The Unreal Universe
A Study in Applied Spirituality

Manoj Thulasidas

1 Overview and Reasons for Writing

We know that our universe is a bit unreal. The stars we see in the night sky, for instance, are not really there. They may have moved or even died by the time we get to see them. This delay is due to the time it takes for light from the distant stars and galaxies to reach us. We know of this delay.

The same delay in seeing has a lesser known manifestation in the way we perceive moving objects. It distorts our perception such that something coming towards us would look as though it is coming in faster. Strange as it may sound, this effect has been observed in astrophysical studies. Some of the heavenly bodies do look as though they are moving several times the speed of light, while their "real" speed is probably a lot lower.

Now, this effect raises an interesting question–what is the "real" speed? If seeing is believing, the speed we see should be the real speed. Then again, we know of the light travel time effect. So we should correct the speed we see before believing it. What then does "seeing" mean? When we say we see something, what do we really mean? Cognitive neuroscience (which studies the biological mechanisms behind cognition) answers these questions, and these answers may surprise you.

From the perspective of cognitive neuroscience, everything we see, sense, feel and think is the result of the neuronal interconnections in our brain and the tiny electrical signals in them. This view must be right. What else is there? All our thoughts and worries, knowledge and beliefs, ego and reality, life and death–everything is merely neuronal firings in the one and half kilograms of gooey, grey material that we call our brain. There is nothing else. Nothing!

Space and time are also cognitive constructs in our brain, like everything else. They are mental pictures our brains concoct out of the sensory inputs that our senses receive. Generated from our sensory perception and fabricated by our cognitive process, the space-time continuum is the arena of physics. Of all our senses, sight is by far the dominant one. The sensory input to sight is light. In a space created by the brain out of the light falling on our retinas (or on the photo sensors of the Hubble telescope), is it a surprise that nothing can travel faster than light?

This philosophical stance is the basis of my book The Unreal Universe, which explores the common threads binding physics and philosophy. Such philosophical musings usually get a bad rap from us physicists. To physicists, philosophy is an entirely different field, another silo of knowledge. We need to change this belief and appreciate the overlap among different knowledge silos. It is in this overlap that we can expect to find breakthroughs in human thought.

This philosophical grand-standing may sound presumptuous and the veiled self-admonition of physicists understandably unwelcome; but I am holding a trump card. Based on this philosophical stance, I have come up with a radically new model for two astrophysical phenomena, in an article titled, "Are Radio Sources and Gamma Ray Bursts Luminal Booms?" and got it published in the well known International

Journal of Modern Physics D in June 2007 (Vol. 16, No. 6 (2007) 983-1000), which soon became one of the top accessed articles of the journal by Jan 2008. This article is a direct application of the view that the finite speed of light distorts the way we perceive motion. Because of these distortions, the way we see things is a far cry from the way they are.

The twist to this story is that we seem to have known all this for a long time. The role of light in creating our reality or universe is at the heart of Western religious thinking. A universe devoid of light is not simply a world where you have switched off the lights. It is indeed a universe devoid of itself, a universe that doesn't exist. It is in this context that we have to understand the wisdom behind the statement that "the earth was without form, and void" until God caused light to be, by saying "Let there be light."

The Quran also says, "Allah is the light of the heavens and the earth," which is echoed in one of the ancient Hindu writings: "Lead me from darkness to light, lead me from the unreal to the real." The role of light in taking us from the unreal void (the nothingness) to a reality was understood for a long, long time. Is it possible that the ancient saints and prophets knew things that we are only now beginning to uncover with all our supposed advances in knowledge?

I know I may be rushing in where angels fear to tread, for reinterpreting the scriptures is a dangerous game. Such foreign interpretations are seldom welcome in the theological circles. But I seek refuge in the fact that I am looking for concurrence in the metaphysical views of spiritual philosophies, without diminishing their mystical or theological value.

This time-tested wisdom on the nature of reality from the repertoire of spirituality is now mirrored in modern neuroscience, which treats reality as a cognitive representation created by the brain. The brain uses the sensory inputs, memory, consciousness, and even language as ingredients in concocting our sense of reality. This view of reality, however, is something physics is yet to come to terms with. But to the extent that its arena (space and time) is a part of reality, physics is not immune to philosophy.

The Unreal Universe examines these interconnections among different branches of human knowledge and applies them to the philosophical foundations of physics. Once identified, they helped me understand how physics is limited by our perception, why space and time behave the way they do and why the speed of light is so fundamental in our reality. It also explained why Zen Buddhism considers our mind an impediment to grasping the nature of reality and provided an interpretation for the *Brahman-Maya* distinction in the Indian philosophy of *Advaita*. Everything began to fall in place like a jigsaw puzzle, both in science and philosophy. It is this excitement in rediscovering and bridging large domains of knowledge using this new found insight that I strive to share with my readers. To the best of my knowledge, nobody has applied a philosophical or spiritual notion of reality to understand physics (or physics to understand spirituality) in such a direct fashion. Recognizing and making use of the interconnections among the different domains of human endeavour may be the catalyst for the next breakthrough in our collective wisdom that we have been waiting for.

2 Testimonials

Wendy Lochner (Senior Executive Editor for Religion, Philosophy and Animal Studies at Columbia University Press) calls *The Unreal Universe* a good read and says, "It's well written, very clear to follow for the nonspecialist." She can be reached at wl2003@columbia.edu.

Bobbie Christmas (author of *Write In Style,* owner of Zebra Communications, editor, ghostwriter, book doctor, copywriter, consultant, seminar and workshop leader) copy edited *The Unreal Universe.* Describing it as "such an insightful and intelligent book," she says, "A book for thinking laymen, this readable, thought-provoking work offers a new perspective on our definition of reality."

Steven Bryant (author of The Relativity Challenge, Vice President at Primitive Logic, San Francisco, CA) says, "Manoj's conveys a deep understanding of the interaction of our physics, human belief systems, perceptions, experiences, and even our languages, on how we approach scientific discovery. His work will challenge you to rethink what you think you know is true."

The physics ideas in the book appeared in an article published in the prestigious International Journal of Modern Physics–D under the title, "*Are Radio Sources and Gamma Ray Bursts Luminal Booms?*" This article soon became one of the top accessed papers in the journal.

3 Manuscript Information

Title

Working Title:	The Unreal Universe
Subtitle:	A Study in Applied Spirituality

Status and Availability

Manuscript:	Copy edited draft available
Copy edited by:	Bobbie Christmas (Zebra Communications, Woodstock, GA)

Level of Presentation

Genre:	Non-fiction: philosophy, religion, science.
Readership:	Educated public, students of philosophy and physics.
Subject discipline:	Inter-disciplinary: Philosophy and spirituality, physics and neuroscience.

Size and Format

Word count:	67,000 words (including preface, introduction, figure captions, tables, glossary and bibliography)
Page count:	284 manuscript pages including six embedded tables.
Number of figures:	15 (12 diagrams & 3 gray-scale images)
Text-processor:	LaTeX
Submission formats:	LaTeXfiles, Text files, Word or PDF format.

4 Readership and Marketing Information

The Unreal Universe targets the students of philosophy, religion (especially Eastern religions) as well as physics, who are interested in the philosophical and spiritual basis of science. The interplay between spiritual philosophy and science holds a fascination to the general public. Their curiosity is at its highest when it comes to the workings of the brain and how they are reflected both in physics and philosophy. For this reason, the book uses intriguing examples from neuroscience to examine the fundamental concepts of time and space, and our sense of reality in general, highlighting the link between the Eastern spiritual philosophy and neuroscience.

As a regular columnist for the popular Singapore newspaper *Today*, and the London based quantitative finance publication *Wilmott Magazine*, I already have a small fan base that enjoys my style of writing. If published, I plan to take full advantage of this channel to promote my book.

I self-published *The Unreal Universe* in early 2007 and distributed in Singapore. It was well received in the media. The national newspaper of Singapore, The Straits Times, called it a "sizzling read" of June, and lauded its readable and conversation style. It recommended the book to anybody who wanted to learn about life, the universe and everything. The book sold about 200 copies (out of the 1000 I printed) in six months.

The physics work presented in the book was published in the prestigious International Journal of Modern Physics – D in June 2007. It soon became the top accessed article of the journal by January 2008. The philosophical arguments in the book have also been published in the Indian Journal of Science and Spirituality. Both articles refer to the book. Other articles have either been accepted for publication or are under review.

The role of religion, spirituality and philosophy in science is the focus of attention of numerous forums and networks. I am a member of the Scientific & Medical Network (http://www.scimednet.org), which promotes views almost identical to those expressed in *The Unreal Universe*. Another organization I am a member of, the Center for Theology and the Natural Sciences (http://www.ctns.org), focuses on the relation between the natural sciences and theology. I expect to be able to promote my work through their journal, *Theology and Science*, which has a readership of about 700 in print and and several thousand online. The Institute of Noetic Sciences (IONS http://www.noetic.org/), founded by Apollo 14 astronaut Edgar Mitchell, attempts to build bridges between science and spirit exploring the frontiers of consciousness. IONS has over thirty thousand members and a quarterly member magazine *Shift* and an online news letter.

