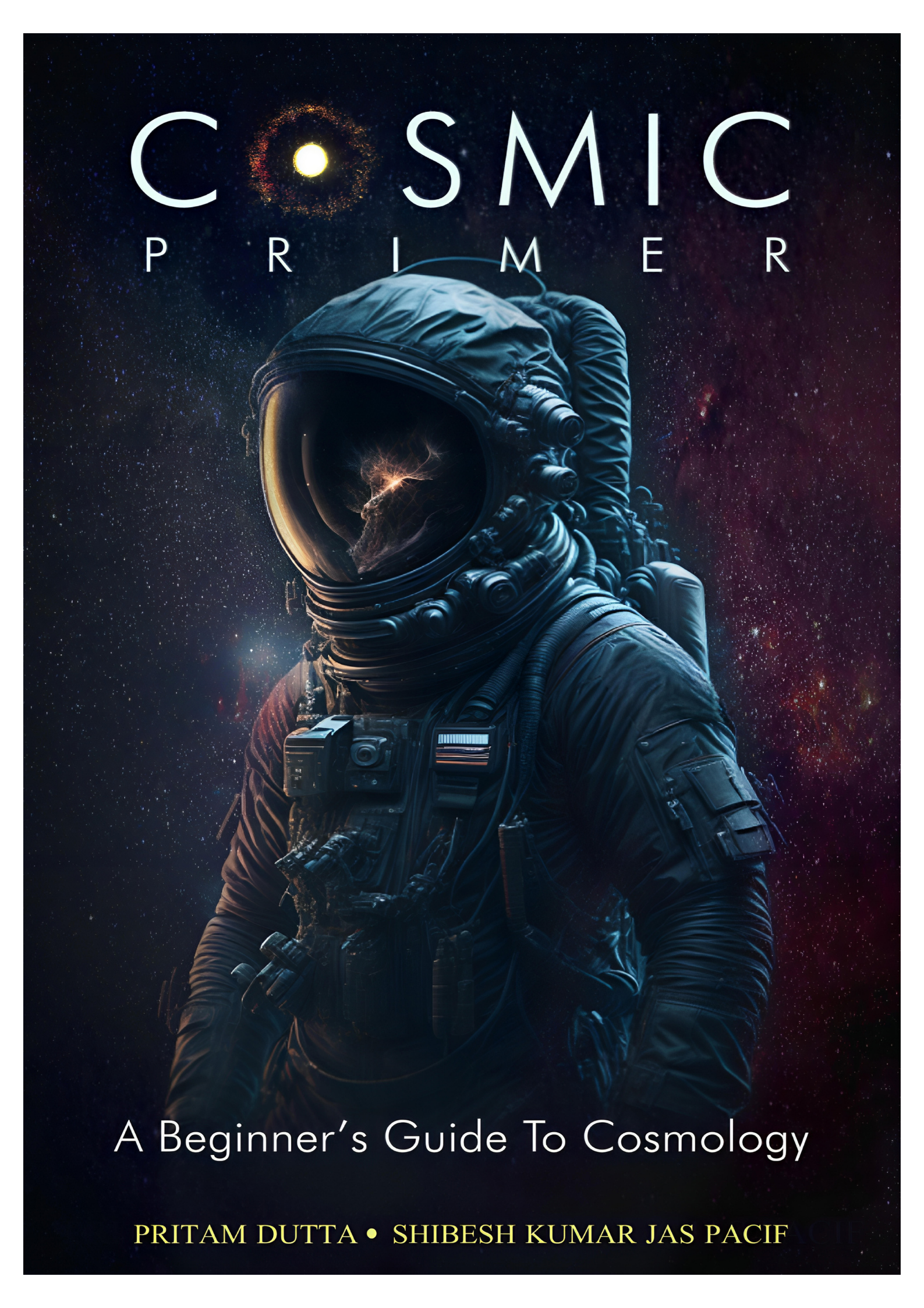
COSMIC PRIMER



A Beginner's Guide To Cosmology

PRITAM DUTTA • SHIBESH KUMAR JAS PACIF

Cosmic Primer

A Beginner's Guide to Cosmology

First Edition

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Foreword

Cosmology deals with the ultimate mysteries of our universe its origin, evolution and eventual fate. What is the origin of the universe? How has it evolved over time? What is our place in the universe? Cosmology is a vast and fascinating subject, and questions like these have captivated people for centuries. The term Cosmology conjures excitement, but also the concern that such a topic is bound to be hard to comprehend. I am happy to introduce to you this book, a primer on Cosmology, which provides a comprehensive discussion on the topic, in a very clear and accessible style. It is suitable for readers with a variety of backgrounds. Whether you are a student, a teacher, or simply someone who is curious about the universe, this book will give you a fascinating view about cosmology. It covers all the major topics in the field, starting from ancient astronomy to the Big Bang theory, the formation of galaxies and stars, cosmic structures and cosmological modelling, and the elusive mysteries in the field such as dark matter and energy. The authors are remarkable in their passion towards Cosmology and their knowledge of the subject. Pritam Dutta, working with Dr. Shibesh, is a phenomenal researcher, possessing a passionate and expert knowledge of a subject as complex as cosmology. Dr. Shibesh Kumar Jas Pacif, as well as being a professor of Cosmology is an active science communicator. As an astronomer myself with many years of experience of working at NASA as well as at the educational organization STEM & Space in India, I have had the pleasure of being associated with his passion for science outreach. He tirelessly strives to engage the scientific curiosity of students. The two authors have collaborated to siphon their knowledge of this complex subject into this comprehensive book written in a

very engaging style. In recent decades, cosmology has made incredible progress. This book describes the evolution of cosmology interweaving it with advances in observational astronomy and theoretical physics, which has led us to a much better understanding of the universe. I have had the privilege to be associated with NASA's Cosmic Background Explorer (COBE) project which confirmed the presence of the Cosmic microwave background. Such notable milestones which have observed and confirmed major theoretical conjectures are highlighted in this book – such as Gravitational waves, exoplanets, James Webb Space telescope's achievements, experiments such as Large Underground Xenon (LUX), Cryogenic Dark Matter Search and the Dark Energy Survey (DES) which will try to unravel the mysteries of Dark matter and Dark energy. As you read this book, you will encounter many thoughts about the universe. Cosmology is a rapidly evolving field, and new discoveries are being made all the time. You may find answers to some of the questions you have about the universe or it may trigger your curiosity further. Cosmology is a journey of exploration and discovery, and I hope that this book will inspire you to delve deep into this amazing subject.

