, 58, 59, 60, 62, 63, 66
artificial intelligence (AI) 33, 36, 98, 118, 161, 162, 266, 272, 293

B

bi-directional graph (bigraph) 339, 348, 349, 350, 353
big bang 40, 41, 42, 55, 163, 168, 170, 174, 175, 176, 182, 184, 185, 186, 257, 258, 259, 299, 303
binary YinYang 368
bio-agent regulation 281
bioeconomics (BE) 266, 267, 268, 269, 270, 271, 272, 273, 274, 280, 281, 288, 291, 293, 297
bioinformatics 160, 161, 178, 180, 182, 185
biomedical engineering 266, 272, 288, 293
biosystem inspired socioeconomics 266, 293
biosystem simulation 280, 296
bipolar adaptivity 160, 161, 166, 177, 188
bipolar agents 232, 233, 234, 240, 253, 254, 255, 261, 299, 328
bipolar atoms 71
bipolar axioms (BA) 78
bipolar causality 232, 233, 240, 253, 254, 261
bipolar cellular networks (BCNs) 232, 233, 234, 237, 240, 245, 248, 249, 261
bipolar clustering 129, 130, 144, 154, 156
bipolar coexistence 121
bipolar cognitive mapping 334, 337, 338, 354, 355, 358, 360
bipolar decision analysis 358
bipolar disorder (BPD) 71, 93, 298, 299, 300, 301, 315, 318, 319, 320, 322, 327, 328, 329, 330, 332
bipolar dynamic environments 97
bipolar dynamic fuzzy logic (BDFL) 97, 99, 100, 102, 103, 121, 124, 127, 160, 166, 170, 232, 253
bipolar dynamic logic (BDL) 65, 66, 67, 69, 70, 71, 75, 77, 78, 80, 81, 82, 91-97, 104, 121, 124, 126, 128, 130, 154, 155, 157, 160, 164, 166, 167, 170, 171, 183, 184, 187, 192, 194, 198, 208, 211, 213, 215, 217, 220, 221, 222, 223, 225, 226, 229, 232, 233, 253, 254, 256, 257, 258, 261, 267, 270, 272, 289, 296, 321, 323
bipolar equilibria 98, 101, 103, 106, 111, 123
bipolar equilibrium 65, 66, 67, 68, 69, 71, 76, 77, 81, 90, 93, 94, 269, 270, 271, 280, 281, 291, 292, 297, 299, 300, 301, 302, 303, 306, 310, 313, 317, 320, 321, 332
bipolar equilibrium-based quantum entanglement 371
bipolar fusion 108, 122, 124, 301, 303, 305, 312
bipolar fuzzy clustering 129, 145, 149, 154
bipolar fuzzy CMs 352, 359
bipolar fuzzy relation 129, 131, 132, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 147, 149, 158
bipolar fuzzy sets 129, 130, 154, 155, 156, 371, 373, 379, 380, 393

