

development of techniques for performing high-resolution spectroscopy of solids, so that it is now possible to routinely obtain a high-resolution nmr spectrum of virtually any material. Thus, the condensed matter physicists, who in the late 1960s left the field, now found that magnetic resonance had left them. Finally, magnetic resonance imaging today provides the materials scientist, the biologist and the physician with a means to examine nondestructively new materials, cells and the human body. Thus, magnetic resonance has had a profound effect not only on the development of physics, but also on chemistry, biology and, most recently, medicine.

Because magnetic resonance affects so many disciplines, the appearance of the third edition of Charles Slichter's now classic textbook *Principles of Magnetic Resonance* is both timely and important. It is timely, since large numbers of new researchers continue to enter the field, and it is important since the book provides an updated and enlarged introduction to the essential aspects of magnetic resonance. The material in chapters 1-5, 10 and 11 was present in the original 1961 edition of the book, which emerged from Slichter's tenure as Morris Loeb Lecturer at Harvard. These chapters cover the basic theory of magnetic resonance, dipolar broadening, the interaction of nuclei with electrons, quadrupole effects and epr, and they introduce the density matrix. In 1978 the second edition appeared, enlarged by chapters 6-8, dealing with spin temperature, double resonance and multiple pulse methods, respectively. Much of the new material in this third edition is contained in these chapters and reflects the expansion of the field along these avenues. Chapter 9, discussing multiple quantum coherence, is also new.

The breadth of a field like magnetic resonance requires that an author be familiar with a large number of different subjects. Slichter's own research has covered a number of areas in fundamental nmr and epr, and in the applications of these techniques to surfaces and most recently to high- T_c superconducting materials. His many important contributions have placed him at the forefront of research in the field for three decades; thus, no more authoritative person could be found to author a book on the subject. This broad perspective of the field is especially important in writing a book like *Principles*, since it is inevitable that material of specific interest to many individuals will be

omitted. Thus, an author is forced to make judgments as to what is and is not essential and important. In my opinion Slichter's choices of subject matter are excellent in that he discusses the fundamentals of every area of current importance in the field.

In writing *Principles*, Slichter did not aim to provide an exhaustive account of all aspects of magnetic resonance. Instead his intent was to prepare a textbook that presents the fundamentals underlying the many diverse branches of the subject. When the student has mastered these, he or she should be able to proceed with studies of the literature or more specialized books devoted to specific topics. Slichter introduces the many areas of magnetic resonance with an emphasis on developing a physical understanding and the essential theoretical tools required to treat the topic. Anyone who has heard him lecture will remember the manner in which he focuses on a topic and presents a clear and lucid explanation of the subject. He does not bother you with unnecessary details, nor does he tell you too little—his book is much the same.

Today there are at least a dozen books on the market that cover various aspects of magnetic resonance. However, they are for the most part devoted to specialized (albeit important) topics—solids, liquids or multi-dimensional spectroscopy. As a consequence, either these books do not cover certain fundamental aspects of the field, or they do not offer a glimpse at the breadth of material presented by Slichter. Thus, this third edition and its predecessor editions occupy a niche that has not been filled by the many excellent books that have appeared in the last few years.

In summary, *Principles of Magnetic Resonance* is an extremely valuable resource for the novice and the expert in magnetic resonance and in related fields. Mastery of the material contained between its covers will prepare one to read and understand research papers in a variety of disciplines. It presents a clear exposition of the important physical concepts underlying the field, as well as a lucid discussion of the theoretical concepts required to treat the phenomena. If I were someday to write a book on magnetic resonance, I would find it difficult to avoid using Slichter's text as a model. It has my strongest recommendation both as a text and as a fundamental reference book.

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Einstein and the History of General Relativity

Edited by D. Howard
and J. Stachel

Birkhauser, Boston, 1990.

445 pp. \$69.00 hc

ISBN 0-8176-3392-8

This is the first volume of the *Einstein Studies*. Volume 1 is based on the proceedings of the 1986 Osgood Hill Conference on the history of general relativity held in May 1986 at the Boston University Conference Center at Osgood Hill. Apparently this was the first conference devoted exclusively to the history of general relativity.

The book is a great pleasure to read. It contains a collection of carefully written articles by experts in general relativity and history of science. It covers roughly the period of 1907-60. The book is divided into four general sections: "Einstein's Discovery of General Relativity," with contributions by John Norton and John Stachel; "The Reception and Development of General Relativity," with contributions by Peter G. Bergmann, Carlo Cattani, Michelangelo de Maria, Jean Eisenstaedt, Peter Havas and A. J. Knox; "Unified Field Theories," with contributions by Michel Biezunski and Vladimir P. Vizgin; and "Cosmology," with contributions by George F. R. Ellis and Pierre Kerszberg.

