Revue de Livres

Lecture Notes in Physics
Vol. 166 : Computer Simulation of Solids

Edited by C. R. A. CATLOW and W. C. MACKRODT

(Springer-Verlag, Berlin-Heidelberg-New York) 1982, 320 p., DM 42,— ; US $ 17.60, ISBN 3-540-11588-9.

This volume is an excellent introduction to the field of computer simulation in solids. It arose from a meeting held at the Daresbury Laboratory of the S.E.R.C. (U.K.) in May 1980. Rather than produce a set of conference proceedings, each set of authors was charged with producing a definitive article on one area of the subject.

The first section of the book is concerned with computer techniques for both static simulations and for molecular dynamics simulation. Monte Carlo methods and quantum mechanical cluster methods are also described, and the editors note that future developments will rely increasingly on the latter. Calculations of both thermodynamic properties and transport properties are treated in depth.

Four chapters deal with the choice of interatomic potentials in ionic and covalent solids and in metals. Finally, applications are outlined for a wide variety of systems from simple oxides and halides to complex minerals and semiconductors.

The editors state that good simulation studies form a bridge between the fundamental physics and experimental work. They are to be congratulated on producing a well balanced and coherent volume which will be of use to students and to workers starting in this and related fields.

J. E. PARKIN.

Springer Series in Chemical Physics Vol. 23
Picosecond Phenomena III

Editors : K. B. EISENTHAL, R. M. HOCHSTRASSER, W. KAISER, A. LAUBEREAU

Proceedings of the Third International Conference on Picosecond Phenomena, Garmisch-Partenkirchen, Fed. Rep. of Germany, June 16-18, 1982

(Springer-Verlag, Berlin-Heidelberg-New York), 1982, 401 p., DM 66,— ; US $ 26.40. ISBN 3-540-11912-4.

This third volume of conference proceedings continues in the same vein as its predecessors, with sections on technical developments and applications in molecular physics, solid state physics and photochemistry of chemical and biochemical systems. The two years since the previous conference has seen the development of pulses in the femtosecond range and the Holmdel group report their generation of 30 fs pulses. Later authors give details of the use of such extremely short pulses in the study of molecular dynamics of liquids. There is ample evidence that many fruitful studies are being made in the picosecond region and authors are presenting completed work rather than preliminary results.

The series is undoubtedly a useful guide to current work and will act as a stimulus to people working in related areas. The volume is well reproduced from authors' copy.

J. E. PARKIN.

The Historical Development of Quantum Theory

J. MEHRA and H. RECHENBERG

(Springer-Verlag, Berlin-Heidelberg-New York).

Volume 1, Part 1 : *The Quantum Theory of Planck, Einstein, Bohr and Sommerfeld : Its Foundation and the Rise of its Difficulties, 1900-1925*. 372 p., DM 75,— ; US $ 31.30, ISBN 3-540-90642-8.

Volume 1, Part 2 : *The Quantum Theory of Planck, Einstein, Bohr and Sommerfeld : Its Foundation and the Rise of its Difficulties 1900-1925*. 506 p., DM 85,— ; US $ 34.00, ISBN 3-540-90667-3.

Volume 2 : *The Discovery of Quantum Mechanics 1925*. 355 p., DM 65,— ; US $ 26.00, ISBN 3-540-90674-6.

Volume 3 : *The Formulation of Matrix Mechanics and its Modifications 1925-1926*. 334 p., DM 75 — ; US $ 30.00, ISBN 3-540-90675-4.

Volume 4, Part 1 : *The Fundamental Equations of Quantum Mechanics 1925-1926*. Part 2 : *The Reception of the New Quantum Mechanics 1925-1926*. 322 p., DM 75,— ; US $ 30.00, ISBN 3-540-90680-0.

The twentieth century has witnessed two of the greatest advances in scientific thought — relativity and quantum mechanics. Up to the end of the nineteenth century Newtonian mechanics and Maxwell's formulation of electrodynamics formed the foundations of physical science. The remarkable success enjoyed by classical physics led to the belief that the view of the physical world as seen through a classical eye was almost complete. However, experimental data that could not be fitted within the then existing classical framework were beginning to accumulate. Strenuous efforts to adapt the classical theory to fit the new facts remained a failure. It was Planck who made a radically new start with the postulate of quanta of energy and the introduction of the constant h through $E = h\nu$. Subsequent development in the hands of a few — Bohr, Born, Dirac, Heisenberg, Pauli and Schrödinger — culminated in the formulation of quantum mechanics in 1925-26.

A key step in the development of quantum mechanics was the realization that our experience of the macroscopic world cannot be extrapolated to the microscopic world in a simple manner. At the macroscopic level, wave and corpuscular properties are mutually exclusive. At the microscopic level this is not so. Electrons, for example, have both particle-like and wave-like properties. Because of the use of concepts or ideas contrary to common sense there was a degree of reluctance to accept the new theory. Common sense at times can be a poor guide. Einstein once said that common sense is that layer of prejudices one acquires before the age of sixteen. What is common sense varies from generation to generation. What was exciting and radically new yesterday is common sense today. It is not surprising that the present-day students accept quantum mechanics with great ease.