bipolar geometry 160, 161, 173, 174, 175, 186, 194
bipolarity 363, 364, 365, 366, 367, 372, 373, 375, 376, 378, 379, 380, 381, 383, 385, 386, 387, 389, 390
bipolar lattices 237, 263
bipolar logic 8, 31
bipolar L-sets 378
bipolar nanomedicine 321
bipolar neurobiological data mining 299
bipolar partitioning laws 342
bipolar quantum bioeconomics (BQBE) 266, 267, 268, 270, 271, 272, 280, 287, 288, 289, 291, 292, 297, 333
bipolar quantum cellular automata (BQCA) 232, 233, 234, 237, 239, 240, 250, 251, 253, 254, 255, 256, 257, 258, 260, 261, 264, 266, 267, 268, 271, 273, 274, 280, 281, 284, 286, 287, 288, 289, 290, 291, 292, 293, 297
bipolar quantum controllability 213, 218, 219
bipolar quantum entanglement 363, 372, 374, 376, 377, 378, 379, 382, 386, 387, 394
bipolar quantum fuzzy lattice (BQFL) 99, 127
bipolar quantum lattice (BQL) 97, 98, 99, 100, 101, 106, 110, 122, 124, 127, 128, 130, 232
bipolar quantum linear algebra (BQLA) 232, 233, 237, 239, 240, 241, 244, 247, 248, 251, 253, 254, 260, 261, 264, 267, 271, 273, 274, 280, 286, 288, 289, 290, 291, 293, 297, 372, 388
bipolar quantum tensor calculus (BQTC) 261, 388, 394
bipolar qubits 195, 197, 198, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 230
bipolar relativity 1-9, 16, 18, 20-26, 31, 33, 160, 161, 162, 168-189, 192, 194, 232, 233, 234, 239, 240, 253, 254, 256, 259, 261, 299, 300, 304, 305, 313, 323, 326, 328, 332, 333, 334, 337, 338, 345, 355, 356, 358, 359
bipolar sets 68, 85, 90, 93, 129, 130, 134, 155, 232, 237, 240
bipolar set theory 233, 254, 261
bipolar strings 209, 210, 225
Bipolar Support Vector Machine (BSVM) 300, 332
bipolar synchronization 213, 218, 220, 223, 226
bipolar tautology 73, 76, 78, 79, 80
bipolar theorem 73
bipolar transistor logic 8
bipolar transitive closure (BTC) 130
bipolar universal modus ponens (BUMP) 65, 66, 74-82, 90, 93, 96, 98, 99, 100, 103, 113, 116-120, 123, 124, 208, 217, 225, 226, 270, 302, 307-316, 321, 365, 367, 369, 370, 374, 375, 377, 379, 380, 382, 383, 385, 386, 389
black holes 2, 8, 19, 40, 41, 42, 55, 163, 174, 175, 176, 182, 185, 257, 258, 259, 299
Boolean logic 1, 3, 65, 66, 71, 93, 199, 223, 363, 367, 368, 372, 374, 376, 378, 381, 383, 386, 387, 388, 394
brain dynamics 299, 300, 328, 331, 332, 333, 334, 358, 359
broken energy equilibrium 240
broken energy symmetry 240, 252, 256
business decision support 266, 292, 293

C

cancer 2
causality 34, 35, 36, 37, 38, 41, 42, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58, 59, 60, 63, 160, 161, 163, 167, 168, 169, 170, 172, 173, 174, 182, 183, 184, 185, 187, 188, 194
cause-effect relationship 370
cellular automata 232, 233, 234, 235, 236, 237, 240, 261, 262, 263, 264
cellular automaton 234, 235, 236, 263, 264
Chinese Meridian 295, 297
classical set theory 66
closed world 281
CM-based multiagent decision 333
cognitive informatics 34, 37, 57, 161, 173, 177, 188
cognitive-map-based (CM-based) 333, 334, 335, 337, 339, 358

cognitive mapping 333, 334, 335, 336, 337, 338, 339, 354, 355, 358, 359, 360
cognitive maps (CMs) 333, 334, 335, 336, 337, 338, 339, 340, 341, 346, 348, 352, 353, 355, 358, 359, 360, 361
complex bipolar quantum linear algebra (CBQLA) 388, 394
complex number 388, 394
computational biology 266, 272, 293
computational neuroscience 298, 299, 300, 301, 302, 303, 304, 321, 328, 331
conceptual cognitive maps (CCMs) 140, 334, 335, 337, 339, 355, 358, 361
Copernicus 2
crisp CM 352

D

data mining 113, 118, 124
decision analysis 333, 336, 341, 354, 358, 359, 360, 361
defuzzification 130, 134, 137, 138, 140, 141, 154
depolarization 130, 134, 138, 140, 141, 154
Diagnostic and Statistical Manual of Mental Disorders version IV (DSM IV) 301, 332
directed graph (digraph) 339, 351
DL (Dynamic logic) 373, 394
dysphoric mania 318, 332

