BOOK REVIEWS

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Relativity, Gravitation and Cosmology: A Basic Introduction. Ta-Pei Cheng. 339 pp. Oxford U. P., New York, 2005. Price: $99.50 (cloth) ISBN 0-19-85295-6; $44.50 (paper) ISBN 0 19 852957. (Andrew J. S. Hamilton, Reviewer.)

This is a great time to have published a fresh new undergraduate text on relativity and cosmology. Recent years have seen a revolution in cosmology, sparked by the discovery by two independent groups in 1998 that supernovae at high redshift indicate that the Universe is accelerating. A remarkable confluence of observational data, headed by observations of the power spectrum of temperature fluctuations in the cosmic microwave background, but including a broad range of other astronomical data, have led to the emergence of a "Standard Model" of cosmology. This cosmological revolution has rendered largely obsolete most texts written before 2000 (and some written since). What self-respecting text could nowadays discuss cosmology without commenting on the extraordinary fact that the Universe appears to be composed 70% of some gravitationally repulsive substance whose properties look a lot like quantum mechanical vacuum energy?

Ta-Pei Cheng's text is an up-to-date text aimed at a typical American physics undergraduate student, and it succeeds admirably. The text would, for example, be a perfect accompaniment to the upper division undergraduate course on "Relativity and Cosmology" that we teach at the University of Colorado. The book is divided into three parts of roughly equal length. The first two parts, respectively on relativity and cosmology, comprise the core of the book, suitable for a one semester undergraduate course. The third part is more mathematically oriented, allowing motivated students a taste of what they might be in for in a graduate course on general relativity.

The nearest comparable book, aimed at the same level, is James Hartle's superb 2003 text, *Gravity: An Introduction to Einstein's General Relativity*. Cheng's book is shorter (340 pages versus Hartle's 580) and his coverage of the applications of relativity is more limited than Hartle's. However, Cheng's coverage of cosmology is better.

As Cheng remarks in his preface, there are many graduate texts on relativity, and many popular texts, but not much in between, as those of us who teach courses on the subject are only too well aware of. When Hartle's book came out, I gave a mental hurrah, and now Cheng's book warrants another. Both authors deserve congratulations for having written thoughtfully organized books that remain accessible without compromising or condescending.

The second, cosmological part of Cheng's book is one of its real strengths. It is up to date, and the choice of topics is right on target. All the things that a student would or should be interested in are there, including dark energy, the cosmic microwave background, inflation, and more. There is even a comment on the possibility, motivated by the low amplitudes of the $\ell=2$ and $\ell=3$ harmonics of the CMB, that the Universe could have a dodecahedral geometry. And there is an appendix on why, if the dark energy is vacuum energy, it might be expected to have a density 120 orders of magnitude more than observed. All this material on cosmology is compressed into not quite a hundred pages.

If the first part of the book, on relativity, is not quite as successful as the second part, it is only because the second part is so good. If one had to summarize what makes a course on relativity successful, one might say, "it's black holes, stupid." Cheng devotes the final chapter of Part I to Schwarzschild black holes, but misses the opportunity to discuss wormholes, white holes, or rotating black holes. These matters are of perennial fascination to students, who long to know the general relativistic truths underlying the science fiction rumors.

The first part of the book is excellent insofar as it goes. One of the challenges of writing an undergraduate text on relativity is to keep the mathematics at a level where it aids rather than hinders conceptual understanding, and Cheng achieves this well. His choice of topics is again on target: special relativity, the principle of equivalence, the metric, geodesics, and an introduction to the idea of gravity as curvature. This is enough to get most students to the place they want to be: at the threshold of being able to comprehend black holes. At the same time, Cheng satisfies the more ambitious student by providing a Part III to the book, where tensors, equations of motion, and Einstein's equations are derived.