An important feature of the theory is the recognition of the impossibility of a complete separation between the behaviour of a quantum object and its interaction with an observer. As Heisenberg remarked, the language of quantum mechanics is one of interactions and not attributes. Processes and not properties are its grammar. Or as Bohr put it, quantum theory reminds us of the old wisdom that in the drama of life we ourselves are both the players and the spectators. Perhaps the most profound impact of

the new mechanics is the realization that nature is not deterministic but statistical. Although a small band of physicists and philosophers still remain sceptical of this view, the essential correctness of quantum mechanics has been amply verified over the years.

The evolution of quantum mechanics is a paradise for the historian of science. A study of the thinking that had gone into the formulation of the theory as well as an analysis of contemporary thought are fascinating for both the historian and the physicist. Several historical studies of quantum mechanics exist. However, The Historical Development of Quantum Theory by Mehra and Rechenberg is the most ambitious attempt so far. The authors have been working on the project for over thirty years. One of them has had the benefit of long discussions with most of the principal architects at various times and these provide additional insight. The authors claim with justification that the « depth and scope of our work are different from many attempted so far : we bring in all the physical, mathematical and human details to provide the reader a complete account of the old quantum theory and the discovery and development of quantum mechanics ». In these volumes the original papers are discussed in great detail and the material is presented in a coherent manner. The presentation is essentially factual without any serious attempt on a critical appraisal. The authors' fascination for details, major and minor, primary and secondary, has resulted in a text lacking in perspective. The reader has to remain alert so that he does not sink in the sea of minute details. The bibliography is extensive and each volume carries an author index, but alas there is no subject index.

Volume 1, which appears in two parts, covers the old quantum theory period. It provides a setting as it were for the birth of the new mechanics. It deals mainly with the works of Planck and Einstein on the quantum nature of radiation and with Bohr's studies of the atom. In addition it describes other important topics such as de Broglie's wave-particle duality hypothesis, electron spin and the exclusion principle, Zeeman effect, Stern-Gerlach experiment, and the Compton effect. These studies showed clearly the inadequacy of the then existing theories and pointed towards the need for a radically new approach. Volume 2 is mainly devoted to Heisenberg. It deals with his early life, the influence of Sommerfeld, Born and Bohr on his scientific development, and the events leading to his formulation of quantum mechanics. With the publication of his paper began the Golden Age of Theoretical Physics. Volume 3 describes the period when the theory was given a more precise mathematical basis and applied successfully to some atomic problems. The principal participants of this period were Heisenberg, Born, Jordan and Pauli. The first half of Volume 4 describes Dirac's formulation of quantum mechanics. It includes a sketch of Dirac's early life in Bristol and later in Cambridge together with a brief account of the intellectual atmosphere of Cambridge during that period. The second half describes the reactions of the physics community to the new theories. It is interesting that the American physicists received the theory with great enthusiasm and went on to apply it to atomic problems with great success.

In these volumes the story of quantum mechanics is told in a language and style appropriate to the period. The authors could have with advantage weaved into the text a view from the modern standpoint. These volumes form a part of a series. The forthcoming volumes are to include wave mechanics, applications, quantum theory of radiation and epistemology. When complete, the series should become a standard source of reference. The general reader would welcome a single volume, sketching the highlights of the story from both the human and scientific points of view.

T. THIRUNAMACHANDRAN.

Nuclear Technologies in a Sustainable Energy System

Selected papers from an I.I.A.S.A. Workshop, May 1981, ed. by G. S. Bauer and A. McDonald

(Springer-Verlag, Berlin-Heidelberg-New York) 1983, 329 p., DM 68,— ; US $ 29.30, ISBN 3-540-12154-4.

This symposium manages to be positive about future world energy supplies without being too utopian.

The tone is set by the first two papers, from the organizers W. Haefele and A. A. Harms. Haefele reviews prospects for the availability of fossil fuels and fissile uranium over the next 100 years. He shows that there is no immediate crisis, at present rates of use, but that there is no clear, proven energy source available to take over from fission around the year 2030. He points out also that we need a variety of transportable and storable liquid fuels, to complement fixed electrical power utilities. In Harms' paper the emphasis is more particularly on nuclear processes, but treated as a menu of flexible options. This is the strength of the symposium — its stress on how any neutron-producing process could be used to enrich the enormous fertile reserves of thorium and uranium. Its weakness is, of course, that only the fission fast-breeder is available today, and that has a doubling time which is comparable with the timescale on which other reserves are known to be running out. Harms' favoured solution to this problem is to develop fusion, not primarily as an energy source but as by far the most copious of possible neutron sources ; to be complemented by accelerator enrichment and other techniques.

