

A non-Einsteinian approach to general relativity

Gravitation and Spacetime

H. C. Ohanian

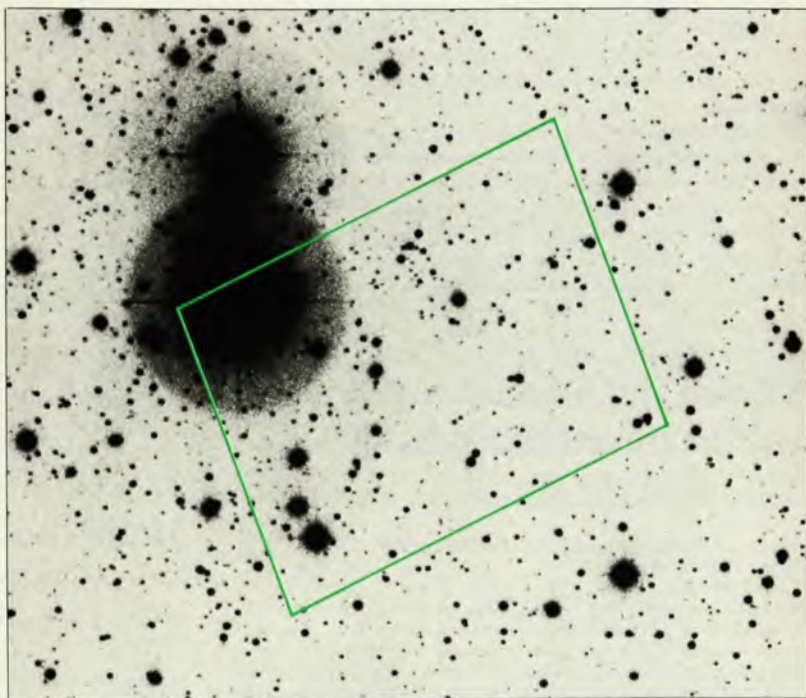
461 pp. W. W. Norton, New York, 1976.
\$18.95

Reviewed by Wolfgang Rindler

This book by Hans Ohanian, a student of John Wheeler's at Princeton and now Assistant Professor at Union College (Schenectady, N.Y.), fills one of the few remaining gaps in the recent spate of didactic literature on relativity. It deals with *general* relativity (a term eschewed by the author in favor of the Princetonian "geometrodynamics") and presupposes familiarity with special relativity—though a brief recapitulation of that is provided. Ohanian develops the general theory from the linear approximation "in the way it would probably have developed without Einstein's intervention," as he says. And he does this—here was the gap in the literature—for undergraduate readers. It must be said at once, however, that the intended undergraduate reader will have to possess a considerable degree of mathematical and physical sophistication.

Modern field theorists find the approach to gravitational theory through the linear approximation congenial. Using standard Lagrangian flat-spacetime field theory and requiring the Hamiltonian to be positive definite, one arrives at Einstein's field equations in the linear approximation; if, by repeated iteration, the self energy-momentum of the field is then incorporated, one gets Einstein's full field equations as infinite series. At that stage one can reinterpret the formalism in curved spacetime, and so end up with standard general relativity. Instead, Ohanian develops the linear approximation by a series of assumptions and largely in analogy with Maxwell's theory; the full field equations are ultimately derived by requiring the usual properties plus conformity with the linear approximation. This method lacks the sweep and elegance of *both* alternatives, but it serves the present purpose well.

As a first application of the linear theory, there is an excellent chapter on the emission and detection of gravitational waves (though Ohanian makes no mention of *exact* radiative solutions). Here, as throughout the book, great care



Possible black hole. The x-ray source Cygnus X-1 is believed to orbit the star HDE 226868 (shown at center), which is approximately 10^4 light years distant from the Earth. The box indicates the uncertainty in Cygnus X-1's position. Hale Observatories photo by J. Kristian, from K. S. Thorne.

has been taken to discuss the experimental results in considerable detail. I also found the chapter on black holes and gravitational collapse beautifully done. (It carries the motto "Abandon all hope ye who enter here.") The illustrations are superb, and the topology and horizon structure of the extended Schwarzschild and Kerr solutions are very clearly and fully explained. Nevertheless, I would expect the average undergraduate to have some difficulties here. The final chapter is on cosmology. Like the rest of the book, it is down-to-earth, with emphasis on the observations, but it also contains a complete account of the isotropic models.

Each chapter is followed by a very adequate set of references (especially to the recent literature), an extensively annotated list of suggestions for further reading, and a set of challenging problems with answers in the back.

