

The youthful universe

The Primordial Density Perturbation

Cosmology, Inflation and the Origin of Structure

David H. Lyth and Andrew R. Liddle
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Reviewed by Chung-Pei Ma

In areas prone to earthquakes, building a new structure is often more economical than retrofitting an old one. In a rapidly changing research field, writing a new textbook is sometimes more efficient than revising an existing one—that is indeed what David Lyth and Andrew Liddle have chosen to do with *The Primordial Density Perturbation: Cosmology, Inflation and the Origin of Structure*. Cosmology has experienced a number of shakeups since the publication of their elegant volume *Cosmological Inflation and Large-Scale Structure* (Cambridge University Press, 2000). The term “dark energy” was absent from their index, and NASA’s *Wilkinson Microwave Anisotropy Probe* had yet to be launched. A fresh start seems well justified.

The structure of *The Primordial Density Perturbation* is simple and transparent. The book is divided into four parts, but parts 2 and 4 present the core of the subject. Part 2 provides standard treatments of the unperturbed and slightly perturbed expanding universes. Topics discussed in part 2 include the Friedmann-Robertson-Walker model on which modern cosmology is based,

the thermal history of the universe, the linear perturbation theory of structure growth, and the cosmic microwave background anisotropy. The presentation is concise and sufficiently detailed to prepare the reader to understand professional publications in the field.

My only quibble is the near absence of illustrations in the first eight chapters. If a picture is worth a thousand words, it must also sometimes be worth a hundred equations. When present, the figures are often curiously simple. Wouldn’t an illustration of the time evolution of the baryonic Jeans mass or the growth factor in different cosmological models be more informative than the plots of polar coordinates shown in figures 10.1 and 10.2?

Part 4 addresses the authors’ specialty with an extensive account of early-universe physics, including inflation, the mystery of baryon asymmetry, and the origin of primordial fluctuations. Practicing theoretical cosmologists and those in training should enjoy this handy and coherent collection of material that is otherwise scattered in hundreds of journal articles. Less specialized readers, however, will find part 2 more approachable and useful.

The rest of the book consists of reviews of relativity (part 1) and field theory (part 3). The brief 40-page summary of special and general relativity is necessary for establishing the mathematical language and notations used in later parts of the book; it also serves as a study guide to relativity. It is not, however, intended for those learning the subject for the first time. The same goes for the 90-page field-theory section, which offers a succinct refresher course on classical and quantum field theory, the standard model of particle physics, and supersymmetry. Any reader who has ventured this far has probably already learned from books and courses that offered more extensive coverage of those important subjects. Future textbook writers would benefit from an informal survey to assess whether such review chapters

are typically read or skipped.

Parts 1 and 2 of *The Primordial Density Perturbation* would be an excellent text for the first part of a one-semester graduate course in cosmology. Excerpts from part 4 would also be well suited for a few lectures on the basics of inflation and its many variations. However, the focus of the book, as “primordial” in the title suggests, is on the youthful universe, in which the fluctuations in photon temperatures, matter densities, and spacetime metrics were small enough to be well described by linear perturbation theory. By contrast, much of 21st-century cosmological research continues to be devoted to deciphering the later stages of cosmic evolution, during which nonlinear structures such as galaxies and clusters formed. For those topics, one may have to rely on journal papers and review articles.

The Primordial Density Perturbation is a welcome addition to the growing collection of advanced cosmology textbooks. The two authors have made major contributions to the field, and their presentation is lucid and modern. Their volume warrants a place on the shelves of all researchers in advanced cosmology, next to such classics as P. J. E. Peebles’s *Large-Scale Structure of the Universe* (Princeton University Press, 1980) and Edward Kolb and Michael Turner’s *The Early Universe* (Addison-Wesley, 1990), and such monographs from the past decade as John Peacock’s *Cosmological Physics* (Cambridge University Press, 1999) and Scott Dodelson’s *Modern Cosmology* (Academic Press, 2003).

Whether this book suffers the same fate as its 10-year-old sibling remains to be seen when cosmology is shaken up again a few years down the road. Perhaps it is time for academic publishers to match the modern pace of scientific discovery by offering more graduate electronic textbooks that can be updated easily every two to three years, as is often done for freshman physics texts. After all, new insights into dark energy and dark matter—and not into Maxwell’s equations—are what cause cosmology textbooks to gather dust on our shelves.

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