Thanks to my long student life in premier academic institutions, I belong to many alumni associations and discussions forums, which provide additional marketing channels. The IIT Madras Alumni Association (http://www.iitmaa.org) has over 20,000 registered members with an online forum frequented by about 1000 of them.

In addition to these networks where I am personally participate in, other organizations such as the Mind and Life Institute (http://www.mindandlife.org/) and the John Templeton Foundation (http://www.templeton.org) are dedicated to pursuing insights at the boundary between theology and science. They may also provide potential channels for endorsing and marketing books like *The Unreal Universe*.

In Singapore, I have had a lot of success in promoting my research work through national TV appearances and newspapers articles. (Details in my *curriculum vitae*.) Using my connections with the media, I will mount an aggressive publicity campaign here to promote *The Unreal Universe*, which may generate sales of a few hundred copies. As a part of this campaign, I have created a website for the book (http://www.TheUnrealUniverse.com), which hosts promotional information about the book.

5 Outline and Chapter Plan

The Unreal Universe is organized in three parts. The first part looks at our notions of time and space using interesting examples from neuroscience and physics. Moving on to the philosophy of reality, it briefly discusses the Zen and Hindu lines of thinking and shows how their view is mirrored in modern sciences. The second part examines the interplay between reality and physics. It starts with a conceptual recap of modern physics and answers the question why light is so important in our space and time. The concluding third part summarizes the various ideas presented in the book. It winds up with a collection of interesting tidbits about physics, philosophy, evolutionary biology and neuroscience, which may inspire the reader to think further along the general theme of the book—accepting no assumptions without questioning, and doubting everything, including reality. The chapters in the three parts are briefly described below.

Part I Perception and Reality

According to cognitive neuroscience, our perceptual experience of reality is only a distant and convenient mapping of our sensory inputs. Sound is a mapping of auditory inputs, and space is a representation of visual inputs. How space and time are "unreal" from this point of view is the subject matter of the first part of the book. It examines the unrealness of reality and looks at the philosophical basis of physics and knowledge. The most important message of this part is how the modern scientific realization of the nature of reality as a representation of our sensory inputs was known for thousands of years in the Eastern philosophy. This interplay between ancient philosophy and modern neuroscience is further highlighted in the chapters examining the ingredients that make up reality.

1. **Mother of Sciences**
   In the opening chapter, the philosophical foundations to our knowledge are introduced. These foundations are assumptions in most cases. Some of the assumptions, especially the ones in physics, are not difficult to spot. Others that pertain to the nature of reality itself are far trickier to appreciate. These elusive assumptions include the existence of time and space, for instance. The realness of reality is not merely a philosophical issue; it is a subject matter of cognitive neuroscience as well. Once the issue of reality gets back to the realm of science, it becomes something that physics has to describe. Physics, in turn, is erected on the philosophical assumptions on the existence of time and space. This overlap among seemingly distinct domains is reflected in the chapter flow of the book.

2. **Nature of Time**
   We can logically accept the virtual nature of time because we have no direct sensory mechanism to sense or perceive it. Despite this glaring absence, we do have a strong sense of time that plays a crucial role in every conscious decision we make in our lives. In this chapter, we argue that the reason for the existence of time is our knowledge of our finite life-span. We illustrate this argument by mapping the history of the universe to forty-five years. This mapping also shows how our physics of the universe is an ambitious extrapolation from a very short span of knowledge to incredibly long time scales. Physics has multiple notions of time—Newton's constant time and Einstein's malleable time. The difference between these notions of time is indicative of its unreal nature. Time is unreal the same way as mathematics is unreal; they are both products of our intellect. And philosophically, they can both be thought of as formal languages.

3. **Unreal Space**
   Unlike time, space does have a sensory correlate. Our perception of space is the end-result of our most precious sense, namely sight. For this reason, the unreal nature of space is not as obvious as that of time. In this chapter, we take a quick look at how sight works from the perspective of neuroscience. In particular, we study the cases where tiny physiological defects manifest themselves as drastic disorders in visual perception. How sight creates space is analogous to how hearing creates sound. Sound is not the intrinsic property of a vibrating body, but our cognitive representation of the air pressure waves our ears sense. In an exact parallel, space is our visual reality, or the cognitive representation of the light inputs to our eyes. It is no more real than sound or smell. Or time.

4. **Pillars of Reality**
Discussing the nature of reality has the curious effect of casting doubt on its realness. In this chapter, we look at the many pillars on which reality rests. Our senses provide the inputs to the brain, which creates a cognitive model that we think of as reality. The cognitive model heavily depends on the other "software" running on the brain, namely consciousness, language and memory. In the absence of consciousness, reality has little significance. Similarly, if the brain does not have a language apparatus to process thoughts, reality cannot be created. Memory is the last essential support to our sense of reality. What does it mean to say something happened if nobody can remember it? An interesting and important aspect of the brain is that it always tries to create a reality that best fits the sensory inputs, resolving any possible sensory conflicts.

5. **Philosophy of Reality**
The suspicion, or the conviction, that reality is not all that real existed in some branches of philosophy, both Western and Eastern. In this chapter, we take a quick look at these philosophies. The Indian and the Zen spiritual lines of philosophy view our senses and mind as actual impediments to an intuitive understanding of the absolute reality behind our experiences. Western philosophy, on the other hand, treats the nature of reality and knowledge as the formal lines of metaphysics and epistemology. Western philosophy also provides the basis of scientific realism in modern physics.

Part II Reality and Physics

The physics part of the book starts with a conceptual description of three aspects of modern physics, the special theory of relativity, particle physics and cosmology. Looking at reality as a cognitive model distorted by the finite speed of light yields a compellingly simple understanding of the special theory of relativity. It also provides simple explanations for a host of astrophysical and cosmological phenomena at vastly different time and length scales. All these explanations are presented in this part with no mathematics or technical details, but with the help of numerous diagrams and examples.

6. **Physics Primer**
In this first chapter on physics, we look at three branches of modern physics. These are (1) the special theory of relativity dealing with objects at high speeds, (2) particle physics dealing with very small length scales and (3) cosmology and astrophysics, dealing with various phenomena in our universe. The common thread binding these different branches is that they all deal with physics beyond the ranges of our senses. Extrapolating physics from our reality to what lies beyond our senses involves deep philosophical assumptions. This chapter uncovers the philosophical basis of modern physics. It shows how scientific realism is the philosophical stance adopted in modern physics and how another stance is possible. This new stance is based on the notion from neuroscience that our reality is our brain's creation, almost identical to the Zen and Hindu view of the world.

7. **Why the Speed of Light?**
Once we adopt the philosophical stance of reality as our brain's creation, we can understand why the speed of light figures so prominently in our physical theories. The theories of physics are a description of reality. Reality is created out of the readings from our senses. Our senses all work at the speed of light. Thus the sanctity accorded to the speed of light is a feature only of *our* reality, not the absolute, ultimate reality which our senses are striving to perceive.

8. **Perception and Special Relativity**
In this chapter, we look at our perception of moving objects. First, we look at echolocation as

an "inferior" sense modality operating at a slower speed. This study will show how the speed of the sense modality influences the perception of motion. From this understanding, we will see that all the strange effects of the coordinate transformation in special relativity can be understood as the manifestations of the finite speed of our senses in our space and time. When it comes to the phenomena that happen well beyond our sensory ranges, we really have to take into account the role that our perception and cognition play in seeing them. The universe as we see it is only a cognitive model created out of the photons falling on our retina or on the photo-sensors of the Hubble telescope. Because of the finite speed of the information carrier (namely photons), our perception is distorted in such a way as to give us the impression that space and time obey special relativity. They do, but space and time are not the absolute reality. They are only a part of the unreal universe that is our perception of an unknowable reality.

9. **Beyond Special Relativity. . .**
After showing that special relativity applies to the cognitive model created by the brain, we will ponder over the physical causes behind the model, the absolute reality itself. It may be possible to guess the nature of the absolute reality and work out how we would perceive it. We will show how this line of thinking explains certain phenomena that have been puzzling scientists for a while. These phenomena include symmetric radio jets and gamma ray bursts from astrophysics. We also end up with a conceptually elegant resolution of the twin paradox and the issue of causality violation in superluminal motion.

Part III Summing Up. . .

After summarizing the various ideas presented so far, the book winds up with a collection of possibly unrelated, but interesting, thoughts. They are presented as a kind of intellectual dessert, which may inspire further thinking.

10. **Last Words**
Summarizing the thoughts presented in the book, we highlight how the nature of the absolute reality is really beyond our grasp and that the choice of accepting the perception of reality as a true image of reality is indeed a philosophical stance. The alternative presented in the book, namely guessing the nature of the absolute reality and comparing its predicted projection to our real perception, may simplify and elucidate some theories in physics and explain some puzzling phenomena. However, this option is just another philosophical stance against the unknowable absolute reality. We also show how different levels of possibly conflicting views of reality may coexist in our minds, giving us physical theories that are in conflict with each other. General relativity and quantum mechanics are examples of such conflicting theories, which are descriptions of realities beyond *different* limits of our senses. Due to this difference in their origin, their unification may prove impossible, unless we are willing to tolerate more arbitrary assumptions and complex mathematics.

