are materials scientists. Similarly, many chemists are also materials scientists. Materials science is at once very broad and highly interdisciplinary. Nonetheless, it constitutes a discipline unto itself, as witnessed by the departments of materials science and engineering (or similarly titled departments) in most research universities. In *The Coming of Materials Science*, Robert W. Cahn of the University of Cambridge, himself a noted materials scientist, offers a historic account of the development of the discipline.

The historical perspective of the book makes it a lively and interesting read. Cahn does not present a detailed scientific account of any part of materials science. Instead he provides selective historical accounts. His book is full of fascinating anecdotes that describe some of the key scientific developments and offer a wonderful insight into the personalities of the scientists who played important roles in defining the discipline. This is probably not a book for young graduate students; instead it is most appropriate for more experienced scientists, those who want to gain perspective on the discipline's past yet who have already developed a personal view of the background of materials science.

Cahn is a metallurgist by training, and the focus of the history he describes is that of the evolution of metallurgy into materials science. Metallurgy clearly did play an essential role in defining the early evolution of the field, however the focus on metallurgy also represents a strong bias that perhaps seriously dates the book. For example, in a discussion of important institutions in materials science in the US, Cahn refers to the Institute for the Study of Metals at the University of Chicago, which played an influential role in the careers of many materials scientists—during its existence from 1946 to 1961. Cahn laments the evolution of the institute to its current incarnation, the James Franck Institute. In this, he fails to acknowledge the very influential and important—if more broadly defined—role it currently plays.

Nonetheless, Cahn does provide a very interesting historical review of the evolution of materials science departments that occurred after World War II. His review includes an account of the materials research laboratories at various universities, which evolved into the modern materials science research and engineering centers and which continue to play an influential role in materials science in the US.

The bias toward metallurgy also influences the author's choice of topics and the perspective he adopts. There is an extensive and quite excellent history of the methods used to characterize materials. Cahn divides materials science into the study of two primary classes of materials: structural materials, which are primarily load bearing, and functional materials, which are important for their physical properties. He suggests that the emphasis of materials science is continually evolving from the study of structural materials to the study of functional ones. Nevertheless, in his metallurgical bias he maintains that it is the microstructure of materials that is most important in the field.

In the discussion of functional materials, the book includes a very readable account of the many modern developments in the field. There is a full chapter, for example, on polymer science, one of the cornerstones of modern materials science. However, Cahn dismisses as irrelevant virtually all of fractal analysis, even excluding one piece of his own work. Such dismissal would seem to ignore the essential importance of fractals in describing the structure of polymers and gels and in the process of gelation, and it would relegate all of percolation theory to irrelevance.

Cahn discusses the evolution of modern research, and points to the move away from "basic" research, which he prefers to call curiosity driven, toward more directed and applied research. An applied bias is certainly a fact of modern materials science research. However, good applied research can also be curiosity driven. Cahn also refers several times to the tension in materials science between those trained in different disciplines, such as physics, chemistry, or metallurgy. Such tensions did play an important role in the formation of the field. However, modern materials science is clearly interdisciplinary, with critical contributions from all these fields. Perhaps this is the true triumph of the field. *The Coming of Materials Science* provides an engaging account of the field's evolution, and, for that, is well worth reading.

David A. Weitz
Harvard University
Cambridge, Massachusetts

Theory of Itinerant Electron Magnetism

Jürgen Kübler
Oxford U. Press, New York, 2000. $120.00 (427 pp.). ISBN 0-19-850028-9

An incredible variety of insulators, conductors, and superconductors are known to present magnetic behavior, making magnetism one of the most important subfields of condensed matter physics. The importance of magnetism is also amplified by a plethora of technological applications. Magnetic materials find their place in our daily lives as permanent magnets in motors, transformers, storage media in computers, cassette tapes, switches, and many other devices.

In the past 15 years, the field of magnetism has exploded with exciting new discoveries. These include new magnetic semiconductors, new magnetic superconductors, the colossal magnetoresistance (CMR) effect in manganese oxides, and the giant magnetoresistance (GMR) and tunneling magnetoresistance (TMR) effects in magnetic multilayers at the nanometer scale. Moreover, magnetic materials play a vital role in the new field of spintronics and may well play an important role in quantum computers—if such devices are ever built.

Theory of Itinerant Electron Magnetism by Jürgen Kübler is a unique contribution to the study of magnetism, in that it attempts to describe a substantial part of the field using the local density functional approximation (LDA). The author concentrates on itinerant electron systems and emphasizes the importance of the electronic structure to the understanding of magnetic properties of realistic materials. Furthermore, Kübler cautions the reader that LDA does not correspond to the independent-particle picture; he advocates the extensive use of computers to solve the many-electron problem within LDA. However, he makes it very clear that LDA programs running on even the most efficient computers are not the answer to all magnetism questions, particularly those dealing with strongly correlated electron systems, for which no controlled general theory truly exists.

Kübler does an excellent job of describing LDA and making connections between the electronic structure of several materials and their magnetic properties. Nonetheless his book is not and was not meant to be a treatise on all aspects of magnetism. It has its place among many books on the subject. The intended audience for *Theory of Itinerant Electron Magnetism* is graduate students and researchers engaged in research in basic and applied magnetism. The book will be useful to many researchers, theorists, and experimentalists alike. It seems too long, however, for an advanced graduate textbook on the theory of magnetism.

