



SANTHOSH MATHEW

ESSAYS ON  
THE FRONTIERS  
OF MODERN  
ASTROPHYSICS  
AND COSMOLOGY

 Springer

PRAXIS

# Essays on the Frontiers of Modern Astrophysics and Cosmology

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Santhosh Mathew

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SPRINGER–PRAXIS BOOKS IN POPULAR ASTRONOMY

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*To the memory of Noah Mathew, who departed us 3 years ago.*



# Foreword 1

By Debra Leahy

What if our construct of time ran circular, or from side to side, rather than in a strictly linear fashion? What if a movement as small and precise as a butterfly flapping its wings in South America affected the weather in Central Park? These questions represent just a sampling of the provocative inquiries posed by Santhosh Mathews as he leads his readers through a journey as much about philosophy as it is about science, and, ultimately, about the human abilities of perception and imagination.

Central to Mathew's narrative is his weaving of Eastern philosophical beliefs, most notably Hinduism, and scientific reasoning. For some, the blending of these will be novel, while for others, this book will mark a continuation of a journey to understand how these two perspectives influence, counter, and complement one another. Throughout the book, scientific voices and views are brought to the forefront, such as Hawkins, Penrose, Newton, Dirac, and Einstein. While the invocation of these essential scientific thought leaders is not surprising, the seamless ways in which they are interwoven with a diverse array of voices and images, ranging from Shakespeare to Faulkner, from Pope to Frost, and from Picasso to Dali, along with the philosophical underpinnings associated with Brahma, Shiva, and Vishnu, are both enlightening and inspiring.

Science and philosophy are often perceived as opposite lines of thought; however, isn't it through the juxtaposition of seemingly opposing ideas that the true existence of both becomes more vivid? In bringing these voices together, Mathew shows how, in many cases, these modes of thought have been shown to be mirrors of one another. For instance, Mathew discusses how human, universal themes, such as the desire for good to prevail over evil, appear in science, through the analysis and beliefs related to matter versus anti-matter, and are also reflected in Hinduism, such as the conflict between Devas and Asuras, and additionally all the way up to contemporary fiction, such as *Angels and Demons*. By positioning these universal themes side by side, reflective images are revealed and we begin to view them as a continuum that narrates the depth and breadth of human history.

Mathew also demonstrates how, in other cases, philosophical beliefs and scientific reasoning have proven to be windows to one another. As patterns are detected and explored in science, and are checked against philosophy, scientific hypotheses gather further validity.



And, as scientific ideas and discoveries draw humans closer to universal truths, the infinite possibilities inherent to philosophy remind us that the answers that we seek are not arrived upon with any semblance of ease and may, in fact, be beyond our grasp. Perhaps the greatest homage that Mathew pays to the window offered through philosophy occurs when he reminds us that many scientists have turned to ancient Eastern texts to test their assumptions and widen and expand their imaginative sources of inquiry.

Readers are reminded of the small, insignificant place that humans hold in the vast expanse of the universe. Throughout the book, humans are the actors who advance science, but, at the same time, readers are continually reminded that the roles played by humans are minute and transient. How can we fully explain existence and meaning when we cannot even fully discern when life, as we know it, began? Although humans are imbued with a narrative that spans back far before their individual birth, the existence of any individual person will leave only an infinitesimal mark on a universe that is infinite.

Although critical scientific history and significant moments of discovery are clearly discussed throughout the book, Mathew continually juxtaposes the satisfaction of discovery and new knowledge with the wonder and beauty of the undiscovered and the unanswered; in doing so, he often holds the latter up as being more divine. Mathew's book presents its readers with a view of the universe as infinite, inviting, and inspiring. Yet, while the universe that Mathew presents is magnificent, it contains a deep narrative that is not yet fully written.

Mathew shows that humans have an inherent desire for knowledge and truth; yet, this has only led to more questions than answers. It is human nature to seek empirical truths and to crave outcomes. Yet, Mathew shows that *enlightened* humans desire questions over simple answers and see beauty and opportunity within continual inquiry. In this latter, more enriched quest, answers are found in less than expected places. Can we understand more from silence than sound, more from what is absent rather than what is present, and more from ancient texts than cutting-edge information? Mathew ponders all of these questions and invites the readers to do the same.

