

appreciation of the importance of these topics causes, quite literally, hundreds of lost man-hours each year in his laboratory. He has been forced to conduct, as he put it, "tutoring programs." Some more emphasis in experimental science on such topics might save both hours and money as well as "strange" data that keep showing up in graphical presentations.

In conclusion, then, these books could be very useful in a college or university laboratory course, and of similar importance and practicality in an industrial laboratory. Despite the great amount of experimental science in the world, techniques and methods are not always what they should be.

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On intermolecular forces

ADVANCES IN CHEMICAL PHYSICS, VOL. 12: INTERMOLECULAR FORCES. Joseph O. Hirschfelder, ed. 643 pp. Interscience, New York, 1967. \$22.50

by I. Amdur

As early as the middle of the nineteenth century it was recognized that a satisfactory description of a wide variety of physical and chemical properties required a knowledge of the character and magnitude of intermolecular forces. Until about the 1930's, however, quantitative treatments of molecular interactions were largely characterized by the use of models chosen more for mathematical tractability than for physical reality. The development of quantum mechanics influenced the treatment of these interactions by showing that for certain systems and under certain asymptotic conditions a theoretically sound form of the intermolecular potential could be deduced. As a result, semiempirical models were introduced for which the potential functions, although still mathematically convenient, were, in part, physically realistic. When used with an understanding of their limitations, these semiempirical functions have proven very useful for obtaining moderately accurate estimates of the magnitudes of interaction energies in simple systems, such as rare-gas atoms in their ground states. To a smaller degree

these functions have also led to information concerning the average interaction energies between atoms and molecules or between molecules and molecules. Although such average potentials wipe out the details of the effects of spatial orientation and of the internal states of the molecules, the potentials are often helpful for correlating experimental results and for predicting magnitudes of certain properties.

A survey of the nature of intermolecular forces is given by Hirschfelder and W. J. Meath in the first chapter as they discuss the types of interactions and the problems, conceptual and practical, associated with the theory. This is followed, in the next five chapters, by treatments of specialized topics in the theory of intermolecular forces. A. D. Buckingham discusses long-range forces, other than retardation forces, between two polyatomic molecules. He shows that such forces can be related to the permanent and induced electric moments of the isolated molecules. Alexander Dalgarno reviews recent advances in calculating long-range forces, except those of retardation. He discusses a priori and semiempirical methods and shows that quite accurate results can be obtained by using perturbation methods and new mathematical techniques. He ends the chapter with a very useful table of recommended values of the attractive dipole-dipole interactions for spherically symmetric systems. The retardation forces omitted from chapters two and three are discussed by Edwin A. Power. These forces come into play at very large separations, of the order of $100 a_0$, in systems involving like atoms in different energy states, and are involved in such phenomena as sensitized fluorescence in gases, fluorescence of certain aromatic or dye molecules, and the resonant transfer of energy between impurity atoms in crystals. Application of the reaction-field technique is discussed by Bruno Linder from the standpoint of a phenomenological method for calculating weak interactions. He shows that the use of this technique permits inclusion of many-body forces so that the method is of particular interest where such forces are dominant, as in properties of liquids. Oktay Sinanoglu treats intermolecular forces in liquids in chapter six, the final chapter in the theoretical section of the volume. He discusses pair potentials, effective pair

potentials, and many-body potentials and their relation to the structure of liquids. He obtains interesting numerical results for nonpolar liquids.

Edward A. Mason and Louis Monchick review methods for determining intermolecular forces, for the most part, from experimental measurements. They discuss the Rydberg-Klein-Rees method of analyzing band spectra as a direct approach to the determination of intermolecular forces and the use of transport and equilibrium properties for finding parameters in empirical potential functions. Mason and Monchick conclude their comprehensive survey with a discussion of the relation of scattering molecular beams to the determination of intermolecular forces. This chapter is appropriately followed by a discussion by Richard B. Bernstein and J. T. Muckermann of the specialized topic of determining intermolecular forces from low-energy molecular-beam scattering. The authors give an excellent description of the experimental basis of the scattering measurements and then proceed to a detailed analysis of the classical and nonclassical features of the scattering measurements that are related to interactions between beam particle and scatterer. Presenting a clear picture of the relation between the theoretical and experimental features of low-energy scattering, Bernstein and Muckermann conclude with a very complete inventory of scattering measurements that include a tabulation of systems studied, the type of scattering measurements used and an excellent annotated bibliography keyed to the tabulation.

In chapter nine George Birnbaum shows that the pressure broadening of spectral lines in the microwave and infrared can be used to obtain information concerning anisotropic intermolecular forces. Although some features of pressure broadening are not yet reconciled with theory, there is no doubt that such experimental observations are useful as an aid to understanding intermolecular forces. It is worth noting that good values of quadrupole moments of molecules have been obtained from studies of pressure broadening. In chapter 10 M. Bloom and I. Oppenheim discuss the use of nuclear magnetic resonance measurements in gases as a means for deriving accurate information about intermolecular forces, particularly about the anisotropy in the potential that is responsible for changes in the

ORDER AND DISORDER IN THE WORLD OF ATOMS

By A. I. Kitaigorodskiy (translated from the Russian)

Edited by S. Chomet

(THE HEIDELBERG SCIENCE LIBRARY, VOLUME 3)

An examination of the distribution in space of the atoms and molecules constituting the world around us.

71 figures viii, 135 pp. 1967. Soft Cover. \$2.80

"... as a first introduction to that part of the theory of matter that treats crystals, their defects, their modifications and their transitions, the book is highly satisfactory... the numerous and appropriate diagrams and illustrations are extremely useful in giving... an intuitive grasp of the nature of crystalline arrays and their defects."

—Lawrence Sklar, assistant professor of the philosophy of science at Princeton University in *Physics Today*, Vol. 21, No. 3, March, 1968.

THE NEW COSMOS

By Albrecht Unsöld

Translated by William H. McCrea

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By Jean Kovalevsky (translated from the French)

(THE ASTROPHYSICS AND SPACE SCIENCE LIBRARY, VOLUME 7)

viii, 126 pp. 1967. Cloth. \$6.40

After the launching of the first artificial satellites preceding interplanetary vehicles, celestial mechanics is no longer a science of interest to a small group of astronomers and mathematicians; it has become a special engineering technique. The author has tried to set this book in this new perspective, by severely limiting the choice of examples from classical celestial mechanics and by retaining only those useful in calculating the trajectory of a body in space.

Distributed in North and South America by Springer-Verlag New York Inc. for D. Reidel Publishing Company.

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By W. H. Westphal

285 figures xvi, 347 pp. 1968. Cloth. \$9.75

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Wallace Arthur and Saul K. Fenster, both of Fairleigh Dickinson University

To illustrate the universality of mechanics and the unity of science, the authors apply the laws of mechanics to a variety of systems (atomic, electromagnetic, nuclear). January 1969/640 pages/\$13.00 (tent.)



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383 Madison Avenue, New York, New York 10017

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-