Dr. Mila Mitra
Astronomer
Co-Founder and Academic Head
STEM & Space
Formerly Scientist at NASA

To the Readers...

Dear Readers,

This book "Cosmic Primer - A Beginner's Guide to Cosmology" is dedicated to you, the seekers of knowledge, the dreamers of the cosmos, and the curious minds eager to embark on a journey through the vast expanse of the universe.

The pages of this book is a gateway to the mysteries of the cosmos for those taking their first steps into the enchanting realm of cosmology. It's an invitation to join on a voyage through the universe, where we explore the birth of stars, the enigma of black holes, the expanding universe, and the building blocks of the matter in the universe. We will encounter galaxies that dance through space, uncover the stories of ancient light, and journey back in time to the very moment of origin.

"Cosmic Primer" is a road-map to the researchers, who just started theirs Master or Doctoral studies. With clear explanations, stunning illustrations, and a passion for sharing the awe-inspiring wonders of the cosmos, we hope to ignite your curiosity and empower you to grasp the fundamental concepts of cosmology.

Thank you for embarking on this cosmic journey with us. Happy reading!

Best Regards,
Pritam Dutta
Shibesh Kumar Jas Pacif
&
Iterative International Publishers (IIP)

Preface

The innate curiosity that drives us to explore the mysteries beyond our celestial sky, to understand the origins of everything, and to contemplate the vastness of this world leads us on an exhilarating journey into the exciting field of study “cosmology” Study of the origin, evolution, structure formation, dynamics, and the ultimate fate of the universe.

Our journey begins with an “Introduction to Cosmology,” offering you a solid footing in the subject’s fundamentals. We then delve into “Historical Perspectives,” tracing the evolution of cosmological thoughts from ancient Mesopotamia to the Newtonian Revolution and beyond. You’ll witness the emergence of the “Expanding Universe,” as we explore the groundbreaking work of Edwin Hubble and the existential reflections it has inspired.

The heart of our exploration lies in "The Big Bang Theory," where we uncover the quest for cosmic origins and the first moments of our universe. We navigate through the mysteries of gravity and gravity theories, from Newton’s insights to Einstein’s groundbreaking theories of relativity.

As we journey further, we delve into the “Evolution of Cosmic Structures,” investigating the life cycle of stars, the Milky Way galaxy, and the cosmic web of large-scale structures. We also encounter high-energy phenomena like black holes, neutron stars, quasars, and gravitational waves.

The “Cosmic Microwave Background” introduces you to the cosmic relic of the Big Bang, and "Cosmological Modeling" explains how we construct models to understand the

universe's evolution. Finally, we explore the enigmatic realms of "Dark Matter and Dark Energy" and peer into the future of cosmological research.

