

Relativistic Cosmology

By George F. R. Ellis, Roy Maartens, Malcolm A. H. MacCallum

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Cosmology has been transformed by dramatic progress in high-precision observations and theoretical modelling. This book surveys key developments and open issues for graduate students and researchers. Using a relativistic geometric approach, it focuses on the general concepts and relations that underpin the standard model of the Universe. Part I covers foundations of relativistic cosmology whilst Part II develops the dynamical and observational relations for all models of the Universe based on general relativity. Part III focuses on the standard model of cosmology, including inflation, dark matter, dark energy, perturbation theory, the cosmic microwave background, structure formation and gravitational lensing. It also examines modified gravity and inhomogeneity as possible alternatives to dark energy. Anisotropic and inhomogeneous models are described in Part IV, and Part V reviews deeper issues, such as quantum cosmology, the start of the universe and the multiverse proposal. Color versions of some figures are available at www.cambridge.org/9780521381154.

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Editorial Review

Review
"... fills a gap in the existing literature on the subject. Written by three experts of General Relativity, it stresses the geometric aspects of cosmology and contains topics which are neglected in most texts on the subject: it discusses fundamental issues like the Copernican principle and the light-cone approach to cosmological observations. I like especially Part 3, where gauge-invariant, covariant cosmological perturbation theory is employed to study structure formation, fluctuations in the cosmic microwave background and different aspects of the Dark Energy problem including, especially a thorough discussion of backreaction. Finally, anisotropic and inhomogeneous models are presented, which at the present status of cosmology research, may turn out to be more than an academic exercise. This text, which always stresses the open questions on each given topic is very valuable and timely for graduate students and researchers in the field. Especially in view of the 'Dark Energy challenge' which requires that we explore all avenues which may shed light in the bizarre apparent acceleration of cosmic expansion. The book helps us to take the necessary step back and re-consider the fundamental assumptions which go into the present cosmological standard model."
Ruth Durrer, University of Geneva

"... a timely offering to the interested graduate student, as well as the astrophysicist realizing that the new astronomical data need concepts from general relativity for their correct interpretation. The authors have been well known for their untiring efforts to educate us all in the use of the general relativistic framework. They have over the years written on many topics concerning observational and theoretical aspects of cosmology. Fortunately now, all this work is integrated into the book in a standardized description which covers all the topics important for cosmology such as gravitational lensing, evolution of small perturbations in cosmological models, the relativistic effects important in the analysis of high redshift objects, the cosmic microwave background, etc. The necessary formalism is laid out lucidly, and elegantly. Deeper issues such as the significance of an inflationary phase, the question of how special our universe is, and even quantum cosmology are addressed. Different cosmological models are presented to illuminate how and to what precision observations single out a specific model. I highly recommend the book."
Gerhard Börner, Max-Planck-Institut für Astrophysik and the Ludwig Maximilians Universität, München

"As more and more accurate observational data of the Universe are accumulating, scientists are now well aware of the necessity of taking full account of general relativistic effects for correct interpretations of the observational data. This is exactly the kind of book that can offer you an occasion to learn such effects in cosmology systematically. The broadness of the topics covered is impressive. Yet, each topic is touched in an admirably concise and clear manner. This book will surely take you to frontiers of cosmology."
Professor Misao Sasaki, Yukawa Institute for Theoretical Physics, Kyoto University

"The science of the Universe has taken Physics and Astronomy by storm over the last few decades. The phenomenal progress in measuring the state of the Universe has made cosmology the premier field of research. While the current theoretical tools have proven to be more than adequate, Relativistic Cosmology now takes cosmology to a new level of sophistication. Ellis, MacCallum and Maartens have brought the geometry space time once again to the fore in a wonderfully comprehensive and coherent survey of the mathematical and physical techniques that need to be deployed to truly understand the origin and evolution of the Universe. This book will become an instant classic."
Pedro Ferreira, University of Oxford

"... a very welcome addition to the textbook literature, and I can only hope that many authors will adopt the careful and critical style in which this text is written. I recommend it to everyone who has mastered a first course in cosmology at the graduate level and seeks a deeper understanding of cosmological models and their relation to observations."
Thomas Peters, Contemporary Physics

"... a valuable and inspiring resource ... [the authors] are well-known experts in general relativity and cosmology ... The layout and graphics of the book are quite appealing. The book's Exercises help the reader to reflect on the presented ideas and concepts, and its Problems highlight unsolved issues in modern cosmology. An extensive index and table of contents make it easy to find a topic of interest ... I strongly recommend, Relativistic Cosmology ... Best suited for graduate students, postdocs, and senior researchers, it offers a lot to explore and to learn about this exciting topic."
Dominik J. Schwarz, Physics Today,

"... a book that makes the mathematical and theoretical aspects of relativistic cosmology accessible to the interested reader, but also a book that bridges the divide between the fields of theory and observation in modern cosmology ... I found this book to be a clear and concise summary of the many different aspects of relativistic cosmology ... it will certainly be a valuable tool for graduate students and researchers alike. I will be recommending it as reading material for my own PhD students, and suspect that I will be frequently returning to it myself as reference material. It is a valuable contribution to the subject."
Timothy Clifton, General Relativity and Gravitation

About the Author
George Ellis, FRS, is Professor Emeritus at the University of Cape Town, South Africa. He is co-author with Stephen Hawking of The Large Scale Structure of Space-Time.

Roy Maartens holds an SKA Research Chair at the University of the Western Cape, South Africa, and is Professor of Cosmology at the University of Portsmouth, UK.

Malcolm MacCallum is Director of the Heilbronn Institute at the University of Bristol and is President of the International Society on General Relativity and Gravitation.

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