11. **Random Thoughts**
In this concluding chapter, the reader is presented with a bunch of interesting thought exercises. It includes a game where the book tries to predict the level of reader's faith in a supreme being by testing how left or right-brained the reader is. It also mulls over such desultory topics as the universality of mathematics, the logic of evolution, the nature of gravity, and the shape of Yin and Yang. How every conscious being is at the center of the universe, its own personal unreal universe, is another piece of ancient wisdom that our sciences are now converging to. The book concludes

with a discussion on how the concept of God is not in conflict with physics, for there is plenty of room beyond the limits of our knowledge for a plausible God.

6 About the Author

I am a scientist from the famous CERN (European Center for Nuclear Research) who recently got seduced by the lucrative field of quantitative finance in investment banking. Despite this incongruous move, I jealously guarded my passion for physics and philosophy as well as writing through a variety of activities. I am a regular columnist for a popular Singaporean newspaper called *Today* and the prestigious *Wilmott Magazine* – a quantitative finance publication based in London. In addition, I publish in physics and philosophy journals. My last physics article, presenting a model based on the ideas of *The Unreal Universe*, is one of the top accessed papers in the International Journal for Modern Physics – D.

After receiving my PhD from Syracuse University in 1993, I moved to Marseilles, France and continued my research with the ALEPH collaboration at CERN, Geneva. During my ten-year career as a research scientist in the field of high energy physics, I co-authored over 200 publications. Always inquisitive about the interplay between mind and matter, perception and philosophy and their implications in physics, I joined the Kent Ridge Digital Labs (KRDL, later to be renamed I^2R) in Singapore in 1998 to study and develop various human body-based measurements and systems. My work in this institute resulted in four invention disclosures, two patents, and numerous academic papers. (Please see the attached CV for selected publications.)

Between 2003 and 2006, before my move to quantitative finance, I was involved in the NeuroInformatics group, focusing neural signal acquisition and processing, which gave me the perfect opportunity to fully appreciate the role of perception and cognition in physics. *The Unreal Universe* is in part the outcome of the insights gained during my professional research career, in addition to my philosophical bend of mind.

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7 Related Work

Books

The interplay between philosophy and science is the subject matter of several books. Here is a list of some well-known books that influenced my work and inspired my thinking. Some of them may be considered competition to my book, although their subject matter and approach differ from mine. To the best of my knowledge, there is no other book dealing with the central theme of *The Unreal Universe*, namely, identifying and removing the perceptual limitations in the theories of physics based on a philosophical or spiritual notion of reality and knowledge.

The Tao of Physics looks at the similarities between the Eastern philosophy and modern physics, mainly from the point of view of the unity or indivisibility of the system and the observer as implied in quantum mechanics. Unlike *The Tao of Physics*, my book looks at the notions of space and time in special relativity. The starting point of the analysis in my book is the notion of reality is a conceptual model of sensory inputs, which *The Tao of Physics* touches upon. However, the theme of my book is an attempt to apply this insight in understanding both physics and philosophy.

Full Title:	*The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism*
Author:	Fritjof Capra
ISBN:	1570625190
Publisher:	Shambhala; 4th edition (Jan. 2000)
First published:	1975
Pages:	366
List Price:	$15.95

The End of Time develops physics without the notion of time. It argues that time is sensed only through change, and uses a collection of "Nows" to do physics. The virtual nature of time is highlighted in my book as well, but from a different perspective of evolutionary biology. *The Unreal Universe* concentrates on perceptual effects in sensing motion and space.

Full Title:	*The End of Time: The Next Revolution in Physics*
Author:	Julian Barbour
ISBN:	0195145925
Publisher:	Oxford University Press (Oct. 2001)
Pages:	384
List Price:	$17.95

Catching the light is a remarkably insightful book on the role of light in our lives. It is an almost lyrical study of the history and science of light. *The Unreal Universe* also highlights the role of light in creating our reality, but my book takes the notion much farther an explores the manifestations of light-based perception in both science and philosophy.

Full Title:	*Catching the Light: The Entwined History of Light and Mind*
Author:	Arthur Zajonc
ISBN:	0195095758
Publisher:	Oxford University Press (Apr. 1995)
Pages:	400
List Price:	$18.95

Impossibility looks at the limits of what is knowable, the finite speed of light being one limit. My book shows how knowledge beyond this limit is attainable, and how it can be applied in understanding the theories of physics as well as spiritual writings.

Full Title:	*Impossibility: The Limits of Science and the Science of Limits*
Author:	John D. Barrow
ISBN:	0195130820
Publisher:	Oxford University Press (Dec. 1999)
Pages:	296
List Price:	$18.95

What Makes You Tick? is a physiological exploration of the building blocks of our sense of reality. Concentrating on visual perception and how it becomes our reality, this book provides numerous examples. Some of these examples (split-brain patients, for instance) are referred to in my book. However, it is only the initial part of my book that deals with the physiology of sensing; the latter part is about the role of perception in science. Despite this difference in the subject matter, my book targets the same readership, using the same level of presentation.

Full Title:	*What Makes You Tick? The Brain in Plain English*
Author:	Thomas B. Czerner
ISBN:	0471209902
Publisher:	Wiley, New Edition (Jan. 2002)
Pages:	240
List Price:	$15.95

The Conscious Mind deals with the difficult problem of consciousness mostly from a philosophical and logical perspective. One of the most striking notions in this book (which I referred to in mine) is the notion of the "explanatory irrelevance." Explanations based on physical processes are not nearly enough to comprehend consciousness, or life. Even after explaining all the physical processes behind brain functions, one might still ask, "Sure, but why should that lead to consciousness?" Chalmers illustrates this paradox using a zombie twin paradigm, who has all the necessary physical processes, but no consciousness. My book does touch upon consciousness as a necessary ingredient in creating our sense of reality, but my subject matter is the role of sensing in science.

Full Title:	*The Conscious Mind: In Search of a Fundamental Theory*
Author:	David J. Chalmers
ISBN:	0195117891
Publisher:	Oxford University Press (Oct. 1997)
Pages:	432
List Price:	$19.95

A Cognitive Theory of Consciousness seeks to develop a formal theory of consciousness. Consciousness is an essential ingredient in our sense of reality, but it is not the focus of attention in my book. One specific aspect of how consciousness shapes reality, what the author calls "the context of conceptual thought," is referred to in my book.

Full Title:	*A Cognitive Theory of Consciousness*
Author:	Bernard J. Baars
ISBN:	0521427436
Publisher:	Cambridge University Press (Jul. 1993)
Pages:	448
List Price:	$48.00

The Blind Watchmaker by Dawkins is one of the most readable books on evolutionary biology. Some parts of my book (the notion of scale in perception, for instance) are inspired by this book. Dawkins describes echolocation with exceptional insight and clarity. Echolocation is made use of in my book, but with a different purpose of illustrating the limitations of perception.

Full Title:	*The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design*
Author:	Richard Dawkins
ISBN:	0393315703
Publisher:	W. W. Norton & Company (Sept. 1996)
First published:	1986
Pages:	358
List Price:	$16.95

Physics of the Soul is an attempt understand the Hindu spiritual views in terms of quantum mechanics. *The Unreal Universe*, on the other hand, attempts to understand special relativity using the Eastern views.

Full Title:	*Physics of the Soul: The Quantum Book of Living, Dying, Reincarnation and Immortality*
Author:	Amit Goswami
ISBN:	1571743324
Publisher:	Hampton Roads Publishing Company (Sept. 2001)
Pages:	289
List Price:	$16.95

Other Resources

In addition to the books listed above, several other resources have inspired or influenced my book. Here is a partial list:

The Emerging Mind: Reith Lectures on Neuroscience (BBC Radio, 2003) given by V. S. Ramachandran, the director of the Center for Brain and Cognition, San Diego, CA, USA. My book refers to several examples of physiological brain anomalies and their perceptual manifestation from this lecture series.

Brain Story: BBC documentary program on brain. Neuroscientist Prof. Greenfield (the director of the Royal Institution and professor of pharmacology at Oxford University) gives a personal view of what it is about our brains that makes us think, act and feel the way we do. My book refers to some examples of brain damage and consequent alterations of sensed reality from this program as well.

No Ordinary Genius: BBC documentary program on Richard Feynman. In this program, Feynman explains the difference between knowing the name of something and knowing something, which is quoted in my book. He also describes a hypothetical, tiny creature in a corner of a swimming pool sensing the waves and inferring the state of the whole pool. He then compares this picture to human vision and our perception of the universe. Although not quoted in the book, this analogy definitely inspired some of my thinking.

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Chapter 1

Mother of Sciences

Science never solves a problem without creating ten more.

– George Bernard Shaw

The realness of reality is an inquiry appropriate to philosophy. The realm of science is reality as we perceive it. All constraints in perception are, therefore, mirrored in science. How can we identify and remove perceptual constraints from science, or at least, understand their manifestations? Before attempting to answer this question the next ten chapters, let's first look at how we organize our knowledge under different domains.