If I have a complaint, it is of the perhaps rather too many categorical statements scattered throughout the book,

such as "The best introduction to special relativity is Taylor and Wheeler, *Spacetime Physics*" (it may well be!) or "The great disadvantage of [Einstein's approach to general relativity] is that it never makes clear just why anybody would entertain the preposterous notion that our beautiful flat spacetime should be curved." I also find Ohanian's remark on the equivalence principle misleading: "Unfortunately, Einstein's [1916] statement has often been generalized to sweeping assertions about all the laws of physics. . . ." Yet it was Einstein himself who made this generalization, and it can be found on page 101 of the same collection of papers that Ohanian cites for the 1916 statement. Needless to say, Ohanian follows Sygne in discarding this "strong" equivalence principle. I think this is a pity, because—at the very least—it heuristically illuminates the formalism of geometrodynamics. It also makes unpreposterous the notion that spacetime should be curved.

In sum, anyone interested in teaching

Les Houches Summer School Proceedings

Each year, the "Les Houches Summer School in Theoretical Physics" is devoted to a particular area of physics in which recent progress has taken place. The courses are organized on a pedagogical and systematic basis and present original work, often constituting some unique reviews and presenting a complete and detailed survey of the field.

In 1975, North-Holland Publishing Company took over the publication of the proceedings of these symposia, commencing with the XXVIth Session. Forthcoming volumes in the series will cover: application of lasers to atomic and molecular physics, methods in field theory, particle physics, and nuclear physics.

Session XXVI (July - August 1974):

Atomic and Molecular Physics and the Interstellar Matter

edited by ROGER BALIAN, Director,
PIERRE ENCRENAZ and JAMES LEQUEUX

1975 xxiv + 634 pages. Price: US \$63.95/Dfl. 160.00.
ISBN 0-7204-0328-6

This Session was devoted to the physics of interstellar matter with special emphasis on atomic and molecular processes. The eight-week duration of the conference made it possible to examine in depth a broad range of topics. The lectures contained in the volume provide detailed descriptions of both the basic physical and chemical processes occurring in the interstellar gas and dust, which, taken together, provide a thorough and up-to-date account of the present status of our observational and theoretical knowledge of this medium.

CONTRIBUTORS: G.B. Field, D. Flower, P. Goldreich, S. Green, E.M. Greenberg, F.D. Kahn, R. McCarroll, H. Nussbaumer, A.A. Penzias, H. Reeves and W.D. Watson.

June Institute (1975):

Structural Analysis of Collision Amplitudes

edited by ROGER BALIAN and DANIEL IAGOLNITZER

1976 xx + 638 pages. Price: US \$59.95/Dfl. 150.00.
ISBN 0-7204-0506-8

These Proceedings present basic theoretical developments of relativistic scattering theory. Multiparticle processes have become of increasing experimental importance during the past decade and this book provides, for the first time, a coherent presentation of basic developments in the study of the analytic structure of multiparticle collision amplitudes. It also contains hitherto unpublished detailed accounts by some of the world's leading specialists of basic developments in the axiomatic foundations of relativistic quantum theory, together with the most recent results and applications in two related important areas of contemporary research, namely the Reggeon calculus and the dual resonance models.

CONTRIBUTORS: D. Atkinson, J. Bros, K. Cahill, C.E. De Tar, H. Epstein, V. Glaser, D. Iagolnitzer, M. Lassalle, G. Mahoux, S. Mandelstam, H.P. Stapp, R. Stora and A.R. White.

Session XXVII (June - July 1975):

Frontiers in Laser Spectroscopy

edited by ROGER BALIAN, SERGE HAROCHE and
SYLVAIN LIBERMAN

1976 about 944 pages. Published in 2 volumes.
Price: US \$111.95/Dfl. 280.00. ISBN 0-7204-0457-6

The program of this session reflected the dramatic impact of the development of lasers in modern spectroscopy. The book gives a general presentation of the theoretical background necessary for the understanding of light-matter interaction problems, and reviews the various new methods in which lasers are now being used to improve our knowledge of atoms, molecules and even nuclei. The ten courses are grouped into five parts dealing first with fundamental problems and proceeding to specific applications to spectroscopy.

CONTRIBUTORS: R.G. Brewer, B. Cagnac, C. Cohen-Tannoudji, M.S. Feld, S. Haroche, A. Javan, P.L. Kelley, J.-C. Lehmann, V.S. Letokhov, S. Libermann, J.-P. Monchalin, S. Mukamel, T. Oka, M. Sargent III, G.W. Series, S. Stenholm, P.E. Toschek and H. Walther.

