Book Reviews

Modern View of General Relativity

Gravitation. CHARLES W. MISNER, KIP S. THORNE, and JOHN ARCHIBALD WHEELER. Freeman, San Francisco, 1973. xxx, 1380 pp., illus. Cloth, $39.50; paper, $19.95.

In July 1955 there was held in Berne a meeting to celebrate the 50th anniversary of special relativity. By sad mischance Einstein died shortly before the meeting began, and its president, Wolfgang Pauli, commented in his opening remarks, "By this unforeseen event this important moment is a turning point in the history of the theory of relativity and therefore of physics."

By one of the ironies of history, the meeting was a turning point in another sense also. The renaissance of general relativity which we are now enjoying can be dated from that meeting in Berne. For the first time isolated relativists were brought together from all over the world, and by their interaction they gained the strength to intensify their efforts, to train brilliant young research students, and to introduce new mathematical methods which have revolutionized our understanding of general relativity and therefore of physics. As a result, even before the discovery of quasars, pulsars, x-ray sources, and the microwave background the number of people working in the field increased dramatically. The sad irony is that Einstein himself never knew of this change in the standing of his great theory.

The year 1955 was memorable for relativists for another reason also. In that year a well-known nuclear physicist published his first paper on general relativity. The paper showed boldness of imagination and a deeply intuitive but very individual approach. Its author was John Archibald Wheeler, who now, together with his one-time students Charles Misner and Kip Thorne, has presented in a massive book his view of general relativity, as based on a 20-year love affair with it. Much of the book is written in the well-known Wheeler style, with its combination of physical insight, vigorous use of analogy, elaborate diagrams and tables, and a prose style varying from the unusually colloquial to the unusually lyrical, ending with an eschatological vision of the theory of the future. Interspersed with this one can recognize the more sober style of the junior authors when they deal with their own specialty.

In my opinion this approach pays off handsomely, and the result is a pedagogic masterpiece that will teach any alert student both insight and technique, and, starting from the foundations of the theory, will prepare him to face most of the rigors of the current research literature. The first sign of attention to pedagogic detail is the division of the book into two tracks. Track 1 is intended to provide "a one-semester course at junior or senior level or in graduate school." When combined with track 2 it becomes a "rigorous full-year course at the graduate level." Each page is labeled track 1 or track 2, and is marked so that the track 1 pages are easily picked out by the eye. The treatment is so designed that "with a few exceptions any track 2 chapter can be understood by readers who have studied only the earlier track 1 material."

This attention to pedagogic detail is by no means restricted to the general design of the book. The writing throughout is passionately concerned with communicating ideas, methods, and techniques, and since the authors do this so well, and are also so obviously enjoying themselves, this book immediately establishes itself as the best introduction to its subject. In addition it is a mine of information, especially for recent developments.

The treatment throughout is modern in spirit, both in its basic mathematics and in its physics, but pedagogic requirements are always kept to the forefront. For instance, the definition of a tangent vector as a directional derivative is carefully explained and frequently used. In the process the reader comes both to understand the definition and to appreciate its power. The same is true for the treatment of the calculus of forms and other mathematical techniques that are not usually described in books on general relativity. However, the discussion only glances at the most powerful mathematical methods that are needed, for instance, in proving singularity theorems. For those the reader must turn to Hawking and Ellis's recent book *The Large Scale Structure of Space-Time* (reviewed in *Science* **182**, 705 [1973]).

Of course there is much more to general relativity than mathematical technique, important though that undoubtedly is. Relativity is part of physics, and it is this physics that motivates the mathematical technique and, in the end, justifies the great interest the theory is now enjoying. In my opinion this book gives an outstanding account of general relativity as a physical theory. The main emphasis is placed on topics to which the authors have themselves made significant contributions. In view of the width of their interests this is not too serious a restriction, although I would have preferred to see a more detailed discussion of the equations of motion, of the algebraic structure of exact solutions, of the asymptotic properties of gravitational radiation, and of the Newman-Penrose spin coefficients.

By contrast, the authors are in their element when they discuss the initial value problem, relativistic stars, cosmology, black holes, the emission and detection of gravitational waves, and experimental tests of general relativity. These topics receive authoritative and modern treatment.

In this era of intense interest in gravitation we may be grateful to Misner, Thorne, and Wheeler for guiding us through its intricacies with such insight.

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Earth Dynamics

Gravity and Tectonics. KEES A. DE JONG and ROBERT SCHOLTEN, Eds. Wiley-Interscience, New York, 1973. xxxii, 502 pp., illus. $24.95.

This volume honors R. van Bemmelen, distinguished author of many papers on the relationship between gravity and tectonics, including some thoughtful papers on global tectonics written in the 1930's, long before this