1.1 Science, Philosophy and Spirituality

Science stems from the basic curiosity innate in all of us. Why is something the way it is? How does something work? Implicit in such questions is an assumed ability to answer them. Science represents that ability, that body of knowledge from which logical answers can be elicited at will. At the other end of the spectrum of knowledge is spirituality, representing our collective ignorance, addressing questions to which we do not have logically satisfying answers. What is right and wrong? What is the meaning of life? Philosophy sits in between these two, dealing with problems such as the nature of knowledge and reality. These vast domains of knowledge may appear to be distinct subjects dealing with totally different problems at the outset of a life of scientific investigation or philosophical inquiry. It takes the wisdom that comes with maturity to realize and appreciate the extent of the overlap among the three.

Philosophy is considered the mother of sciences. To a student of science whose faith is entirely with physical sciences, this claim may sound like the wishful thinking of a frustrated philosopher, but philosophy is a unique field. It addresses questions in every aspect of human life, and its techniques apply to problems in any field of study or endeavor. No brief definition expresses the richness and variety of philosophy; it is nothing less than the attempt to understand the universe as a whole. Its sphere of interest is boundless. It is a reasoned pursuit of fundamental truths, a quest for understanding, a study of principles of conduct. Philosophy seeks to establish standards of evidence, to provide rational methods of resolving conflicts, and to create techniques for evaluating ideas and arguments. These techniques, of course, provide the basis for modern sciences.

Despite this basic connection, philosophy seems irrelevant to physics mainly because of the apparent ease with which physics seems to answer the “why” and “how” questions up until the undergraduate years.

Once one passes the undergraduate level, the arbitrariness of some of the assumptions and hypotheses in physics begins to shake the logical faith we have developed thus far. We may suspend our disbelief mainly because the theories, despite their arbitrary nature and extreme complexities, seem to work. But by that time, we realize that the role of physics is no longer to explain why things are the way they are, but to describe how they behave in a mathematical fashion. This role, of course, is a lot less satisfying. But it is when we begin to question the hypotheses themselves that we find ourselves on a slippery slope toward philosophy.

1.2 Assumptions and Knowledge

Nature's laws are tricky to figure out, but once we do figure them out, they are surprisingly simple. This simplicity is what Albert Einstein hinted at when he said, "Subtle is the Lord, but malicious he is not."1/ Simplicity also implies the absence of arbitrariness. For this reason, arbitrary assumptions and axioms to explain physical phenomena and complicated computations describing them should always be viewed with skepticism.

Some of the arbitrary assumptions in physics are easy to spot--e.g., the speed of light is a cosmic speed limit; nothing can travel faster than light. This is one assumption we will go into in great detail. Another palpable assumption introduced in modern cosmology is the one about dark matter.

1/ Also quoted as "God is clever, but not dishonest."

Dark matter was postulated to account for the speed anomalies in galaxies. The speed at which stars and galaxies should be moving was calculated based on the visible matter in galaxies. The calculated speeds did not agree with the observations. The celestial objects were moving faster than predicted, as though the galaxies contained more matter than the scientists could see. They postulated dark matter as the matter that could not be seen.

A similar ad hoc assumption of dark energy was introduced to account for another anomaly; the universe is expanding faster than it should be. Dark energy is the invisible force pushing things away from each other. Such ad hoc assumptions in physics are easy to spot.

The assumptions dealing with the nature of reality itself are far trickier to spot. Examples of such assumptions are: there is a three-dimensional space, there is a continuously flowing time, and so on. These fundamental assumptions are as philosophical as the statement that there is a God. In this book, we will ponder over these philosophical assumptions as well. We may not be able to explain away all these assumptions and arbitrarinesses. However, we may be able to see what they are based on, where they come from. Some of these philosophical assumptions are embedded so deeply in the way we look at the world that they form the fundamental concepts on which our physical sciences are built.

1.3 Nature of Reality

One of the foundations of physics is the concept of time. Time is so pervasive in our daily lives that we take its existence to be self-evident. Despite this appearance, time is in fact an abstract and arbitrary concept. It is a mathematical construct much like numbers. How such imaginary things as time and numbers could describe "real" physical phenomena is indeed a surprise. Later on, we will find a plausible explanation for the existence of time, not in physics, but in evolutionary biology. Evolution has played a large role in our perception, and thereby in physics. The role of evolution in our sense of reality (which includes space and time) is an insight that provides surprising answers to a wide range of questions.

While the realness of time may be logically debated, we never find ourselves suspecting space, because we sense and perceive it directly. Despite this direct perception, our faith in space is easily shaken by a cursory exposure to neuroscience and the study of consciousness. Losing faith in the realness of space is not all bad, because in the process, we gain insights into one of the most arbitrary assumptions in modern physics, namely the sanctity of the speed of light. The speed of light is considered a kind of cosmic speed limit for matter. It is also a constant no matter how we measure it (i.e., irrespective of our state of motion). Once introduced to this assumption, the immediate question that confronts any serious student of physics is, what is so special about the speed of light? Why the speed of light? Why not some other number, the speed of something else? We will see later that the answer lies not just in physics but in neuroscience, in how our brain creates a reality for us.

The nature of reality used to be in the realm of philosophy or even religion and spirituality, but sciences have started staking a claim to it. In the last couple of decades, cognitive neuroscience has begun to understand the true nature of reality [1] as a representation of our sensory inputs. Reality is a model created by our brain. It is a representation that maximizes our chance of survival. Once this scientific understanding of reality (as opposed to a philosophical conjecture) percolates to other modern sciences (especially physics), what is explored in this book will become part of our basic knowledge. We will see clearly the role of sensing and perception in the theories of physics.

The unreal nature of space and time may be a little unsettling at first. However, it is important to realize that our perceived reality is the reality we have to live by. It is this perceived reality that we have to describe in our sciences, that we have to build theories on. The physical causes behind the perception, the absolute reality of which our perception is only a representation, are largely irrelevant to us. This irrelevance is precisely the reason why our senses did not evolve to sense the physical reality as it is.

We will come back to the virtuality of time and space (mainly in the form of the distinction between a sensed reality and an absolute reality) again and again in the book. We will use concepts from evolutionary biology, neuroscience and, most of all, from physics to understand the unrealness and its implications. We will see interplay between modern sciences (biology, physics, neuroscience, etc.) and the philosophical schools of thought. We will see clearly what it means to say that reality is a representation of our sensory inputs.

If our reality is merely a representation created in our head, what is it that is being sensed? Paradoxically, the absolute, physical reality cannot be known. The sensed reality, the representation is the Unreal Universe. The distinction between the sensed reality and what is being sensed is not a new insight. Such questions about the nature of reality have been articulated and attempted in metaphysics and in many lines of Eastern philosophy. Similar inquiries into the basis of reality and knowledge are found in epistemology.

What is novel in this book is the application of these philosophical concepts to answer some real physical questions. This book is an attempt to extrapolate from what is known into what is not knowable. We hope that the insight represented in this extrapolation will have some impact on the way in which we understand the workings of the universe, that it may take us a little closer to "God's own thoughts."

Toward the end of the book, we will see how the workings of physics, and indeed of all sciences, are inextricably intertwined with our philosophical stances on the nature of reality. Philosophy provides the ground rules and the arena where the sciences play out their games. Perhaps this line of thinking, rather than worries about its own irrelevance, is behind the maternal claim that philosophy stakes on sciences.

Chapter 2

Nature of Time

The only reason for time is so that everything doesn't happen at once.

– Albert Einstein

Of the many philosophical assumptions in physics about the nature of reality, none is more mysterious than the existence of time. Time can be relatively easily discredited by imagining deserted islands or other settings devoid of conscious beings. Yet, despite the logical acceptance of the unreal nature of time, we do know that a year from now, we will be a year older. Why is it that we cannot escape the unrelenting hold of time? The reason is that the origin of time is linked to our most basic knowledge--our self-awareness, the knowledge that we exist. Before proving this assertion, let us examine some aspects of time.

2.1 Sensing Time

Unlike space, time does not have any of our five senses assigned to it. Our primary sensory mechanism, sight, creates a 3-D world around us. Even in the absence of vision, hearing can place point sources in a 3-D space. A 3-D map of objects in our immediate vicinity can be created by our touch sense also. Time is totally different from this sense of 3-D space. We have no built-in mechanism to perceive or sense time. Despite this glaring absence, human beings do have a sense of time. Where does this sense come from? What is the origin of this sense of time that permeates all our physical sciences and plays a crucial role in every single conscious action and decision we make in our lives? To answer this question, we need to understand the notion of scale in our perception and the evolutionary process that brought about such a notion.

Millions of years of evolution ensured that our senses are best suited for our survival and reproduction. We can best sense objects and movements at scales comparable to our body dimensions and speed. We can clearly see a person running, but not a bullet coming at us, nor the movements of the hour or minute hand of a clock. We can appreciate the difference in size between an adult and a child, but not between two celestial objects or micro-organisms. This sweet spot where our senses and perceptions work best is not limited to the tangible measures such as speed and size.

Our sense of numbers is also related to human scale. Human beings are poor in assessing long odds--a fact illustrated by the thriving casinos in Las Vegas. Another example of our collective inability to assess probability is the fear of flying. Many people suffer from a fear of flying; not many suffer from a fear of crossing a street, even though, statistically, it is more dangerous to cross a street than to travel in an airplane. If we crossed a street every day, and if our average life expectancy were a million years, we would almost certainly get run over one day. But, we might still be able to fly everyday without crashing. And if we had such long lives, it would be obvious to us that crossing the street is a much more dangerous proposition than flying because we would be sensitive to such tiny probabilities and differences between them.