The first section, which covers the years 1907 through 1915, begins with a fascinating discussion by Norton of the equivalence principle, explaining what Einstein had in mind and how he used his principle. This section ends with two contributions on general covariance (by Stachel) and the search for and final form of the field equations of general relativity (by Norton). Stachel describes how Einstein, in the period that immediately followed his first joint paper with Marcel Grossmann in 1913 (the *Entwurf* paper), came to the conclusion that general covariance can not in fact be a property of the gravitational field determined by the covariant field equations of gravitation. A certain restrictive choice of coordinate systems seemed to be required. This was concluded from the "hole" argument, which describes the freedom in choosing coordinates in a matter-free domain joined smoothly to the outside world. The "hole" argument turned out later not to be correct in all its aspects. It took Einstein until the end of 1915 to regain general covariance and set up the field equations of gravitation in their final form. In December 1915 Einstein wrote in a letter to his friend

Besso: "My wildest dreams have been fulfilled. General covariance. The perihelion motion of Mercury wonderfully exact . . . This time the most obvious thing was the correct one."

The second section begins with an account by Cattani and de Maria of the controversies between Einstein and Abraham (1912, 1914) and between Einstein and Levi-Civita (1915). This is followed by a lucid description by Eisenstaedt of the early interpretations of the Schwarzschild solution. This recounts the work of Karl Schwarzschild, Johannes Droste, Arthur Eddington and others up to about 1960, describing the ups and downs in the interpretation of the "Schwarzschild singularity"—the singularity of the metric at the Schwarzschild radius. Another contribution by Eisenstaedt in this section describes the "lonely years" in general relativity (1925–55) when the theory was established and accepted, but most physicists turned to the newly developing fields of quantum theory and quantum field theory, which then were regarded as the revolutionary new physical theories. In fact, this development and competition between the two fields of research continues to the present day: The fusion of classical general relativity and quantum physics into one coherent theoretical framework is still missing.

In this section one finds furthermore a truly exciting summary by Havas of the early history of the "problem of motion" in general relativity. In the initial form of the theory of 1913, as well as in its final form (published in 1916), Einstein introduced as a separate postulate the geodesic law—the property that the motion of a mass point should follow a geodesic of the pseudo-Riemannian metric in four-dimensional space-time. It was only recognized later that within the theory of general relativity, the laws of motion cannot be postulated independently of the field equations (as is indeed the case in electromagnetism) but are consequences of these equations. Hermann Weyl in the early 1920s had used the differential conservation laws to derive the equations of motion of structureless matter particles. However, the works of Einstein and Grommer (1927) and of Einstein, Infeld and Hoffmann (1938) are generally regarded as the crucial papers deriving the approximate equations of motion of (slowly moving) particles in general relativity. Weyl's priority in the derivation of the geodesic law was apparently not acknowledged by Einstein.

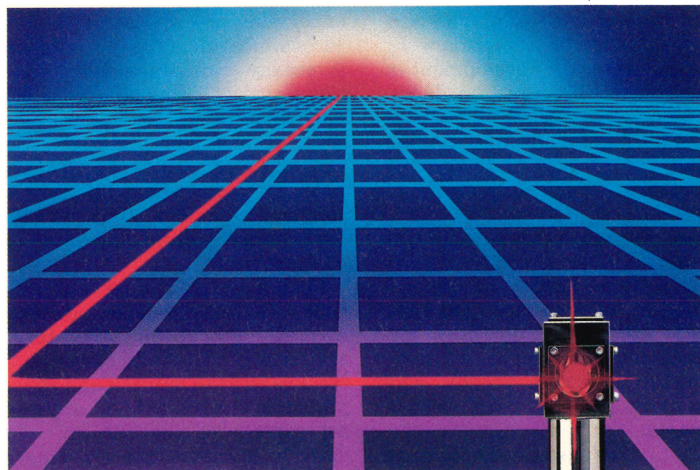
The second section ends with a

short review by Bergmann of the problems encountered in the early endeavors to set up a canonical formulation of general relativistic theories during the years 1930–1959. Abhay V. Ashtekar's talk at the conference reviewing the more recent progress on the canonical formulation and the quantization of general relativity is unfortunately not included in this volume.

The third section, on unified field

theories, is devoted to the contributions of Einstein, Hilbert and Weyl (by Vizgin) and to the Einstein–Cartan discussion over the years 1929–32 on distant parallelism (by Biezunski). The Einstein–Cartan theory is a gravitational theory involving metric and torsion. A teleparallelism arises for zero total curvature in the presence of torsion, that is, when the Riemannian (metric) curvature of space-time and the torsion contribution to the full

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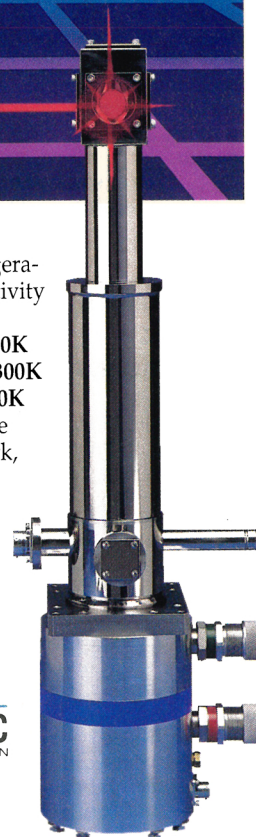


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curvature tensor compensate each other. The theory of distant parallelism was unsuccessful despite the intense discussion in the letters exchanged between Einstein and Cartan. "The Einstein-Cartan correspondence shows—as Biezunski puts it—[that] these two men followed from the start parallel but distant paths."