However, in Mathew's journey, there are no absolute outcomes or answers, and, in that space, we rejoice. Beauty lives in inquiry, and it lives in process over outcomes; it lives in wondering not how something works but why something works. Imagine a world where we are more comforted by what we don't know than what we do know. Imagine a world where skepticism was the positive choice that ignited imagination in infinite ways. Imagine a world where a simple algebraic equation holds answers to some of life's most pressing existential questions. Imagine a world where we do not accept convention with ease and where we are not held captive to time, measurement, distance, or borders. Mathew envisions that world and presents it to his readers throughout his book, and we are better for seeing it in such a fluid, unfixd way and through multiple lenses.

In a period where we are experiencing access to more information than ever before, this book is a gift to the reader who wishes to be a responsible steward of that immense array of information and use it to advance inquiry rather than accept the semblance of truth so readily at our fingertips. Mathew extends an invitation to take this mode of inquiry and pass it to the generations beyond us. Like his aptly titled chapter that begins with "Once upon a time," his narrative is meant to be passed on.

What will future generations think when they ponder the mark that we have left, albeit small in scope, on this universe? With each chapter we add or subtract a brick to our warehouse of collective understanding, Mathew suggests that we play our role as architect, teacher, and fellow explorer to the generations to come. The present generation has the gift of being able to inspire the joy of wondering and questioning from schoolchild to schoolchild. Mathew's book is just one tool in that arsenal, and his readers are encouraged to use this book to its fullest potential as one way to encourage future generations to their fullest potential.

*Boston, MA, USA*  
July 2, 2012

*Debra Leahy*



## Foreword 2

By Ishwar K. Puri

Chinese mythology describes a prehistory during which the Heavens and Earth were intermingled in an egg-shaped cloud. The Mossi of Africa believed in an initial phase devoid of matter and time, thus circadian rhythms. The Hindu Upanishads refer to a beginning when there was nothing. Such philosophical ruminations about our inception and origin have consumed us for millennia.

The American Hopis speak of four original couples. Each of these couples spoke a different language, but all four understood the others. Their progeny spread over the world and lived harmoniously. Over time, though, the groups separated, as they dwelt more on their differences than their similarities.

Such separations lead to dissolution. In 1854, President Franklin Pierce demanded of the Northwest Duwamish tribe that the U.S. government receive two million acres of their land. A resigned Chief Seattle responded, “No, we are two distinct races and must ever remain so. There is little in common between us.” But he also said, “We *may* be brothers, after all. We shall see.”

At an atomic and cosmic level, we are all one with our universe, which, in turn, is also part of us. Then, while yearning for an understanding of our existence, why do we embrace different answers, often stridently? Why do we separate from each other when we are able to reassemble and prosper?

Clearly, many forces can separate us from one another. However, since there are many more that bind us together, one can only hope that a common understanding of our inception will strengthen our bonds and fray our disagreements.

Modern science has led to a more thorough explanation about our origins. However, its pursuit has also led to many new questions. These delightful essays that describe our current understanding of the universe are therefore timely.

Intertwining cosmology and astronomy with philosophy, the themes are eloquently covered and provide a common understanding in an accessible manner for most readers. As a result, this book makes for a wonderful read.

As our scientific understanding advances, so does our society. What had previously seemed impossible becomes likely. It took about 1,400 years from the time of Ptolemy in AD 150 to Copernicus in the year 1543 to advance a geocentric view of the world to one that was heliocentric.

In the book, our author quotes Vera Rubin, whose work established that galaxies contain dark matter. “In a spiral galaxy, the ratio of dark-to-light matter is about a factor of ten. That’s probably a good number for the ratio of our ignorance-to-knowledge. We’re out of kindergarten, but only in about third grade.”

Look what we’ve been able to do as a result of realizing that our Earth revolves around the Sun. Imagine then what we’ll be capable of when we are able to more clearly understand the workings of our universe.

*Blacksburg, VA, USA*  
July 5, 2012

*Ishwar K. Puri*

# Preface

“I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.”

– Isaac Newton

As a child, I grew up in the southern Indian state of Kerala, where the only thing that can come from the sky is the raindrops. However, the year 1979 changed that notion. One of the events I still remember vividly is the falling of Skylab scattering debris across the southern Indian Ocean and sparsely populated western Australia. Weeks before its descent from the orbit, where it had been in action for 6 years, there was mounting speculation over where the spacecraft would come down. My hometown newspaper and the radio had been constantly providing information about Skylab and the consequence of its imminent plunge. Even when people were discussing their gruesome fate in the event of it falling over our hometown, I had only one question in my mind: Why is it coming down?