Here is another, more concrete example of our life expectancy modulating our risk assessment. If our life expectancy were only five years, AIDS would not be a serious illness, for our life would most likely end before AIDS could kill us. This is probably why some monkeys can be carriers of the dreadful disease without dying of it. Their life span is much too short.

Now, what does all this have to do with time? The human scale modulates our sense of time, much like it does our perception of size, speed and probability [2]. Our sense of time is modulated by our life expectancy. If we lived forever, would we have a sense of time? Let us consider the possibility that if we were immortal, we probably would not have a sense of time. Time is sensed through change. Does immortality imply a lack of change as well? It should because changes can be thought of as small deaths and rebirths. Some cells die, some others take their place; that is how a biological change takes place. The real question about the existence of time is not so much whether we would have a sense of time under the conditions of immortality, but whether there will be time at all if we are not here to sense it, or if we were all incapable of sensing time for whatever reason? The uncertainty we feel in answering these questions should point to the virtuality of time.

2.2 Physics of Time

The whole argument on the virtuality of time boils down to this--we sense time as a fraction of our expected lifetime. If our lifetime were infinite (or if we did not know that it was finite), then all finite spans of time would be so small in comparison that we probably would not have a sense of time. If we did not have a sense of time, would that mean there was no time? Does time have an existence independent of our minds? More to our purpose in this book, would it be possible to do physics without a notion of time? Physics, as we know it today, (e.g., Newton's laws of motion and the special theory of relativity) has time figuring prominently as an essential ingredient. A physics with no explicit time was attempted by Julian Barbour (in The End of Time), which shows that time is not essential. Time, however, makes it far more convenient to do physics.

To get to real, physical time from our sense of time is not a small step. Interestingly, there are two different concepts of time in physics. One is the "normal" continuous time that we have a natural sense of. The other is the malleable time that can get dilated. Let's take a closer look:

Galilean Time: In the Galilean view of space and time, the physical existence of an absolute and global time is assumed. Isaac Newton defined it as follows: "Absolute, true and mathematical time, in itself, and from its own nature, flows equally, without relation to any thing external; and by other name called Duration. Relative, apparent, and vulgar time, is some sensible and external measure of duration by motion, whether accurate or unequable, which is commonly used instead of true time; as an hour, a day, a month, a year. It may be, that there is no equable motion, whereby time may be accurately measured. All motions may be accelerated and retarded, but the flowing of absolute time is liable to no change."

In this view of time, there is no fundamental reason against superluminal (faster than light) travel. There is a notion of simultaneity. That is, if two things happened at the same instant somewhere, there would be no doubt of its happening at different instants. Your past cannot be in another's future; there is no time travel. In other words, this is our natural sense of time. However, this notion of time will not work for the special theory of relativity. But, we are getting a bit ahead of ourselves...

Minkowski Space-Time: The Minkowski view of reality is fundamentally different. In this notion of space and time, there is no absolute, global time that is physically meaningful. This notion of time is based on Albert Einstein's revolutionary paper [3] that redefined the notion of simultaneity. In a move akin to Copernicus's abandoning the notion that we were the center of the universe, Einstein decided to abandon the notion of absolute time. Instead, he postulated two principles:

1. All physical laws are immutable in all reference frames.
2. The speed of light is constant in all reference frames.

> The second postulate, which is a bold assumption, redefines time. It implies, in contrast to Galilean time, that simultaneity is not an absolute physical quality, but a relative one, depending on the motion of the observer (i.e., the reference frame). Mathematically, it mixes space and time.

We will get into more details of the space-time issue later on. Let's ask ourselves which one of these two notions of time is the "real" one because the Galilean time is different from the Minkowski space-time.

A physicist will tell us the Minkowski picture is a generalization of the Galilean notion of space-time. This is absolutely true, in a mathematical sense. However, we lose something in this generalization--we lose the sense of a global absolute time. Along with that, we lose our ability to say whether two events take place at the same time--simultaneity. In other words, we lose the fundamental qualities of our natural sense of time. If we are willing to sacrifice these qualities, are we also willing to forgo our natural sense of time altogether and think of it as a mathematical construct? This construct may be unnecessary for our understanding of nature and the universe.

2.3 Philosophy of Time

The existence of time (or a sense of time) has been a problem in philosophy. Let us take a quick look at time from this angle.

Our treatment is a bit different from the traditional philosophy of time.1/ Here, we look at the interplay between language and time. Let's take a quick look at the philosophy of language so that we can see how time fits in it.

Some consider language the most important part of our relation with reality. Language is not merely a communication tool, but also the canvas on which our conscious existence is painted. Without a language, we may not even have conscious thoughts. We will get back to the philosophy of language a bit later and look at it in much more detail. Here, we want to understand how time figures in language.

Language has a syntax specifying the grammatical rules and semantics that give meaning. At the semantic level, there is a reflection-correspondence theory of language. In this theory, language can be thought of as a collection of the correspondences between words and objects in the external reality. If we look at any word in our language and ask ourselves what it means, we will see that it represents something in the external reality.

Language mirrors the external world. However, a little bit of thinking along this line will convince you that this definition of

1/ I should start this section with a disclaimer that I am approaching these issues as a physicist, not as a philosopher. For this reason, the terminology used in articulating these musings on the philosophy of time may differ from the one in traditional philosophy.

language, at best, is incomplete. Language has a much richer structure. There are structures in language that need explaining. e.g., the word "book" represents the thing you are holding. A "small book" adds a quality to the object "book." Smallness is a physical quality, so the qualifier still has a kind of correspondence to an external physical attribute. But we can see that qualifiers are at a deeper level of hierarchy in the inner structure of language.

There are other qualifiers that fall in a different category. For instance, if we think of a "great book," the qualifier "great" is different because the quality does not correspond to a physical attribute. So this class of qualifiers is at an even deeper hierarchy. This hierarchy is where abstract nouns such as "happiness" and "wisdom" belong (along with the corresponding qualifiers).

Now, let's look at numerical qualifiers. "Two books"--the qualifier here refers to something entirely different. In fact, numbers, along with the rules (syntax), in mathematics form a kind of formal language. The formal language of mathematics, however, is a little weak in semantics. This weakness is the reason the efficacy of mathematics in explaining real physical phenomena never ceases to amaze. The same weakness puts the entire formal language of mathematics roughly at the same hierarchal level as abstract qualifiers such as great, happy, wise and so on. Thus, although "two books" means something easily understandable, "two" by itself is an abstraction. The semantic weakness disappears when mathematics is used in physics. Physics provides the meaning.

Like mathematics, time can be thought of as a formal language. The syntax of time is not as rich as the one in mathematics, but semantically, time is much stronger. Unlike mathematics, its meaning is not as open to interpretation. Time can be considered an abstract formal language embedded in almost all languages in the world. Where exactly do we embed time in our languages? Its position is at least as deep as that of mathematics, probably deeper. Even the syntax of the formal language of time is defined in abstract terms such as past, present and future, along with a concept of its flow and direction.

Thinking of time in terms of the philosophy of language serves only one purpose. It illustrates the virtual nature of time, much like that of mathematics. Mathematics gets its semantics mostly from physics; time, on the other hand, derives its meaning indirectly from our knowledge of our demise. Although we cannot directly test this conjecture, we can consider a few thought exercises that may shed some light on the issue.

1. Do animals have a sense of time? It is unlikely that they are conscious of their death. So, by our conjecture, they should not have a sense of time.

2. If you grew up on an island, without contact with other human beings, would you have a sense of time? It seems obvious that you would not have a language in the conventional sense of the word. Some philosophers believe that you would not even have any thoughts at all. But does the sense of time come <u>before</u> or <u>after</u> thoughts?

3. Is it possible that our sense of time changes as we grow older? Don't we feel as though years are getting shorter and shorter as we grow older? Is it possible that our sense of time is related, not only to the knowledge of our demise, but also to our sense of how long we have left to live?2/

2.4 History of the Universe

We argued that our sense of time was modulated by the natural scale involved--our life span. This is why we are not able to appreciate the huge difference between large time scales, such as the difference between the time dinosaurs went extinct and when human beings evolved. One way of appreciating it would be to "translate" or map these cosmological or evolutionary time scales to a human scale. Table 2.1 is one such mapping.

Here, we think of the universe as a forty-five year old. Thus, the current estimate of the age of the universe (about fifteen billion years) maps to forty-five years. The early years of the universe are fuzzy, much like our memories of our childhood. Most of the prime years of the universe were spent on building a universe worthy of hosting life. The first event of our direct interest took place about fourteen

2/ I realize that the question is a little cyclic because it defines our sense of time in terms of our sense of the duration we have left to live, which serves to show how deeply time is embedded in our mode of thinking.

Table 2.1

Table 2.1: A time-line of the significant events in the life of the universe. The first column is the "time", presented as though the universe is forty-five years old now. The second column is the event that took place at that time. The last column is when it happened, in real time.

