Gen Relativ Gravit (2011) 43:359–360
DOI 10.1007/s10714-010-1102-5

BOOK REVIEW

# Ta-Pei Cheng: Relativity, gravitation and cosmology: a basic introduction (second edition)

## Oxford university press, 2009, 456 pp., Hardback: GBP55.00, ISBN: 978-0-19-957363-9, Paperback: GBP27.50, 978-0-19-957364-6

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Received: 17 September 2010 / Accepted: 18 September 2010 / Published online: 13 October 2010


Ta-Pei Cheng's *Relativity, Gravitation and Cosmology: A Basic Introduction* is perhaps a bit modest in its title: *Comprehensive* rather than *Basic* is probably more appropriate. This second edition expands upon the 2005 textbook, which is a 'Physics First' presentation of relativity and cosmology. As such, Cheng defers the full tensor formulation of Special and General Relativity to the last of the four parts of his book, giving us nearly 280 pages of relativity and gravitation before we meet the rigours of tensor analysis.

Part I (Preliminaries) introduces the invariance principles of relativity, some key attributes of GR as a field theory and the basics of Special Relativity. Parts II (Relativity: Metric Description of Spacetime) and III (Cosmology) form the core of the book. Part II deals with the geometric description of Special Relativity, the Principle of Equivalence, the metric description of spacetime and the geometric nature of the gravitational field, before introducing the Schwarzschild solution, the classical tests of GR and (new to the second edition) black holes. As well as deriving and discussing the global properties of Kruskal–Szekeres spacetime, this new chapter includes a brief treatment of rotating black holes and the quantum physics of black holes. Part III is a fairly extensive introduction to relativistic cosmology, starting with homogeneous and isotropic models, working through the evolution and thermal history of the expanding universe (including an ambitious treatment of photon decoupling and the CMB), and going as far as inflation, CMB anisotropy and the accelerating universe. The relatively short discussion of gravitational waves is reserved for the last of the four chapters of Part IV (Relativity: Full Tensor Formalism), which also deals with tensor analysis in Special and General Relativity, general covariance and the derivation of the Einstein field equation.

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The main differences and additions to the first edition are the new chapter on black holes and an expanded and rearranged discussion of Special Relativity. Part I is also newly separated from the following chapters. The high production standards of the first edition and the Oxford Master series are maintained (and indeed improved upon: the publishers appear to have switched their paper suppliers and so the second edition comes absent the noxious smell of the pages of the first).

The text is accompanied by some familiar pedagogical devices; side notes, boxes separating heavier calculations and peripheral details, conceptual review questions as well as exercises and problems at the end of each chapter, each of which usefully begins with a bullet-point abstract. But as with any textbook, it is the core text that is most important, and in that regard, this is a fine book. Of course Cheng has wonderful raw material to work with, and its presentation is clear and comprehensive. The large coverage given to cosmology and the much shorter treatment of gravitational waves will suit some readers and teachers, but the appearance of this second edition is perhaps an opportunity missed to provide a brief discussion of gravitational waves using the mathematical tools available in Parts I–III. It is perhaps also the depth of the treatment of cosmology that leads the author to be fairly demanding of his readers' knowledge of particle physics and thermodynamics in this part of the book. (Of course this simply means that what is required goes beyond my very basic knowledge of these areas, but to be more objective, we have not been forewarned of these prerequisites in the introduction.) While I'm being slightly negative, I will also mention that Cheng incorrectly refers to the Kruskal–Szekeres extension as being "geodesic complete". This is the only significant mistake that I noticed in a longish book that draws on many different areas of physics.

I sometimes imagine students being presented with a 'Physics First' approach to GR scratching their heads in bewilderment and wondering how much more complicated a 'Maths First' approach would be. Nevertheless, these same students *will* see that they can access new and exciting physics that genuinely does make only modest mathematical demands of them. Cheng's book, like that of Hartle before him [1], provides students with the means to do that. Comparisons with Hartle are inevitable and appropriate, given the alignment of the philosophies of the two books and the similarities of the choices of topics. Cheng has slightly more mathematical content in the "physics" chapters than Hartle, and leans towards discussions of conceptual principles rather than physical phenomena in the earliest sections of the book. Hartle also has an overall surety and clarity of presentation not quite matched by Cheng. For these reasons, I suspect that if you were teaching GR to physics undergraduates, you would prefer Hartle's book. I also suspect that you already have a copy of Hartle. If so, you will find Cheng's book a useful addition to your bookshelf—for its more extensive treatment of cosmology, its supply of interesting end-of-chapter questions (several with solutions), its overall high quality of presentation and—for variety—its extra pinch of mathematics.

## Reference

1. Hartle, J.B.: Gravity: An Introduction to Einstein's General Relativity. Addison Wesley, San Francisco (2003)