

molecular rotations. The inclusions of chapters nine and ten points up very clearly the importance of intermolecular forces in a wide variety of macroscopic and microscopic properties, since until relatively recently the experiments described in these chapters were not quantitatively related to molecular interactions.

The feature that stands out most strongly in this excellent treatise on intermolecular forces is its flavor of authority and expertness. Not only the editor, but each of the contributors is known for his contribution to the understanding of intermolecular forces. To be sure, other topics might have been included and the treatment might have been extended until a small library, rather than a single volume, was produced. In a field as broad as intermolecular forces it is only relevant to ask if the topics chosen by the editor and the contributors are representative and important, and if the authors have treated these topics clearly and accurately. The answer to these questions is definitely yes. Most serious workers in the field, graduate students and seasoned investigators, will welcome the book enthusiastically.

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The reviewer, professor of physical chemistry at the Massachusetts Institute of Technology, has worked extensively on the experimental determination of intermolecular forces from gaseous transport properties and scattering of molecular beams.

A conference on atoms

ATOMIC PHYSICS. Conf. Proc. (New York University 3-7 July 1968) Benjamin Bederson, Victor Cohen, Vernon W. Hughes, Francis M. J. Pichanick, eds. 635 pp. Plenum Press, New York, 1969. \$25.00

by Benjamin Bederson, Vernon W. Hughes and Larry Spruch

Atomic physics is one of the oldest branches of modern physics, and the study of atoms has played a central role in the development of modern physics. Atomic spectroscopy and atomic collisions have provided the principal testing ground for the development of quantum mechanics, special relativity and quantum electrodynamics, and still provide an important testing ground for fundamental physical

theory. The study of the structure and collisions of atoms, based on known forces and well-established fundamental principles, is also a broad and rich field in itself; it is developing rapidly after a long period of relative inactivity. The applications of atomic physics to many other fields of science are extensive.

In the late 1940's the rapid development of atomic physics included important discoveries such as the Lamb shift and the anomalous magnetic moment of the electron. With precision tools available from radar research, measurements of atomic and electronic properties were vigorously pursued, principally by atomic-beam magnetic resonance and microwave spectroscopy. The methods of optical pumping and optical level-crossing spectroscopy were introduced in the 1950's. Simultaneously the field of atomic collisions expanded rapidly by crossed-beam experiments that were made possible by advances in technology; interest in atomic collisions also was stimulated by its relevance to space physics, astrophysics, chemistry and gas discharges.

The objective of the International Conference on Atomic Physics held 3-7 July at New York University—to our knowledge the first such general conference on modern atomic physics—was to bring together physicists working in the various subfields of atomic physics and related fields and to review the state of fundamental research in the entire field of atomic physics, emphasizing present advances and future possibilities. This volume contains 25 invited review-type papers on fundamental problems, atomic structure, atomic collisions, new experimental methods and application of atomic physics to other scientific fields.

Gerald Feinberg of Columbia University gives a stimulating discussion on tests of Lorentz invariance and invariance with respect to parity, charge conjugation and time reversal. Although some of the symmetry invariants arose in atomic studies, these invariants have not been as thoroughly studied in atomic physics as in some other fields. Feinberg emphasizes that the observed equality of the magnitudes of the electron and proton charges represents the situation of a symmetry in search of an invariance principle. The present status of tests of quantum electrodynamics in atomic physics is discussed by Vernon W. Hughes of Yale and Sidney Drell of

Stanford University. Theory and experiment are now in rather good agreement. New measurements of the fine-structure interval in hydrogen appear to disagree with the early result of Edward S. Dayhoff, Sol T. J. Triebwasser and Willis E. Lamb. The new measurements give a value of the fine-structure constant that agrees with the values determined from the ac Josephson effect and from hydrogen hyperfine structure.

The relatively new field of mesic atoms is reviewed by Valentin L. Telegdi of the University of Chicago. Muonic atoms are effectively single-electron atoms and are therefore theoretically tractable. With advances in gamma-ray spectrometry made possible by germanium-lithium detectors, unusually detailed information about nuclear structure can be obtained.

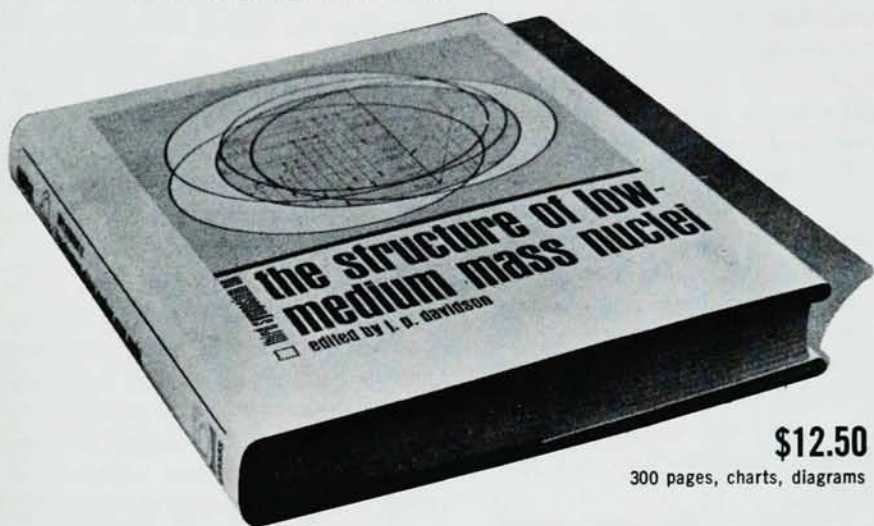
P. A. M. Dirac's speculation, some time ago, that the gravitational constant varies inversely with time, has generated many interesting and many exotic papers. (Is it true cosmologists have more fun?) The variety of "constants" that have been assumed to vary either with space or time or both, the attempts to put these ideas on a sound theoretical footing by an appropriate modification of general relativity theory and the experimental status of these ideas are reviewed by Robert H. Dicke of Princeton University.