Time mapped to 45 years	Event	Real Age
	Cosmological Era	
45 years ago	The universe is born.	15 Billion years ago
39 years ago	Clusters of galaxies begin to form.	12 Billion years ago
36 years old	Milky way forms.	11 Billion years ago
14 years ago	Solar system forms. Disc planets.	4.7 Billion years ago

12 years ago	Earth forms, with liquid water and rain. Origin of organic material.	4 Billion years ago
	Evolutionary Era	
11.5 years ago	Cells form.	3.9 Billion years ago
11 years ago	Bacterial life, spores.	3.5 Billion years ago
3 years ago	Colony of algae, hormones and fungi.	1 Billion years ago
2 years ago	Jelly fish.	650 Million years ago
20 months ago	Flat worms, animal groups.	570 Million years ago
29 months ago	Vertebrates.	500 Million years ago
14 months ago	Sharks, finned fish, insects.	390 Million years ago

12 months ago	Ferns, invertebrates, amphibians.	350 Million years ago
9 months ago	Dinosaurs.	250 Million years ago
7 months ago	Mammals.	200 Million years ago
23 weeks ago	Birds.	150 Million years ago
70 days ago	End of dinosaurs.	65 Million years ago
55 days ago	Spread of mammals.	50 Million years ago
44 days ago	Cow family.	40 Million years ago
	Human Era	
3.3 days ago	Recent ice age. Homo erectus.	3 Million years ago
18 hours ago	Fire.	700 thousand years ago

5 hr 15 min ago	Neanderthals.	200 thousand years ago
2 hr 38 min ago	Humans.	100 thousand years ago
17 min 20 sec ago	Nomads and farmers.	11 thousand years ago
9 min 28 sec ago	Cities.	6 thousand years ago
4 min 44 sec ago	Iron.	3 thousand years ago
3 min 9 sec ago	Christianity.	2000 years ago
2 min 12 sec ago	Islam.	1400 years ago
	Scientific Era	
43 sec ago	Copernicus.	450 years ago
33 sec ago	Birth of Sciences.	350 years ago

9 sec ago	Special theory of relativity.	100 years ago
5 sec ago	Nuclear energy, quantum mechanics.	60 years ago

years ago--the birth of our blue green planet. These early years can be called the cosmological era. The estimate of these time scales in this cosmological era is mostly theoretical or phenomenological.

We then move on to the evolutionary time scale, from about twelve years ago to less than a week ago. Life on earth developed during these twelve years. We have a better estimate of the time scales in the evolutionary era because of radiometric dating.3/ The first semblance of human-like primates appeared about three days ago, heralding the human era.

3/ Carbon dating works for fossils from living organisms, and is good for about 50 000 years, though it may work up to 100 000 years. Other dating techniques can estimate the age of the rock that hosts fossils. The Potassium/Argon method is good for up to 4 million years, and the Rubidium/Strontium method can be used for up to 90 million years. Beyond that, the Uranium/Lead technique can be used.

But in any real sense, our reign on this planet began only today, within the last eighteen hours or so. We began forming villages and building cities only ten to twenty minutes ago. We began subdividing humanity in the name of God and religion about five minutes ago. We invented the pride and joy of our global civilization, the modern sciences, less than a minute ago. Our most influential theories and technologies are about ten seconds old! Even this table mapping forty-five years of our cosmic existence is based on an insight about nine seconds old. And I am typing this using a technology barely a second old!

Our reign on this planet looks set to continue for the foreseeable future--which is about twenty years when our sun will expand into a red giant4/ and life as we know it will come to an end. At least, so says the modern cosmology, which is about five seconds old!

Amusing as this thought exercise is, it has a much deeper point hiding beneath the surface. Certain theories in modern physics are extrapolations from a limited experience (or knowledge) to immense time scales. The big bang theory is an extrapolation of our insights in the last ten or so <u>seconds</u> to about 45 years. Should we really limit our quest for knowledge to the bounds of such incredibly large extrapolations? Richard Feynman's words [4] seem appropriate here: "We are only at the beginning of the development of the human race; of the development of the human mind, of intelligent life--we have years and years in the future. It is our responsibility not to give the

4/ See the life-cycle of a typical star in §6.3.2 – page 132.

answer today as to what it is all about, to drive everybody down in that direction and to say: ‘This is a solution to it all.’ Because we will be chained then to the limits of our present imagination.”

2.5 Unreal Time

Time does not exist the same way a physical object exists. In other words, time is a secondary sense without any direct sensory percept or reason for its existence. Does this mean that time is useless? Far from it. Mathematics is unreal the same way time is unreal, in the sense that it is a creation of our intellect, without corresponding to anything real. But it is supremely useful in our physical sciences. So is time. The true nature of time is something to be kept in mind in understanding its place in the foundations of physics. For instance, one way of looking at the time dilation in the special theory of relativity is to understand that time is merely a matter of definition. If time is a creation of our intellect, its measurement is open to interpretation--this is one reason why Einstein [3] could easily redefine the meaning of simultaneity.

Along with the notion of time come other intertwined concepts. One such concept is motion. Perception of motion is known in neuroscience to be an artifact created in a specific location of our brain. This fact was proven by the loss of the sense of motion as a result of a specific, localized brain lesion. Sensing motion is a mechanism that enhances our chance of survival. It is also connected with the indirect sense of time.

Causality is another fundamental concept that is intertwined with the flow of time. The reason special relativity does not permit faster-than-light travel is that such superluminal travel will break causality. In a universe where time is unreal, is causality real?

If time is unreal, why don't we feel it that way? The most likely reason is that we accept time before we learn to question it. A lot of the things that we accept before we are able to question them are difficult to relinquish (e.g., concepts of God and religion). Looking at "time" as a formal language and according it a proper place in the hierarchy of our knowledge system may bring some benefits in the form of a more objective understanding of the world and reality.

Chapter 7

Why the Speed of Light?

It is impossible to travel faster than the speed of light, and certainly not desirable, as one's hat keeps blowing off.

– Woody Allen

What is so special about light that its speed should figure in the basic structure of space and time and our reality? This is the question that has nagged many scientists ever since Albert Einstein published On the Electrodynamics of Moving Bodies [3] about 100 years ago. It also perplexed the humorous among us. Some years ago, I saw a Larson cartoon on Einstein. It showed Einstein trying to derive his famous equation. First he writes $E = ma^2$, then strikes it off and writes $E = mb^2$. He is not happy with that either. Finally, he writes $E = mc^2$ and decides to stay with it! Larson's dig is at the arbitrariness in the choice of the letter. The choice of the letter, by the way, is supposed to be from the Latin word celeritas, which means speed. Our question here is not very different on the surface. Why is it c, the speed of light? Why not the speed of something else? What indeed is so special about light?

7.1 Perceived Reality

In order to understand the specialness of light in our space and time, we need to study how we perceive the world around us and how reality is created in our brains. We perceive our world using our senses. The sensory signals that our senses collect are then relayed to our brains. The brain creates a cognitive model, a representation of the sensory inputs, and presents it to our conscious awareness as reality. Our visual reality consists of space, and our auditory world is made up of sounds. Just as sounds are a perceptual experience rather than a fundamental property of the physical reality, space also is an experience, or a cognitive representation of the visual inputs, not a fundamental aspect of "the world" our senses are trying to sense. Time, as we saw earlier, is an embellishment added in for no direct sensory reasons, but possibly due to our knowledge of our finite lifespan, or our brain's ability to reconstruct motion. Space and time together form what physics considers the basis of reality. The only way we can understand the limitations in our reality is by studying the limitations in our senses themselves.

At a fundamental level, how do our senses work? Our sense of sight operates using light, and the fundamental interaction involved in sight falls in the electromagnetic (EM) category because light (or photon) is the intermediary of EM interactions.1/ The exclusivity of EM interaction is not limited to our the long-range sense of sight; all

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1/ Recap of particle physics §6.2 (page 119): Electromagnetic interaction is one of the four kinds of interactions in the

the short-range senses (touch, taste, smell and hearing) are also EM in nature. To understand the limitations of our perception of space, we need not highlight the EM nature of all our senses. Space is, by and large, the result of our sight sense. But it is worthwhile to keep in mind that we would have no sensing, and indeed no reality, in the absence of EM interactions.

Like our senses, all our technological extensions to our senses (such as radio telescopes, electron microscopes, redshift measurements and even gravitational lensing) use EM interactions exclusively to measure our universe. Thus, we cannot escape the basic constraints of our perception even when we use modern instruments. The Hubble telescope may see a billion lightyears farther than our naked eyes, but what it sees is still a billion years older than what our eyes see. Our perceived reality, whether built upon direct sensory inputs or technologically enhanced, is a subset of electromagnetic

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Standard Model [30] of particle physics. It is the interaction between charged bodies. Like charges repel, unlike charges attract. Despite the electromagnetic repulsion between them, however, the protons stay within the tiny nucleus because of the strong interaction, whose magnitude is much bigger than that of EM interactions. Then there is the weak interaction. The last interaction the gravitational interaction, which is always attractive, and everything is subject to it.

particles and interactions only. It is a projection of EM particles and interactions into our sensory and cognitive space, a possibly imperfect projection.