E

Einstein, Albert 1-11, 17, 18, 20, 21, 22, 25, 26, 27, 29, 34, 36-44, 48, 49, 54, 56, 57, 58, 63, 160, 168, 174, 176, 182, 183, 186, 196, 210, 224, 227
electrical engineers 3
electromagnetism 160, 161, 182, 186, 187
element zero (E0) 285
energy equilibrium 232, 234, 240, 242, 243, 244, 248, 249, 251, 252, 256, 260, 261
energy symmetry 240, 242, 252, 256
entanglement 363, 366, 368, 371, 372, 374, 375, 376, 377, 378, 379, 380, 381, 382, 386, 387, 389, 394
EPR paradox 34, 35, 41, 44, 196, 197, 201, 208, 210, 211, 226
equilibrium 232, 233, 234, 237, 2390244, 248, 249, 251, 252, 254-261, 263, 298-321, 323-328, 331, 332
equilibrium energy 131, 153
equilibrium laws (ELaws) 342
event-related potential/electroencephalography (EPR/EEG) 299, 336, 337, 358

F

FOUR 367, 368, 369, 372, 374, 375
functional magnetic resonance imaging (fMRI) 299, 334, 336, 337, 355
fuzzy clustering 356, 358
fuzzy CMs (FCMs) 352, 359
fuzzy equilibrium laws 143
fuzzy lattice 97, 99, 101, 102, 103, 104, 110, 112, 113, 115, 121, 124
fuzzy logic 3, 16, 24, 25, 31, 97, 99, 100, 101, 102, 103, 110, 119, 121, 122, 127, 363, 367, 373, 374, 392, 394
fuzzy set community 365, 371, 373, 374, 380
fuzzy sets 129, 130, 137, 146, 154, 155, 156, 371, 373, 378, 379, 380, 390, 391, 393
fuzzy set theory 98, 100

G

Galileo 1, 2, 16, 40, 54
genomics 266, 293
global equilibrium 276, 277, 280, 284
global regulation 118, 123, 126, 129, 130, 131, 153, 154, 156, 158, 266, 272, 290, 292, 293, 333, 334, 335, 336, 337, 353, 358, 360
global warming 2
Gödel, Kurt 65, 66, 90, 91, 92, 93
graphical user interface (GUI) 137, 256, 279
growing processes 279

H

homomorphism 366, 394
Human Genome Project 2
Hume, David 3, 26, 34, 36, 37, 45, 46, 47, 48, 56, 57, 59

I

incompleteness theorem 65, 66, 91, 92, 93
international relations 333, 334, 335, 336, 348, 353, 354, 358, 359, 360
intuitionist logic 363
isomorphism 363, 364, 365, 366, 367, 370, 373, 388, 394

J

Jingluo 288, 289, 292, 293, 297

K

knowledge representation (KR) 365

L

lattice quantum chromodynamics (lattice QCD) 98
law of excluded middle (LEM) 71, 96, 110, 119, 369, 374, 376, 377, 380
life sciences 34, 37, 50, 57
linear spaces 237
linear transformations 237
local equilibrium 347
Logical Axiomatization for Illogical Physics (LAFIP or LAFIB) 1, 2, 3, 4, 11, 13, 20, 23, 24, 26, 33, 65, 66, 69, 93, 197, 199, 214, 215, 223, 240, 302, 372, 377, 378
logical paradigms 363
logical systems 65

M

market analysis 266, 293
mental big bang 299
mental quantum gravity 299, 333, 337
MentalSquares (MSQs) 298, 300, 304, 305, 316, 318, 320, 321, 322, 324, 326, 327, 328
metabolism 266, 272, 288, 293
mixed episode 332
mixed state 318, 319, 320, 332
modern science 37, 38, 42, 43, 50, 57
modus ponens (MP) 367, 370, 382, 383, 389
multiagent coordination 266, 272, 292, 293
multiagent macroeconomics 129, 130, 154
multidimensional equilibria 303
multiple-valued logic 363, 369, 390

N

nanotechnology 321
nearest neighbors 235
neurobiological data 299, 300, 316, 323, 328, 331, 332
neurobiological data mining 118
neurobiological universe 299
neurodynamics 160, 168
Newton, Isaac 1, 2, 3, 7, 38
non-equilibria 303, 306
non-equilibrium 232, 233, 234, 237, 239, 240, 241, 243, 244, 248, 251, 252, 254, 256, 258, 259, 261, 263, 266, 268-274, 279, 281, 282, 285, 286, 287, 289, 293, 296, 297, 298, 299, 301, 306, 314, 319, 321, 327, 328, 334, 338
non-equilibrium analysis 243
non-linear dynamic polarization 374
null law 112, 113, 114, 115