Session XXVIII (July - September 1975):

Methods in Field Theory

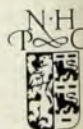
edited by ROGER BALIAN and JEAN ZINN-JUSTIN

1976 xviii + 387 pages. Price: US \$39.95/Dfl. 100.00.
ISBN 0-7204-0433-9

The XXVIIIth Session was devoted to the developments and applications of quantum field theory elaborated in the last few years. This book presents the essence of the courses, the texts retaining both their elementary and thorough character. The first lectures give a solid background in field theory, followed by the development of the theory of quantization and renormalization of gauge fields. The application of the renormalization group to high-energy lepton-hadron interactions is demonstrated and finally, the applications of the field theoretical methods in other contexts are treated. Thus the volume constitutes a self-contained account of the modern methods in field theory which is both consistent and pedagogical. It will play the role of a handbook which will be of value for years to come in helping clarify some of the concepts and set the basis for future developments in the field.

CONTRIBUTORS: E. Brézin, C.G. Callan Jr., S. Coleman, L.D. Faddeev, D.J. Gross, B.W. Lee, T.D. Lee, G. 't Hooft, M.J.G. Veltman and K.G. Wilson.

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relativity to undergraduates—and perhaps also to himself—will find Ohanian's book suggestive, and many of the details interesting and original.

* * *

Wolfgang Rindler is Professor of Physics and Mathematics at The University of Texas at Dallas and is himself the author of two texts on relativity. He coined the terms "event horizon" and "particle horizon" and gave those entities their earliest systematic treatment.

Structure and Evolutionary History of the Solar System

H. Alfvén, G. Arrhenius

276 pp. D. Reidel, Dordrecht, Holland, 1975. \$32.00 clothbound, \$24.00 paperback

The book is based on, and is in fact almost identical to, four papers published in "Astrophysics and Space Science." The authors give their own views of the structure and formation of the solar system and make no attempt at reviewing, or even mentioning, rival theories. Consequently, this is a very useful book if one is interested in the theories of Hannes Alfvén and Gustaf Arrhenius, but it is of little use for general information regarding the subject. Of course, both Alfvén and Arrhenius are major contributors to the field, and their personal views are therefore of considerable interest.

Alfvén and Arrhenius believe that the Sun, with a magnetic field many times stronger than its present field, accreted matter from an interstellar cloud. During its infall this matter becomes ionized. The authors recognize three distinct ionization regions, roughly where the nonvolatiles, the compounds of carbon, oxygen and nitrogen and hydrogen and helium become ionized. When ionization occurs, the material is influenced by the magnetic field, which prevents further infall and gives the material angular momentum. Thus three rings—or bands—are formed, each of different composition. (Unfortunately, these compositional bands do not correspond to those found in our planetary system; the ordering is different.)

The authors then discuss the formation of planets within such rings and describe the idea of "jet streaming," a form of gravitational focusing where collisions between the particles in a band produce a tighter and tighter ring or stream, which eventually accumulates into one body. Alfvén and Arrhenius also believe that the satellite systems formed by a similar process, except now of course with the appropriate planet as a parent body.

The book is certainly valuable to all astronomers actively working in the field

of planetary cosmogony or who are contemplating entering it. It has little value if all that is required is a "potted" version of the current stage of knowledge. The volume should certainly be available in all scientific libraries.

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Solid State Physics

N. W. Ashcroft, N. D. Mermin

826 pp. Holt, Rinehart and Winston, New York, 1976. \$19.95

For several years members of the solid-state community have been aware of the fact that two well-known Cornell physicists, Neil Ashcroft and David Mermin, were writing a textbook on solid-state physics. Rumor had it that this book would take a new look at this well-trodden field and that it would be of great help to those who taught introductory courses in the solid state for physicists or for engineers, and had mixed luck in choosing a suitable text or texts. No doubt the book lives up to its expectations as far as a refreshingly new attitude is concerned.

Whether it will prove to be a boon for the students and for those like myself who taught the subject for a few decades, only practice will show, but the prognostications are very good indeed.

In contrast with many other texts the book is well organized from a pedagogical point of view. As the authors point out in their preface, the book does not have a "linear" arrangement of topics. Right from the first three chapters ("Drude Theory of Metals," "Sommerfeld Theory of Metals," "Failure of the Free Electron Model"), it is clear that the sequence of chapters is so chosen as to give the students an early grasp of the elementary concepts of solids on the basis of which they can then find their way to other more advanced topics. In fact, there is a most enlightening, detailed table showing not only the necessary prerequisites for each chapter, but also how to use the book for a one-semester or for a two-semester course. This feature will undoubtedly appeal to many readers and users.

The strength of the book is in the stress it puts on the basic concepts of the theory of solids and of the various phenomena. This is achieved by giving first a carefully structured intuitive picture or argument, which is then followed by a quantitative formulation. In this connection it may be worth pointing out that the book has



Proposed Fermi surface for bcc tungsten. The structure at the center is an electron pocket, surrounded by hole pockets in zone faces and at corners. From the book, after A. V. Gold.