This statement about the exclusivity of EM interactions in our perceived reality is often met with a bit of skepticism, mainly due to a misconception that we can sense gravity directly. This confusion arises because our bodies are subject to gravity. There is a fine distinction between "being subject to" and "being able to sense" gravitational force. This difference is illustrated by a simple thought experiment: Imagine a human subject placed in front of an object made entirely of cosmological dark matter.2/ There is no other visible matter anywhere the subject can see it. Given that the dark matter exerts gravitational force on the subject, will he be able to sense its presence? He will be pulled toward it, but how will he know that he is being pulled or that he is moving? He can possibly design some mechanical contraption to detect the gravity of the dark matter object. But then he will be sensing the effect of gravity on some

2/ From §6.3 (page 131): Dark Matter is non-luminous material proposed to explain the rotational speeds of galaxies. Computations based on the rotational speeds indicate that up to 90 percent of the matter in a typical galaxy is invisible. This invisible matter is called dark matter, and it can be detected using gravitational lensing, which is the bending of light rays in the presence of strong gravitational fields.

matter using EM interactions. For instance, he may be able to see his unexplained acceleration (effect of gravity on his body, which is EM matter) with respect to reference objects such as stars. But the sensing part here (seeing the stars) involves EM interactions. It is impossible to design any mechanical contraption to detect gravity that is devoid of EM matter. The gravity sensing in our ears again measures the effect of gravity on EM matter. In the absence of EM interaction, it is impossible to sense gravity, or anything else for that matter.3/

This assertion that there is no sensing in the absence of EM interactions brings us to the next philosophical hurdle. One can always argue that, in the absence of EM interaction, there is no matter to sense. This is exactly where our arguments are headed. In the absence of EM interaction, there is indeed no reality--no perceived reality. To put it differently, if we did not have senses that responded to EM interactions, there would be no reality. Reality is nothing but a cognitive representation of the sensory inputs in our brain, with light being the primary sensory input. Knowing that our space-time is a representation of the light waves our eyes receive, we can immediately see that light is very special in our reality. Its speed is a fundamental constant. However, this lofty status of light is only a part of our unreal universe, not of the absolute reality.

3/ This inability to measure gravitational interaction by itself is related to the strong equivalence principle of general relativity. But GR is beyond the scope of this book.

7.2 Gauge Boson of Our Senses

As we saw earlier, the fundamental interactions are modeled as fields with gauge bosons4/ in quantum field theory. In quantum electrodynamics (the quantum field theory of EM interactions), photon (or light) is the gauge boson mediating EM interactions. Electromagnetic interactions are responsible for our sensory inputs. Sensory perception leads to our brain's representation that we call reality. Any limitation in this chain leads to a corresponding limitation in our sense of reality.

One limitation in the chain from senses to reality is the finite speed of photon, which is the gauge boson of our senses. The finite speed of the sense modality influences and distorts our perception of motion, space and time. Because these distortions are perceived as a part of our reality itself, the root cause of the distortion becomes a fundamental property of our reality. This is how the speed of light becomes such an important constant in our space-time. The sanctity of light is respected only in our perceived reality.

Another limitation of our perception of reality is the fact that we can sense only EM particles and interactions. The reason we can

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4/ From §6.2 (page 119): In quantum field theory, each interaction consists of emitting a particle and absorbing it in an instant. These so-called virtual particles emitted and absorbed are known as the gauge bosons that mediate the interactions.

sense only EM interactions is not that it is a long-range force, but that we have sensory mechanisms that respond to it. The reason we can sense gravity, on the other hand, is that it acts on matter that we can sense using EM interactions. Thus, gravity is sensed only through its interactions with matter that also has EM interactions. The same is true of the inferred strong interaction because the particles interacting using strong force have EM interactions as well; protons attract electrons; quarks are charged.5/

Just because we sense only an EM universe does not mean it is the only universe out there to be sensed. It is entirely possible that there are other kinds of interactions and particles with no coupling to the EM universe, which form parallel universes. There may be intelligent beings in such parallel universes with their own modes of sensing, and consequently, their own private perceived realities or unreal universes.

We can also look at the limitations of our senses and reality from the point of view of evolutionary biology. Our senses are best suited to the purpose of the DNA replication algorithm that our bodies are running. Sensing the cosmos has no evolutionary advantage, hence the senses are not suited for that purpose. Thus, our senses (or our

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5/ This coupling between the strong and EM interactions provides a plausible philosophical reason for quark confinement--the quarks are confined to color singlet states because we cannot directly sense color.

technological extensions to them) are imperfect tools to perceive the universe. If we trust the imperfect perception and try to describe what we sense at cosmological scales, we end up with views of the world such as the big bang theory in modern cosmology and the general and special theories of relativity. These theories are not wrong, and the purpose of this book is not to prove them wrong, just to point out that they are descriptions of a perceived reality. They do not describe the physical causes behind the sensory inputs. The physical causes belong to the absolute reality.

7.3 Theories beyond the Limits

Physics is a pragmatic science. It takes our perception of reality for granted and builds equations that work in this perceived reality. This trust in our perception is the basis of the world view called scientific realism, which is not only at the core of sciences but is our natural way of looking at the world as well. Scientific realism has helped physics tremendously, with all its classical theories. However, scientific realism and the trust in perceived reality should apply only to the useful ranges of our senses. Within the ranges of our sensory perceptions, we have fairly intuitive physics. An example of an intuitive picture is Newtonian mechanics that describe "normal" objects moving around at "normal" speeds.

When we get closer to the edges of our sensory modalities, we have to modify our sciences to describe the reality as we sense it. These modifications lead to different, and possibly incompatible, theories. When we try to apply our picture of perceived reality to a realm where our senses do not function, we have to be extremely careful about the physics we create there. It is when we try to extrapolate physics to the reality beyond the useful ranges of our senses that we begin to get non-intuitive theories. Thus, we have quantum mechanics at length scales below our perception and relativity at speed scales way above our perception. Here is a look at some of the theories beyond our perception:

Special Relativity applies at speeds much greater than we can sense. The major physical assumptions in this theory are the constancy of the speed of light, along with the homogeneity of space and time.6/ As a result of these assumptions, we get a time that is stretchable (or shrinkable) and we lose the concept of simultaneity. Mathematically, special relativity amounts to defining a different metric for the space-time. The philosophical

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6/ Recap of relativity §6.1 (page 107): Einstein's Special Theory of Relativity is built on two postulates. (1) the laws of physics remain the same for any frame of reference. (2) the speed of light is constant in all inertial frames. The speed of light being a constant in all inertial frames at the same time leads to various intriguing effects, such as time dilation and length contraction. Mathematically, this constancy postulate in special relativity maps c to ∞.

basis of special relativity is scientific realism; the notion that reality as we sense it is the absolute reality.

Cosmology handles large length scales, well beyond our sensory limits. Cosmology is built on the special (and general) theory of relativity. The philosophical assumption is the same as before, that what we sense is the absolute reality.

Quantum Mechanics is the theory that handles size scales well below our perception. Quantum mechanics is heavily used in particle physics along with special relativity. The physical assumptions involved in quantum mechanics are more ad hoc and nebulous than those in special relativity and cosmology. The philosophical assumption of quantum mechanics is far more interesting. In quantum mechanics, our ability to sense anything is limited by the Heisenberg uncertainty principle. The process of our sensing, or observation, changes the state of the system.

Along with our inability to sense and specify everything about a physical system, all systems are probabilistic in nature. Specifying the state of the system at a given instant is not enough to predict all the future states, and classical determinism is lost. This radical departure in the philosophical assumption has far-reaching consequences. Among other things, it negates a God who is capable of controlling every aspect of the universe at all times--a consequence that led to the famous protestation from Einstein: "God does not play dice with the universe."

Quantum mechanics is a perfect example of physics beyond the limits of our perception, but its relevance to the arguments in this book ends there.

All these different theories are descriptions of our sensed reality beyond our sensory limits. More importantly, they handle different limits on our perceived reality. This fundamental difference in their domain of applicability is the possible reason why a unification of different theories has proved troublesome for so long.

7.4 From the Unreal to the Real

As we saw in chapter §5 (page 84) discussing philosophy, it is possible to argue this idea of absolute reality and sensed reality from a philosophical point of view. In fact, almost all branches of philosophy grapple with this issue to some extent. Metaphysics and epistemology in the Western philosophy and the spiritual lines of Eastern philosophies (Indian and Zen) tackle the unrealness of reality head on.

When such a spiritual or philosophical insight makes its way into science, great advances in our understanding can be expected. This convergence of philosophy (or even spirituality) and science is beginning to take place, most notably in neuroscience, which views reality as a creation of our brain. Physics has not yet come completely to terms with this notion, but the effects due to the finite speed of light are well known. We know, for instance, that what we see happening in distant stars and galaxies now actually took place quite awhile ago.

We will explore some more "advanced" effects due to the light travel time in the following chapters. In this chapter, we showed that the lofty status of light and its speed in our space-time is due to the fact that our reality is a reality created based on light inputs.