On the subject of atomic structure, Keith Brueckner of the University of California, San Diego, reports on an application of many-body theory to the determination of the correlation energy, which is the difference between the experimental energy and the Hartree-Fock energy. The correlation energy for atoms from oxygen to potassium is overestimated by nearly a factor of two, and Brueckner concludes that any agreement of the uniform electron-gas theory with experiment is fortuitous, because an expansion using the density gradient as a perturbation does not converge for atoms. The powerful analytic tools and the insights that many-body theory has provided will surely yet prove very fruitful in atomic-structure analyses. Though the correlation energy is small its effect can often be crucial. Oktay Sinanoglu of Yale University and Orta-Doğu Teknik Üniversitesi, Ankara, cites a number of examples. He discusses the techniques (and the justification) for the approximate separation of the N -electron problem into $N(N-1)/2$ decoupled two-

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Experimental papers are presented mainly by scientists associated with laboratories using electrostatic accelerators. Topics of these papers include gamma-ray spectroscopy and structure studies using charged particle induced reactions.

The contributors include Dr. J. A. Becker, Lockheed Missiles and Space Co.; Dr. M. R. Cleland, Radiation Dynamics, Inc.; Professor J. P. Elliott, University of Sussex, England; Professor P. M. Endt, Rijksuniversiteit, The Netherlands; Dr. Edith C. Halbert, Oak Ridge National Laboratory; Dr. D. S. Koltun, University of Rochester; Professor A. E. Litherland, University of Toronto; Dr. J. W. Olness, Brookhaven National Laboratory; Dr. P. H. Rose, High Voltage Engineering Company; and Dr. G. Ripka, Princeton University and Rutgers University, on leave from Saclay.

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electron problems. A comparison of theory and experiment for electron affinities and negative-ion excitation energies, term splitting ratios in excited configurations and transition probabilities showed good agreement.

A measure of recent progress in the calculation of electron-atom collision parameters is the tolerant smile that can be produced on the face of a theorist by the phrase "Born approximation." The close-coupling approximation, in which the trial function Ψ is chosen to satisfy the Schrödinger equation "on the average," is a particularly useful approach. It is known that the estimates improve monotonically as the number of terms in Ψ is increased. Aided by a knowledge of how to extract long-range polarization effects exactly and how to account for short-range correlation effects, and abetted by the availability of high-speed computers, we may use the approach to give reliable results for an increasing variety of problems involving light atoms. Many examples are given by Philip G. Burke of The Queen's University of Belfast. He also discusses methods that are not so well founded but that have proved useful in estimating cross sections rapidly and fairly accurately over wide energy ranges. Burke includes semiclassical methods and adaptations of the impulse approximation.

Doubly excited states of atoms, of central interest in recent years, are discussed by Ugo Fano of the University of Chicago. These states can be produced by photon absorption or by particle impact, and they can be detected relatively easily because the discrete line radiation emitted on deexcitation stands out against the background continuum. The states also play a dominant role in resonance scattering. For $e^- + \text{He}^+$ scattering for example, the resonance positions are largely determined by the positions of the doubly excited states of neutral helium. Though the positions of the $e^- + \text{He}^+$ resonances can be accurately calculated from first principles, they are not fully "understood." Fano discusses the insight to be gained by introducing an approximate two-valued quantum number that describes whether the electron-electron interaction generates radial oscillations with the two electrons in or out of step.

The field of heavy-particle collisions is in a phase of rapid growth largely because of improved energy resolution and the measurement of angular distri-

butions. Felix Smith of the Stanford Research Institute reviews the field, discussing elastic scattering and inelastic processes involving electronic excitation, ionization and electronic energy or charge transfer. The theoretical emphasis was on simple concepts useful in the interpretation of large bodies of data. These include scaling laws, electron-symmetry effects present, for example, in $^4\text{He}^+ + ^4\text{He}$ scattering and in $^4\text{He}^+ + ^3\text{He}$ scattering and nuclear-symmetry effects present in the first example but not in the second.

Problems in low-density astrophysics for which atomic processes play a significant role are discussed in two papers, one mainly on neutral atomic-hydrogen regions and the other mainly on ionized atomic-hydrogen regions. George B. Field of the University of California, Berkeley, discusses the determination of the chemical composition of the interstellar gas—atomic versus molecular hydrogen, CH , CH^+ , CN —and the processes by which the gas radiates. Shock waves receive particular attention. Michael J. Seaton of University College London concentrates on the determination of the electron temperature, comparing the values obtained by a variety of methods, including the intensity ratios of particular lines of O^{++} , the Balmer line to Balmer continuum intensity ratios, the radio continuum of the free-free (bremsstrahlung) radiation emitted in the transition $\text{H}^+ + e \rightarrow \text{H} + e + h\nu$ and the radio recombination lines arising from transitions between states with principal quantum numbers n' and n , where $n' - n$ is small compared to n , and n is of order 100.

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The three reviewers consider atomic physics among their most important interests and activities. Benjamin Bederson and Larry Spruch are professors of physics at New York University and Vernon Hughes is professor of physics at Yale University.

NEW BOOKS

ELEMENTARY PARTICLES

- The CP Puzzle: Strange Decays of the Neutral Kaon.** By P. K. Kabir. 137 pp. Academic Press, London, 1968. 40s
- Hadrons and Their Interactions.** (Conf. Proc.) A Zichichi, ed. 718 pp. Academic Press, 1968. \$26.50.
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