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Introduction to Cosmology [book review]

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Review of B. Ryden's Introduction to Cosmology for Physics Today, _____, ___, 2004.

Introduction to Cosmology

Barbara Ryden and Bruce Partridge

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In the context of PHYSICS TODAY'S readership, the actual audience is more likely to consist of graduate students with an intellectual curiosity about probability theory or faculty members with the luxury of a sabbatical in which to immerse themselves in a new way of approaching statistical problems. For both groups, the rewards of reading *Probability Theory* can be immense.

Ralph Baierlein
Northern Arizona University
Flagstaff

Introduction to Cosmology

Barbara Ryden
Addison Wesley, San Francisco, 2003. $59.00 (244 pp.).
ISBN 0-8053-8912-1

For more than 30 years, I've been teaching cosmology to third- and fourth-year undergraduates. For as many years, I've been seeking an ideal cosmology text for such students. Is Barbara Ryden's *Introduction to Cosmology* that ideal text? It comes very close, to judge from my experience last sem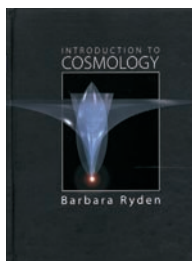ester, when I used it for the first time. The book is a compact and clear presentation of modern cosmology and of key observations supporting physicists' current understanding of the structure and evolution of the universe. Cosmology is a rich and rapidly maturing subject, fully deserving a spot in the undergraduate curriculum. This book will help us teach it with clarity and rigor.

Ryden's text is idiosyncratic, which my students and I both like and dislike. For instance, she spends rather more time developing cosmological models than do other recent cosmology texts for undergraduates. I find her attention to the models to be a strength: Deriving the Friedmann equation for the dynamical evolution of the cosmic scale factor, finding solutions to it, developing the Robertson–Walker metric, and exploring the properties of curved space are all useful exercises in the application of mathematics to physics and astronomy. But the extra attention to models does, to some degree, squeeze her treatment of both the observational material and the physics of the early universe.

Another feature that sets Ryden's presentation apart is the order in which the cosmological models are presented. Many texts and lecturers start with the simplest model, in which the only force is gravity and the only matter is noninteracting dust. They then add successive complications—radiation, a cosmological constant, quintessence, and so on.

Ryden takes a different tack. Starting with Newtonian ideas that, strictly speaking, work only for noninteracting dust, she first develops a general form for the Friedmann equation and the equation of state. That development allows her to treat all single-component models together, including the radiation-dominated and cosmological-constant-dominated universes. She then turns to the currently favored multicomponent models, in which cosmic dynamics are determined by a mixture of ordinary matter, dark matter, and the cosmological constant or perhaps quintessence. Her treatment is fully up to date, treating both the widely adopted "benchmark" (also called concordance) model with its accelerated expansion and the evidence supporting that model.

In the rest of the book, the presentation order is more conventional. Ryden begins with two chapters that may be loosely titled cosmological tests: On the basis of observations, how do physicists decide what model best describes the universe? What does one learn from measurements of the age and average density of the universe? Can one measure the spatial geometry directly? Those two chapters are a little skimpy. For instance, the author derives quantities like the luminosity distance and angular-diameter distance only for redshifts much less than one. Even those suffice to show, at least qualitatively, how spatial curvature or changes in the expansion rate affect the connections between observables like magnitude and redshift. The full quantitative results, however, are simply presented in the form of figures, without supporting argument.

The author then turns to the early universe; she starts with a carefully crafted chapter on the microwave background, then discusses nucleosynthesis. The penultimate chapter considers inflation and the very early universe. The last chapter is on the formation of cosmic structure. One might ask why it appears at the very end, but the answer is clear: Understanding the interaction of radiation and matter in the early universe and the dynamics of the universe are necessary to understand the formation of structure.

Ryden's presentation is crisp; little is extraneous. The level is both uniform and appropriate for an audience of college juniors and seniors. And the style is informal, personal, and even occasionally witty. All three properties are much appreciated by my students. They—and I—also like the author's attention to the history of the field and her care with defining terms.

Since *Introduction to Cosmology* is a textbook, student reactions are important. As I have noted, they are largely quite positive. One gripe my students have is that the material on the particle content of the universe seems out of place and rather intimidating in chapter 2; it could be saved until later. In addition, references to the benchmark model pop up well before we are told why it is the currently favored model. And, as an instructor, I would add a plea for a few more problems. Those that are there are at an appropriate level, though sometimes focused on less-than-central aspects of the material.

These are, however, small quibbles about a fine, useful book. The text is excellent and speaks to students clearly, succinctly, and authoritatively. It would also serve any physical scientist as an excellent introduction to the beauties, certainties, and intricacies of modern cosmology.

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Fields, Flows and Waves: An Introduction to Continuum Models

David Parker's book *Fields, Flows and Waves: An Introduction to Continuum Models*, based on his lectures at the University of Edinburgh in Scotland, is a fine addition to the Springer Undergraduate Mathematics Series. Parker is a professor in the school of mathematics at the university. His book focuses on the use of classical analytical techniques in the continuum description of real-world phenomena. Topics include heat flow, electrostatics, hydrodynamics, elasticity, electromagnetism, chemical diffusion, and biological modeling.

For the subjects considered, the author provides masterly compact accounts of the physical phenomena, develops an appropriate conservation or balance law in one, two, or three dimensions, and solves interesting problems. Parker takes particular care to examine the physical implications of the mathematical solutions, offering many insightful remarks. The book is firmly rooted in the tradition of excellent British texts in mathematical physics, but Parker has supplemented the traditional coverage with many examples of current scientific or technological interest.

Of the book's ten chapters, the first seven contain about enough material for a mid-level undergraduate course for applied-mathematics, physics, or engineering majors. In those seven chapters, Parker treats in a clear and concise manner the heat equation, Laplace's equation, Poisson's equation, the wave equation, hydrodynamics, and elasticity. Standard methods of solution are illustrated. The author assumes a basic knowledge of multivariable calculus and introduces vector operators, but avoids tensor algebra. An adequate selection of student exercises is included, with solutions