This book is a guide to understanding the cosmos, a journey of exploration and discovery. It is designed to make the complex simple, the distant accessible, and the unknown exciting. As you read these pages, we hope you'll embrace the wonder of the universe and find inspiration to gaze at the night sky with a newfound sense of wonder.

This introduction is your road map whether you're an astronomer staring through a telescope or a daydreamer who has looked up at the stars and thought about the cosmos.

Keep in mind that we are all cosmic travelers as we navigate these cosmic pages. Beyond the arbitrary distinctions between our respective countries and flags, our shared humanity unites us. Our ability to think deeply about the deep mysteries of the cosmos and our shared curiosity define who we are as a species. Let us therefore paint the concepts of cosmology into the canvas of our understanding, connected by our shared humanity and propelled by our shared desire to comprehend the cosmos.

Welcome to "Cosmic Primer."

Acknowledgment

We express our gratitude to the global community of researchers and scientists for generously sharing their data and information, which greatly enriched our research. We extend our special thanks to the following individuals for significant contributions to this manuscript in the form of reviews, comments, feedback, and suggestions: Margarita Safonova, Indian Institute of Astrophysics, Benguluru ; Prof. Pradyumn Kumar Sahoo, BITS-Pilani, Hyderabad; Prof. Arbab Ibrahim Arbab, Qassim University, Saudi Arabia; Dr. Mila Mitra, Co-founder and Academic Head of Stem and Space, and Formerly Scientist at NASA; Dr. Priya Hasan, Assistant Professor at Maulana Azad National Urdu University, Hyderabad for their invaluable manuscript reviews. Additionally, we acknowledge Ayush Phiyak, Harshwardhan Pathak and Yukterez for their outstanding contributions in providing illustrations that have enhanced the quality of our manuscript.

Contents

ABOUT THE AUTHORS

Pritam Dutta, an inquisitive researcher affiliated with the Pacif Institute of Cosmology and Selfology (PICS), embarks on a compelling exploration of the universe in the pages of this book "Cosmic Primer." Hailing from Uttar Majh Gram, West Bengal. Pritam's unwavering curiosity and determination have propelled him into the realms of science and innovation. Pritam's published articles reflect his analytical thinking and exceptional writing skills, while his another published book , "What Is Astronomy?", offers a glimpse of his profound knowledge and passion for making complex scientific concepts accessible. With "Cosmic Primer," Pritam takes a giant leap into the cosmos, aiming to unravel its mysteries and intricacies. Fuelled by a personal quest to bridge the gap between complex astronomical concepts and everyday understanding, Pritam's latest endeavour promises to be a remarkable voyage through the cosmos. His diverse skill set and unwavering dedication to knowledge make him a young author in the field of astronomy.

Shibesh Kumar Jas Pacif is a cosmologist and mathematics professor, and an avid science popularizer. His intellectual journey effortlessly combines scientific exploration with a deep dedication to advancing humanity. Professor Shibesh's career as a cosmology researcher is characterized by an insatiable curiosity that has led him to significant achievements. Through unwavering dedication, he has made a lasting impact on academia, inspiring numerous individuals to pursue their intellectual pursuits. His science popularization initiatives in the past few years inspired thousands of students towards astronomy, cosmology, astrophysics, and space science. Yet, his explorations go beyond the tangible cosmos. He recognizes a profound connection between unravelling the mysteries of the outer universe and understanding the intricacies of the inner self. His philanthropic quest for cosmic and self-discovery highlights a strong commitment to enhancing the world. This commitment culminates in the establishment of the "Pacif Institute of Cosmology and Selfology (PICS)," a unified platform dedicated to exploring both the vastness of the universe and the depths of the self. In this book "Cosmic Primer," Prof. Shibesh extends a warm invitation to readers from various backgrounds—whether you are an aspiring enthusiast, a novice in astronomy or cosmology, or a seasoned explorer. The book assures a deep and boundary-defying journey that enhances your understanding of the universe.

Personal homepage : www.shibeshkumar.in

The Pacif Institute of Cosmology and Selfology (PICS) in Sambalpur, Odisha, spearheads interdisciplinary research that integrates science and consciousness studies, offering diverse programs in cosmology and Selfology. Through workshops, seminars, and science talks, PICS fosters collaboration, aiming to unlock cosmic mysteries and deepen our understanding of human consciousness. Supported by patrons and sponsors, PICS is dedicated to inspiring the next generation of scientists and unravelling the enigmas of the universe for a brighter future.

Explore more at www.pacif-ics.com.

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