How do we guess the nature of the absolute reality from what we experience, our perceived or phenomenal reality? Is it possible to go from the unreal to the real? This is a tricky question: the answer is yes and no. For example, we saw (§3.5.1 – page 50) that the experience or the sensation of sound was, in fact, an incredibly distant representation of the physical cause--namely air pressure waves. We are aware of the physical cause because we have a more powerful sight sense. Is the physical cause (the air pressure waves) the absolute reality? Not really. Air pressure waves are still a part of our perception; they are part of the intellectual picture we have come to accept. This intellectual picture is an extension of our visual reality, based on our trust in the visual reality and our acceptance that the constructs and concepts in physics are real. This extension also represents our acceptance of scientific realism as our philosophical stance.

The new extension of reality proposed in this book, again an intellectual reality, is not based on scientific realism. This intellectual reality is an educated guess. We guess the nature of reality and predict what the consequent perceived reality should be. If the predicted perception is a good match with the perception we experience, then the guesswork is taken to be fairly accurate. The consistency between the predicted perception and what we do perceive is the only validation of the guess on the nature of the absolute reality. Furthermore, the guess is only <u>one</u> plausible absolute reality; there may be different such "solutions" to the absolute reality all of which end up giving us our perceived reality.

As we can see from the preceding paragraph, we have different layers of reality that we handle without being bothered by their incompatibilities. In the case of sounds, we have the auditory reality of tones and intensities, the visual reality of a vibrating body or a falling tree, and the intellectual reality of air pressure waves. It is a mistake to think of the qualities of our subjective experience of sound for the properties of the underlying physical process. In an exact parallel, it is a fallacy to assume that the subjective experience of space and time is the fundamental property of the world we live in. The space-time continuum, as we see it or feel it, is only a representation of an unknown physical universe.

Most of physics works in an "extended" intellectual reality, with concepts such as forces, light rays, atoms, particles and so on. When we ascribe the natural limitations of our senses and the consequent limitations of our reality to the fundamental nature of reality itself, we end up introducing complications in our physical laws. Our physical laws are descriptions of this unreal universe; they do not apply to the absolute physical reality. This is not to say that our physical laws are wrong or useless, just that they describe the <u>perceived</u> reality. The distinction between the absolute reality and our perception of it is further developed in the chapters that follow, and it is applied to certain specific astrophysical and cosmological phenomena. When it comes to the physics that happens well beyond our sensory ranges, we really have to take into account the role that our perception and cognition play in seeing them. The universe as we see it is only a cognitive model created out of the photons falling on our retina or on the photosensors of the Hubble telescope. Because of the finite speed of the information carrier (namely photons), our perception is distorted in such a way as to give us the impression that space and time obey special relativity. They do, but space and time are not the absolute reality. They are only a part of the unreal universe that is our perception of an unknowable reality.

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Research Interests

Astrophysical and cosmological phenomena, foundations of physics.
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Education

Syracuse University, Syracuse, New York, USA
Ph.D. in Experimental High Energy Physics (August 1993)

Indian Institute of Technology, Madras, India
B.Tech., Electronics Engineering (July, 1987)

Career History

Standard Chartered Bank, Singapore
Associate Director **Since October, 2007**

Team lead and Senior Quantitative Developer for the Front Office Quant Integration team (of three to five quantitative developers) for adapting and integrating pricing models developed in-house for Front Office deployment.

OCBC Bank, Singapore
Vice President, Market Risk Management **October, 2005 to September 2007**

Lead a team of quantitative analysts for financial model validation, assessment of the bank's value at risk, and develepment of in-house risk analysis and product valuation tools. In-depth expertise in stochastic pricing models and their implementation, experience validating Murex, Kondor+ systems.

Institute for Infocomm Research (I^2R), Singapore
Associate Lead Scientist **April, 2003 to October, 2005**

Neuro-Informatics: Research and development on Brain-Computer Interface. Designed and implemented a BCI system using Near Infrared Spectroscopy (NIRS), being used at the Tokyo Institute of Psychiatry, Japan and Eberhard-Karls-University of Tübingen, Germany. Developed EEG based systems, awarded Samsung Digit*All* Hope grant. Several peer-reviewed articles.

Laboratory for Information Technology (LIT), Singapore
Research Scientist **April 2002 to March, 2003**

Physiometrics: Bio-signal analysis for new biometric features. Analyzed ECG and bio-impedance data and discovered identifiable characteristics in bio-signals and measurements. Patent filed.

Kent Ridge Digital Labs (KRDL), Singapore
Associate, Research Staff **September 1998 to March, 2002**

BodyNet: Developed a low voltage, robust and safe communication system over human body using on-off keying. Developed a prototype and filed patent.

Wearable Computing: Analysis and detection of irregular activities using a wearable system. Developed an accelerometer based tug detection system in intelligent attire. Patent filed.

CPPM, Marseilles, France and **CERN**, Geneva, Switzerland.
Research Engineer, CNRS, France **September 1993 to July 1998**

Vertex Detector: Research and development of the precision tracking device Vertex Detector) for the ALEPH experiment, including a detailed simulation and analysis package modeling the track energy deposits and random noise.

Developed a rigorous mathematical treatment of the alignment errors in the detector resulting in a near perfect agreement between the data and simulation. Numerous publications.

Syracuse University, Syracuse, **Cornell University**, Ithaca, New York, USA.
Graduate Assistant **August 1987 to August 1993**

Detector development and detailed modeling, data analysis to answer specific problems in high energy physics. **Dissertation Research:** Measured the partial widths of transitions between different $b\bar{b}$ quarkonia through neutral dipion channel analyzing the e^+e^- collision data at center-of-mass energy equal to the $\Upsilon(3S)$ mass taken at Cornell Electron Storage Ring facility using the CLEO II detector.

Studied the inclusive production of D, D^* and ϕ mesons in B decays and measured their spectra analyzing e^+e^- annihilation data taken at the $\Upsilon(4S)$ region.

Honors and Awards

January 2008 Singapore. TV coverage (Channel 5 and Channel News Asia) commenting on the subprime crisis and economic outlook.

January 2008 London. Featured in the cover story of the Wilmott Magazine, commenting on the volatile year as a quantitative finance expert.

December 2004 Singapore. TV coverage on the Brain-Computer Interface research results, 11 minute program on Channel News Asia.

November 2004 Singapore. Samsung Digit*all* Hope award (research grant) and local TV news coverage on Channel i.

Best paper award at MEDSIP'04, Malta.

September 2004 Singapore. Coverage in the Straits Times newspaper on Brain-Computer Interface.

November 1995 CPPM, Marseilles, France. Chosen by the French National Center for Scientific Research (CNRS) as Ingenieur de Recherche (Research Engineer) following an open nation wide competition.

Fall 1987 – Summer 1993 Syracuse University, USA. Graduate Assistantship and Tuition Scholarship awarded on the basis of the academic merit.

Summer 1983 Trivandrum, India. Ranked 63rd in India in the Joint Entrance Exam (out of about 75,000 students).

Summer 1982 Trivandrum, India. Ranked 3rd in the state of Kerala, India in the Engineering Entrance Exam (out of about 10,000 students).

Selected Publications

Over 200 peer-reviewed articles.

Regular columnist for the *Wilmott Magazine* (London), the *Today* paper (Singapore).

M. Thulasidas, "The Philosophy of Special Relativity: A Comparison between Indian and Western Interpretations," *Omega – Indian Journal of Science and Religion* Vol. **VI** No. 2 (Dec. 2007) pp. 138–150

M. Thulasidas, "Are Radio Sources and Gamma Ray Bursts Luminal Booms?" *International Journal of Modern Physics – D* Vol. **16** No. 6 (June 2007) pp. 983–1000

M. Thulasidas, "Perceptual Effects in Relativity and Astrophysics," *Gal. Electrodynamics* (To appear in 2008.)

M. Thulasidas *et al.*, "Robust Classification of EEG Signal for Brain-Computer Interface," *IEEE Tran. Neural Systems and Rehab. Engineering* Vol. **14** (2006) pp. 24–29.

M. Thulasidas *et al.*, "Robust classification of event-related potential for brain-computer interface," *Proc. Intl. Conf. Advances in Medical Signal and Information Processing, Malta*, (2004) pp. 321–326 (***Best paper award.***)

D. Creanza *et al.*, "The new ALEPH silicon vertex detector," *Nucl. Instrum. Meth.* Vol. **A409** (1998) pp. 157–160.

CLEO Collaboration, L. Gibbons *et al.*, "The inclusive decays $B \to DX$ and $B \to D^*X$," *Phys. Rev.* Vol. **D56** (1997) pp. 3783–3802, `hep-ex/9703006`. (PhD Thesis project.)

CLEO Collaboration, F. Butler *et al.*, "Analysis of hadronic transitions in $\Upsilon(3S)$ decays," *Phys. Rev.* Vol. **D49** (1994) pp. 40–57. (PhD Thesis project.)

Others

Nationality:	Singapore
Languages:	Fluent in English, French and Malayalam. Fair in Hindi and Tamil.
Computer skills:	Applications ranging from Office suites to video editing, research tools (Mathematica/Matlab) to development environments (Visual Studio), page layout (LaTeX) to operating systems (Linux), programming languages (C#, C++, C, Fortran, Pascal, HTML, XML, assembly level...) to hardware and networks.
Hobbies:	Badminton, writing, pool, chess, swimming, physics, computers and gadgets.