Parts of the book are probably well suited for a special-topic graduate class in magnetism, but students may have to read first (or concurrently) more broad-based discussions of magnetism. In particular, *Theory of Magnetism*, by Key Yosida (Springer-Verlag, 1996) includes discussions not only of itinerant magnetic systems but also of magnetism in localized spin systems and in dilute alloys. In addition, the shorter monographs, *Spin Fluctuations in Itinerant Electron Magnetism*, by Toru Moriya (Springer-Verlag, 1985), and *Quantum Theory of Magnetism*, by Robert M. White (Springer-Verlag, 1970, 1983) can provide some alternative views of the state of the field—at least up to the early 1980s.

Theory of Itinerant Electron Magnetism contains very clear presentations of some important aspects of magnetism of the 1990s. Discussions of half-metallic ferromagnets and of the GMR effect in magnetic multilayers are very illuminating. More recent developments, such as TMR, CMR, and magnetic quantum phase transitions, are not included. However, as these new areas of research unfold, readers might expect these topics to appear in later editions.

In summary, *Theory of Itinerant Electron Magnetism* by Jürgen Kübler is a very good book for researchers engaged in basic and applied magnetism. It offers a personal and focused view of itinerant magnetism based on LDA from a leading expert in the field, and it describes in detail the relationship between electronic structure and magnetic properties of itinerant electrons in realistic systems.

Carlos A. R. Sa de Melo
Georgia Institute of Technology
Atlanta, Georgia

Neutron Interferometry: Lessons in Experimental Quantum Mechanics

Helmut Rauch
and Samuel A. Werner
Oxford U. Press, New York, 2000.
$120.00 (393 pp.)
ISBN 0-19-850027-0

The availability of copious quantities of thermalized neutrons makes them an ideal probe in condensed matter physics and materials research. This same abundance makes them the particle of choice for many fundamental physics investigations. A prime example is neutron interferometry, which is a technique developed to investigate a wide variety of fundamental aspects of quantum theory.

Helmut Rauch and Samuel Werner have been pioneers in the field of neutron interferometry since the first demonstration of a neutron interferometer in 1974; their book, *Neutron Interferometry: Lessons in Experimental Quantum Mechanics*, is both a very readable introduction to the subject and a comprehensive and up-to-date review of this elegant experimental technique. It is written for the advanced graduate student and researcher and serves as a reference text for the field of neutron interferometry.

Interferometry is a technique familiar to all physicists and can be carried out with any wave phenomenon. An incident beam of particles with wavelength λ is split and then recombined, forming an interference pattern that is sensitive to any change in the effective path length of one or both legs of the interferometer. Changing this "optical" path length in a controlled manner allows the experimenter to probe the perturbing interaction with extraordinary precision.

In contrast to the familiar optical interferometers, which employ wavelengths $\approx 10^{-6}$ meters, for neutron interferometry the de Broglie wavelength is about 10^{-10} m. The neutron interferometer uses Bragg reflection from perfect silicon single crystals, in place of mirrors, both to split the beam and recombine it. Neutrons are advantageous in that they are sensitive to the four basic interactions—strong, weak, electromagnetic, and gravitational—which makes the neutron interferometer a particularly versatile tool for testing fundamental physics concepts. Indeed, just the existence of the neutron interferometer is a striking example of the wave–particle duality of quantum mechanics.

The first half of *Neutron Interferometry* introduces the basic aspects of neutron interferometers and the interactions of neutrons with matter. It is a very readable exposition, which, by necessity, includes the detailed quantum mechanical mathematics to elucidate fully the fundamental operation of neutron interferometers and the utility of the technique. This material can be compared with the compendium of articles edited by Ulrich Bonse and Rauch, *Neutron Interferometry* (Oxford U. Press, 1979). The present text brings together in a coherent description most of the material in this earlier collection; it also, of course, includes developments in the field in the intervening 20 years.

The second part of the book describes some of the benchmark experiments of neutron interferometry. For example, rotating a classical vector by 2π restores the original state, while, quantum mechanically, the rotation of the spin of an $S = 1/2$ fermion particle is expected to change the sign of wavefunction, and the spin must be rotated by 4π to return to its initial value ($\Psi(0) = -\Psi(2\pi) = \Psi(4\pi)$). This 4π spinor symmetry of fermions was for many years thought to be an unobservable nuance of quantum mechanics—until it was demonstrated experimentally, with a neutron interferometer, by varying a magnetic field in one leg and observing the change in the interference pattern. The neutron interferometer has been used in an analogous manner to examine a wide variety of topological and geometrical effects on the phase of the neutron. Examples include the Aharonov–Casher effect (vector Aharonov–Bohm effect) and gravitationally induced quantum interference.

One of the interesting aspects of the Rauch–Werner work is the willingness of the authors to gaze into the future. They discuss possible applications of interferometry in materials science, an application that is just in its infancy, and they include an intriguing chapter on "forthcoming and more speculative experiments." This chapter incorporates tests for nonlinear terms in the Schrödinger equation, quaternions in quantum mechanics, delayed choice experiments, non-Newtonian gravity effects, and a host of other fascinating possibilities. The only shortcoming in Rauch and Werner's text is the very short, two-page index. Interferometry is a complex and advanced subject, and a more complete index would have been useful, particularly in a reference text for people who are not full-time practitioners in the field.

It is clear that the field of neutron interferometry will continue to be vital and exciting for many years to come and that Rauch and Werner's *Neutron Interferometry* will become the standard text for the field.

Jeffrey W. Lynn
National Institute of Standards and Technology
Gaithersburg, Maryland

The Structure of the Nucleon

Anthony W. Thomas
and Wolfram Weise
Wiley-VCH, New York, 2001.
$90.00 (289 pp.).
ISBN 3-527-40297-7

Nuclear physics has entered a new and challenging period. The discipline's