The local priest in my hometown, as usual, offered a divine explanation linking the plunge of Skylab to the fulfillment of the scriptures and God’s retribution for humankind’s efforts to voyage into space or reach for the stars. He used this opportunity to exhort people to be more faithful, and embrace the holy wisdom that has been on a decline, a sign of apocalypse in his view. Although the neighboring Hindu temple had a special Puja<sup>1</sup> to divert the path of Skylab, not surprisingly the leftists in the state were enthused by the apparent fall of an American spacelab.

The only logical answer, which I partially remember now, came from my brother Abraham Mathew, who was an undergraduate student those days. He tried to explain the fierce competitive space programs Americans and Soviets were engaged in, and this was the result – Americans losing control of their spacelab. Truly, this was a convincing example of how the laws of nature can be characterized by the customs and beliefs of people,

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<sup>1</sup> Puja is the act of showing reverence to a God, a spirit, or another aspect of the divine through invocations, prayers, songs, and rituals.

and how it can have a profound impact on the way science is perceived among the different segments of a society.

Nevertheless, it took me many years to fully recognize the fact that the force that pulled down Skylab is the same force that brought down a coconut tree nearby my home a couple of days before this event or, later on, to appreciate the omnipresent force of gravity that creates all the structures of the universe like a cosmic sculpture. Yet, the same force of gravity destroys the very same structures it once made in a never-ending process that has been going on since the beginning. But, this event was an enormous learning experience for me.

As I quoted Newton above, I am still a boy looking at the great ocean of the universe to which we all are linked in many ways. "We are made of star stuff," said Carl Sagan, and his influential words still resonate in my heart. When my thoughts ponder over the universe, it's a perfect moment of joy and contentment. However, deeper efforts are needed to know the universe, and that process helps us to know ourselves better.

This book is a collection of 12 essays on different topics that I have written in the past 2 years. This is my earnest effort to share with you the underpinnings of the magnificent cosmos where you and I are given a chance to exist briefly. I have avoided technical jargon and mathematical equations, except where absolutely necessary, to reach readers across the spectrum.

One of the fundamental questions I like to ask myself and in turn share with my readers throughout the book is the meaning of the laws of nature and our ability to comprehend them. To begin to understand, for example, that the force pulling on terrestrial objects is the same as the force that keeps the celestial structures is to understand an unimaginably powerful tool in science.

While modern science is able to answer some of our queries, it also poses many new questions. My approach was to intertwine cosmology and astronomy with philosophy and mythology, as these seemingly different schemes of thoughts provide a stimulating intellectual exercise.

I have to confess that the tenets of religion and mythology cannot fit into the rational and coherent framework of science; yet, the fundamental questions posed in any stage of human evolution are reflective of our curiosity at large.

Why do we seek answers or ask questions?

Some would argue that many cosmological studies transcend any practical purposes. True, but our species is distinct from any other because of our ability to ask questions and think beyond mere survival and procreation. Practical purposes change from time to time, not the fundamental science. We are here, it seems, to know our universe and thus ourselves better.

We live in an exciting time where our world is changing rapidly. Our scientific voyage is becoming more and more intriguing, where the minute particles such as the Higgs boson and the planets beyond our Solar System are no longer just pure dreams. Armed with imagination and curiosity, our species is on a journey that, I consider, is more enjoyable than the destination. This book is an attempt to join that great scientific expedition, and I hope you will be part of that journey along with me.

I believe that this book will mark a tiny footprint on the vast sand of space and time even as our sublime lives depart to become part of the grand cosmos.

I hope that you enjoy reading it.

*Santhosh Mathew*  
July 2013

# Acknowledgments

This book would never have been a reality without the help and support of many people. Apart from my own effort, the success of this book depends largely on the encouragement and guidance of many others. In that respect, a great debt of gratitude is due to many people who supported me throughout the process of writing this book.

I am indebted to my friends and colleagues for their valuable time and suggestions in preparing many topics. Many individuals from the community have inspired and encouraged me since I began writing, and I express my gratitude to all of them.

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Thank you to all who are drawn to read this book. Finally, I want to thank all those who provided support, talked things over, read, wrote, offered comments, and assisted in the editing, proofreading, and design.

I hope these essays will inspire you to learn about the unknown facets of the known universe and empower you to explore the meaning of existence.

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## About the Author

**Santhosh Mathew, Ph.D.**, is a professor, researcher, and science writer. He has written extensively on scientific topics of popular interest. His regular science blog can be found at <http://www.huffingtonpost.com/santhosh-mathew-phd>. His writings on science and Eastern philosophy have been widely read. His research interests include developments in modern physics, mathematics, and cosmology.