The more technical articles which follow are organized under the headings : « Fission and Fission Breeding », « Fusion and Dense-Plasma Neutron Sources », « Accelerator Breeding » and « Handling the Waste ». None is at the technical research-paper level of specialization but all go well beyond the level of mere journalistic review. One learns a great deal from them of the possibilities of such new technologies as hydrogen production through fusion, the disposal of waste in self-sinking capsules which melt their way into the earth's crust by using their own radioactive heat, families of small fission reactors depending on one local breeder. The tone is positive but avoids shallow optimism, and the final papers contain warnings from Freeman Dyson and Hans Bethe about the dangers of setting grandiose goals when what is needed is steady progress.

This is an important contribution to the debate on future energy supplies. It does not pretend to solve the technical problems, but it helps define which of those problems are important.

D. J. MILLER.

Dynamical Gauge Symmetry Breaking

A collection of reprints edited by E. Farhi and R. Jackiw

(World Scientific) 1983, 403 p., £ 14.50, ISBN 0-971-95025-1.

Seeing around the next corner is the theorist's job. Experimental particle physicists can see very clearly where they must go for the next five years or so, and have an idea of what is to be found out about the electroweak theory and about Q.C.D. But what comes after that ? The road « beyond the Z » is completely hidden.

These papers represent a major school of thought among those who claim to be able to see around the corner. They reject the idea of a simple Higgs field, and invoke a « naturalness » criterion which tries to account for the mass-differences between the quark-lepton generations as a dynamical effect coming from a new class of particles, often referred to as « technicolour » particles.

The collection begins with « Prehistory » — the papers of Anderson (1958) and Nambu (1960) on the implications of the B.C.S. theory of superconductivity. Then the development goes on with (among others) Schwinger, Migdal and Polyakow, Cornwall and Norton, through Weinberg to Susskind and the fully developed technicolour theory. Ellis and others discuss possible tests and current experimental constraints. The most recent papers in the collection include 't Hooft's 1980 work on « Naturalness, chiral symmetry and spontaneous chiral symmetry breaking » and Abbott and Farhi (1981) on « A confining model of the weak interaction ».

It would be a good going away present for a new Phd in theoretical physics, but it may have very little to do with what we will find when we get around the next experimental corner.

D. J. MILLER.

Weak Interactions of Leptons and Quarks

E. D. COMMINS and P. H. BUCKSBAUM

(Cambridge University Press) 1983, 474 p., £ 16.50, ISBN 0-521-27370-6.

Ten years ago one of the authors of this book (EDC) wrote a monograph called « Weak Interactions » which was to become a standard postgraduate text. Since that time elementary particle physics, and weak interactions in particular, has undergone a revolution, with the emergence of renormalizable theories which unify the weak and electromagnetic interactions, and major new experimental discoveries such as neutral currents and charmed particles. A new book was therefore much needed to interpret these new results in the framework of modern theory. This is the aim of the present monograph, whose title reflects the changed emphasis of the field.

The book starts with a brief historical survey of weak interactions, and motivates the need for a new theory. Unfortunately the new theories (renormalizable Gauge theories) are technically more difficult than ealier ones and the author of a book such as this, whose emphasis is on the phenomenological aspects of the subject, must face the problem of when, and in what depth, to present the theoretical framework. The solution of Commins and Bucksbaum is to give (in Chapter 2) an overview of what has come to be known as the Standard Model, and to reinforce the ideas with the results of practical calculations in later chapters were appropriate. This approach seems very sensible because it means that Chapter 2 may be omitted by readers who already know the theory, or who do not but are only interested in the results. Readers not falling into either of these two categories, and that should include most students, may find Chapter 2 rather hard going, because a lot of material is compressed into some sixty or so pages. This chapter also requires a passing acquaintance with quantum field theory in addition to the general knowledge of elementary particle physics and relativistic quantum mechanics which is needed throughout the book. Nevertheless, perseverance should bring its rewards in a better understanding of the calculations that follow in later chapters.

The style and division of material, in the rest of the book, follows that of Commins' earlier work. Thus there are (updated) chapters on such topics as leptonic weak interactions, neutral K-mesons and CP violation, nuclear β-decay, etc. In addition, there are new chapters on the parity non-conserving eN and NN interactions (where experiments have provided important evidence of electro-weak interference effects crucial for the new theories), on lepton mixing, neutrino oscillations and neutrino mass (an area of great current interest for extensions of the Standard Model), and on neutrino astrophysics (reflecting the growth in links between particle physics and cosmology). The book ends with some useful technical Appendices, and an excellent bibliography.

Like Commins' earlier work I confidently expect this book to also become a standard text, to be replaced only when new theoretical developments and experimental results demand it.

B. R. MARTIN.

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