Still, it would have been nice to see the book devote more space to selected applications of relativity in Part I. For example, the book is missing the cherry on the cake of special relativity, namely a discussion of special relativistic travel, of what things actually look like when you pass through a scene at near the speed of light, and of superluminal sources in astronomy, the primary observational example of relativistic travel in action. The book gives the briefest possible mention of the observational evidence for black holes in astronomy, a curious contrast to the insightful coverage of observational cosmology. Finally, the book does not discuss Hawking radiation and black hole evaporation, another topic of student fascination. It might be argued that Hawking radiation is too complicated to be covered at this level, but there is no doubt that the student interest is there, and we should do our best to satisfy it.

Cheng does cover gravitational radiation, which he cleverly consigns to the more mathematical Part III. Once again he is on target in describing the binary pulsar as currently the primary observational evidence for gravitational radiation.

A strength of the book is that it includes extensive sets of review questions and problems at the end of each chapter. Appendices provide hints on the review questions and solutions to some of the problems.

In summary, this is an excellent textbook which this reviewer would rate as the text of choice for a course on relativity and cosmology aimed at physics and astronomy undergraduates.

Note added in proof. A substantial number of corrections,

mostly editorial, have been incorporated in the new printings of this book. Readers in possession of the original print can consult the book's website (http://www.umsl.edu/~tpcheng/grbook.html) for this list of corrections.

Andrew J. S. Hamilton is a Fellow of JILA and Professor of Astrophysics in the Department of Astrophysical & Planetary Sciences at the University of Colorado, Boulder. He does research in astrophysics, cosmology, and relativity.

BOOKS RECEIVED

Analytical Mechanics for Relativity and Quantum Mechanics. Oliver Davis Johns. 597 pp. Oxford U. P., New York, 2005. Price: $79.50 ISBN 0-19-856726-X.

Conservation Chemistry—an Introduction. Ted Lister and Janet Renshaw. 111 pp. Royal Society of Chemistry, London, 2004. Price: $59.95 (paper) ISBN 0-85404-395-0.

Double and Multiple Stars and How to Observe Them. James Mullaney. 131 pp. Springer, New York, 2005. Price: $39.95 (paper) ISBN 1-85233-751-6.

Is There a Laser in the House? Amy E. Bieber. 89 pp. Pearson Custom Publishing, Boston, 2005. Price: $33.33 (paper) ISBN 0-536-91903-8.

Life in the Universe. Edited by Joseph Seckbach *et al.* 387 pp. Kluwer Academic Publishers, Norwell, MA, 2004. Price: $199.00 ISBN 1-4020-2371-5.

Metal-Catalysed Reactions of Hydrocarbons. Geoffrey C. Bond. 666 pp. Springer, New York, 2005. Price: $129.00 ISBN 0-387-24141-8.

Phase-Modulated Optical Communication Systems. Keang-Po Ho. 430 pp. Springer, New York, 2005. Price: $129.00 ISBN 0-387-24392-5.

The Quantum Theory of Fields, Vol. I: Foundations (paperback edition). Steven Weinberg. 609 pp. Cambridge U. P., New York, 2005. Price: $45.00 (paper) ISBN 0-521-67053-5.

The Quantum Theory of Fields, Vol. II: Modern Applications (paperback edition). Steven Weinberg. 489 pp. Cambridge U. P., New York, 2005. Price: $45.00 (paper) ISBN 0-521-67054-3.

The Quantum Theory of Fields, Vol. III: Supersymmetry (paperback edition). Steven Weinberg. 419 pp. Cambridge U. P., New York, 2005. Price: $45.00 (paper) ISBN 0-521-67055-1.

The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics. Robert Oerter. 304 pp. Pi Press, New York, 2005. Price: $29.95 ISBN 0-13-236678-9.

Thermodynamics: A Dynamical Systems Approach. Wassim M. Haddad, VijaySekhar Chellaboina, and Sergey G. Nersesov. 187 pp. Princeton U. P., Princeton, NJ, 2005. Price: $49.50 ISBN 0-691-12327-6.

Wrong for the Right Reasons. Edited by Jed Z. Buchwald and Allan Franklin. 228 pp. Springer, New York, 2005. Price: $129.00 ISBN 1-4020-3047-9.