The book ends with two contributions on cosmology. In the first Kerszberg reviews the dispute between Einstein and de Sitter during the years 1916–17 over the early applications of the theory of general relativity to the universe as a whole. Discussed here are the role of Mach's principle, the origin of inertia, the "distant masses" and the boundary conditions, as well as the universality of the integration constants appearing in the solutions of the field equations in general relativity. This section concludes with a summary by Ellis of the historical development in cosmology from the Einstein-de Sitter dispute to modern times (about 1960). This interesting contribution contains an extended bibliography that is of great value to any scholar of cosmology.

Let me conclude by saying that this first volume of the *Einstein Studies* devoted to the history of general relativity is a true and valuable source of information on the origin and development of Einstein's theory. The reader may only wonder why such a book had not been written decades ago.

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Nonequilibrium Hypersonic Aerothermodynamics

Chul Park

Wiley, New York, 1990. 358 pp.
\$59.50 hc ISBN 0-471-51093-9

Spacecraft entering planetary atmospheres create flow conditions that defy experimental laboratory simulation and require extension of theoretical models to include nonequilibrium processes. The logarithmic mass ratio in the rocket equations for spacecraft design places a great premium on thermally and aerodynamically efficient structures. This book covers the principal aspects of physics, chemistry and high-speed fluid dynamics that must be understood by those who would contribute to the aerodynamics and propulsion of future interplanetary space flight. Many of the methods are so new that no other book has this

scope. Chul Park's initiative must be applauded.

The title helps specify the scope of the subject matter presented. Equilibrium thermodynamics was put on a firm physical base by quantum statistical mechanics, and the continuum theory of compressible fluid flows at hypersonic speeds—Mach numbers greater than five—was developed during the first space age, the 1960s. What we could not deal with adequately then were any but the simplest of rate processes: vibrational energy changes described by a relaxation time and chemical reactions described by the Arrhenius equation.

The fundamental problem is that interplanetary approach speeds, in the range of Mach number 30, lead to equilibria where chemical reactions, ionization and radiation all become important. But the bow shock wave enveloping the spacecraft first converts almost all of the incoming kinetic energy into Maxwellian translational energy within only a few molecular mean free paths. Thereafter all sorts of reactions occur with rates ranging over many orders of magnitude, including some that are slow compared to flow time for small probes but significant for large piloted spacecraft.

Park is well qualified to write this book. He has developed new experimental methods for laboratory research at NASA Ames Research Center; has written many sound research papers in theoretical and experimental aspects of the subject; and is actively involved with the emerging methods of computational fluid dynamics, computer-based techniques for solving the coupled sets of nonlinear partial differential equations. Much of the material in this book is drawn from a course he has taught at Stanford.

Who should study the book? Anyone who wants to work in space-vehicle aerodynamics or propulsion, implosion fusion or high-powered gas-dynamic lasers. Who can study the book successfully? The author says a familiarity with supersonic aerodynamics and with the book by Walter Vincenti and Charles Kruger, *Introduction to Physical Gas Dynamics* (Wiley, New York, 1965) are necessary. This reviewer agrees these are necessary but not sufficient conditions. Physicists can manage the necessarily brief review of basics and nomenclature but those with other backgrounds will have a tough time with the quantum mechanics of atoms and molecules; eigenfunctions; quantum numbers; the identification of atomic and molecular energy levels;

and selection rules in line and band spectra. To ease this task the author includes in each chapter many helpful figures, several meaningful problems, lots of tables of data and a gratifyingly complete list of references in case the reader gets stuck. The student reader will be well advised to work all the problems in each chapter before proceeding to the next one.

The first five chapters deal with atoms and molecules, transitions between states, rate equations, fluid conservation equations and methods for setting up equations for computation. Included in Chapter 5 is a section charmingly titled "Pitfalls and Tricks," a refreshing reminder that art and skill are required in manipulating even the greatest computers.

Chapters 6 through 8 include a broad range of applications with both experimental and theoretical results being presented and discussed. This section of the book is actually a very authoritative assessment of our present level of knowledge and ignorance about the problems discussed in the opening paragraphs of this review. Chapter 9 concludes the work with reactions at surfaces, including evaporation and condensation. Heterogeneous reaction theory is far less advanced than gas phase theory so the text is necessarily more discursive and more empirical than the rest of the book. Inclusion of this topic is a wise choice in this reviewer's opinion simply because successful spacecraft design requires an integrated effort of aerodynamicists with materials experts: Hence some common language for communication is needed. Perhaps spacecraft materials books should end with a chapter on gas dynamics.

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NEW BOOKS

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Community Food Webs: Data and Theory. *Biomathematics* 20. J. E. Cohen, F. Briand, C. M. Newman. Springer-Verlag, New York, 1990. 308 pp. \$79.00 hc ISBN 3-540-51129-6. *Monograph*