O

online analytical mining (OLAM) 336, 340, 346, 348, 359
online analytical processing (OLAP) 336, 340, 346, 348, 359
open world assumption 281

P

paraconsistent logic 363, 369, 394
paraconsistent logic FOUR 369
partial equilibrium 347
pathogen-associated molecular patterns (PAMPs) 291
pathogen recognition receptors (PRRs) 291
p-conorms 115, 116, 117, 124
Plato 34, 42, 43, 44, 60, 62, 63
p-norms 99, 113, 114, 116, 117, 120, 124
positive elements 67
psychiatric drug therapy 118

Q

Qi 272, 273, 274, 279, 290, 292, 293
QiGong 293

quantum bioeconomics 333, 358
quantum bit (qubit) 195, 197-206, 211-226, 230
Quantum Cellular Automata (QCA) 232, 233, 235, 236, 237, 262, 263, 264
quantum cellular automaton 236, 263
quantum computing 195, 196, 197, 198, 199, 202, 205, 207, 208, 213, 215, 218, 220, 221, 222, 223, 224, 225, 226, 229, 230, 231
quantum cryptography 202, 218, 221, 223, 225
quantum electrodynamics (QED) 8, 20, 27, 67, 94, 106, 107, 125, 364, 385, 391
quantum entanglement 34, 35, 36, 37, 40, 49, 50, 51, 53, 54, 56, 61
quantum lattices 129
quantum mechanics 160, 161, 163, 167, 171, 173, 174, 182-187, 196-201, 207, 208, 211-216, 224, 226, 227, 230, 231, 321, 323, 332
quantum teleportation 195, 197, 198, 201, 202, 208, 214, 217, 218, 219, 220, 221, 225, 226, 228
quantum theory 161, 163, 184, 188, 189, 192, 195, 196, 197, 198, 207, 211, 223, 224, 225, 227, 229

R

rebalancing 273, 275, 276, 281, 282, 284, 285, 287, 288, 289, 290
relativity theories 1, 2
robot pet therapy 118

S

Schrödinger, Erwin 195, 198, 201, 215, 225, 226, 228
Schrödinger's cat 195, 198, 215, 225, 226
secret agents 162
social dynamics 293
social quantum gravity 333
social world 34, 37, 57
socioeconomics 160, 161, 163, 167, 173, 174, 181, 182, 186, 187, 188, 266, 270, 272, 293, 333, 334, 358, 359
Socrates 62
software engineering 33
spacetime relativity 1, 2, 3, 5, 6, 7, 19, 20, 22
superdense coding 201
superintelligence 42
Support Vector Machine (SVM) 300, 301, 332

T

Taiji 371
t-conorms 98, 99, 115, 116, 117, 118, 124, 127, 128
theory of everything 162, 163, 172, 185, 188
thermodynamics 206
Toll-like receptor (TLR) 291
traditional Chinese medicine (TCM) 38, 50, 51, 241, 244, 245, 246, 250, 254, 259, 260, 261, 262, 263, 264, 266, 267, 268, 272, 273, 274, 279, 280, 281, 282, 287, 288, 289, 290, 293, 294, 295, 296
triangular norms (t-norms) 97, 98, 99, 113, 114, 116, 117, 118, 119, 120, 124, 125, 127
truth 363, 364, 366, 367, 369, 370, 372, 373, 374, 375, 376, 377, 378, 380, 381, 382, 383, 384, 387, 388, 389, 390, 394
truth-based dynamic logic 363

U

unification 333, 334, 358, 361
unipolar fuzzy lattice 97, 103
unipolar theorem 73
US National Institute of Mental Health (NIMH) 118

V

visual cognitive maps (VCMs) 140, 334, 335, 337, 355, 358, 361

W

WuXing 268, 272, 273, 274, 276, 277, 292, 293

Y

YinYang1 (YY1) 233, 244, 263
YinYang bipolar agents 160
YinYang bipolar geometry 160, 161, 173, 174, 175, 186, 194, 232, 233, 234, 254, 261