Principles of Condensed-Matter Physics

P.M. Chaikin and T.C. Lubensky
(Cambridge University Press, Cambridge, 2000)
699 pp., $47.95
ISBN 0-521-79450-1

This substantial text clearly aims to be the definitive work on condensed-matter physics. With over 600 pages, it has the potential to become a reference for most standard problems, while at the same time appearing as a rather daunting prospect to the uncommitted reader (the field theorist introduced in the preface who would find this "nice bedtime reading" perhaps ought to get out into the lab a bit more). Condensed-matter physics can of course mean many things to different people, and this is one of the book's problems. Despite the preface expressing the laudable aim of offering a single course that spans a broad area of condensed-matter physics, it is probably impossible for a single text to cover both functional solid-state physics and the structural behavior of fluids and solids while preserving a high degree of rigor. Consequently, the book is confined to the ordered states of matter and the response of such systems to external and internal stimuli, and largely leaves the electronic and magnetic properties of such systems to other works. Thus this work and, say, Ashcroft and Mermin's *Solid State Physics* (Saunders College Publishing, Philadelphia, 1976) are largely complementary and could be used in parallel to provide a thorough grounding in all aspects of condensed-matter behavior. However, to my mind (admittedly a largely experimental one), it lacks the lucidity and panache that have made the latter book the indispensable work on electronic systems for experimental condensed-matter physicists.

The book begins, through an illuminating discussion of the properties of water in all its phases, with a systematic classification of the types of order possible in solid and liquid systems, placing considerable emphasis on the additional ordering possibilities in liquid-crystalline systems. The thermodynamics of the transitions between these states is dealt with coherently, leading to analysis of the dynamics of condensed-matter systems. As might be expected, much of the analysis is based around the types of information obtainable from x-ray and neutron diffraction and scattering. The glossary at the end is extensive and a useful reference point in its own right.

Professional condensed-matter theorists will, I imagine, be the largest users of this work. The structured and rigorous approach ensures not only that the coverage is essentially complete, but also that the fundamental basis of all results is readily accessible. Although the jacket notes to the book imply a relevance to teaching across a range of disciplines, few courses will cover this area in anything like the level of detail of the book; in particular, a high level of basic knowledge is assumed on the part of the reader, and much of the mathematics required is well beyond the scope of the average physics undergraduate.

As this book provides a rigorous understanding of many aspects of condensed-matter physics, I anticipate that it will become a standard theory text at the graduate level for many years. However, despite succeeding at this level, it has a number of failings that may make it less generally appealing. The pedagogical development of the subject from classifications of order require the introduction at an early stage of concepts that are only developed later in the book; however, there are very few cross-references and, without the background knowledge alluded to earlier, the average reader may find the treatment rather dry and opaque. For example, Ising models are introduced in Chapter 1 in a review of ordered states with no reference to their scope or where further information can be found.

In summary, this is an excellent book for its target audience, and its appearance in paperback suggests the potential for significant sales among graduate students. If condensed-matter theory is your field, I suspect there is much in this book for you.

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Introduction to Diffraction in Materials Science and Engineering

Aaron D. Krawitz
(Wiley-Interscience, New York, 2001)
xvi + 408 pp., $110.00
ISBN 0-471-24724-3

Although writing a textbook on crystallography and diffraction is a demanding enterprise, scores of such books have been published in the last 30 years or so. In the days when I taught diffraction, long ago, I used a number of these. The justification for yet another book rests primarily with the choice of subject matter to be covered in depth and the attention paid to new techniques; it is impossible to cover every relevant topic in a student text of practicable size and price. The book under review makes good choices.

Krawitz's book covers a number of central topics in quantitative detail, with good exercises of various kinds to help cement understanding. Well-covered topics include the elements of formal crystallography, the use of space groups, and formal crystallographic calculations, including the use of the reciprocal lattice in detail. Structure factors and powder diffraction are also well explained in depth, while structure analysis and textures are dealt with more superficially, and instrumentation is covered more superficially still. There are, however, chapters covering material not usually treated in such books: the scattering of neutrons, stress analysis (especially by means of neutron diffraction), phase analysis by use of the powder diffraction file, and the Rietveld method of assessing the reliability of a structure analysis. There is the necessary material here for a fine introductory college course on diffraction, although my view is that (because of the inevitable omissions in any one text) such a course should preferably be based on more than one book.

Some of the omissions here make good sense; thus the decision to restrict treatment to kinematic theory, leaving dynamic theory to one side, is sensible for readers who will not specialize in structure determination (i.e., most materials scientists), although it is a drawback for those who wish to apply diffraction theory to the understanding of electron microscope images. However, a better treatment of instrumentation would have been desirable; thus the discussion of the operation of proportional counters (and the reason even for their name) is inadequate, as is the terse account of synchrotron radiation; the reader is not told why this kind of radiation has become so important for materials scientists, such as the ability to determine complex structures reliably by powder methods. The treatment of line broadening on account of small particle size gives no hint that rapidly varying lattice strains can also broaden diffraction lines, or how these two sources can be teased apart. In the short discussion of neutron diffraction (in which the "barn" unit suddenly appears without explanation), there is no hint of the use of the technique for identifying the location and nature of magnetic spins on individual atoms. There are a number of careless minor errors: on page 90, we find reference to "the scattering angle, which is actually half the scattering angle"; the caption to Figure E3.6 makes no sense; part of Figure E11.1 is missing; and the proposed explanation of the origin of annealing textures (admittedly, a topic much argued over) is certainly invalid.

Some recent sources that would be helpful to use in conjunction with Krawitz's text to provide a rounded treatment would be the chapter on synchrotron x-rays in the book *X-Ray Characterization of Materials*, edited by E. Lifshin (Wiley-VCH, New York, 1999); the parts on instrumentation and on phase-diagram analysis in *X-Ray Diffraction, A Practical Approach*, by C. Suryanarayana and M. Grant Norton (Plenum, New York, 1998), another good elementary text; and, indeed, the incomparable treatment of phase transformations, textures, epitaxy, and the like in a veteran text of great distinction, *Structure of Metals, 3rd edition*, by C.S. Barrett and T.B. Massalski (Pergamon, New York, 1969).

Reviewer: *Robert W. Cahn is a semi-retired materials scientist attached to Cambridge University. He serves* MRS Bulletin *as a 2002 Volume Organizer, as well as a member of the Editorial and Book Review Boards.*

Lectures on the Theory of Phase Transformations, *2d Ed.*

Hubert I. Aaronson, Editor
(The Minerals, Metals & Materials Society, Warrendale, Penn., 2001)
ix + 284 pp., $84.00
ISBN 0-87339-476-3

The first edition (1975) of this set of lectures has been twice reprinted over the years, proving a valuable textbook at the postgraduate level for those studying (notably, solid-solid and solid-liquid) phase transformations. The new edition contains five articles to the previous one's four and a new contribution by William C. Johnson addressing the influence of elastic stress on phase transformations. The remaining titles and principal authors are unchanged, although the book itself has significantly increased in length as a result of the updating process. Its style, like that of its predecessor, includes a more detailed presentation of the mathematics involved than is encountered in review articles and advanced monographs, which makes it particularly attractive to the advanced student reader.

The opening chapter is a masterly account by Mats Hillert of applications of Gibbs energy-composition diagrams, and he is the only author not to include a reference list. Trivedi contributes a chapter on the theory of capillarity, essentially updating his contribution to the earlier edition. This is followed by Aaronson and Lee on "the kinetic equations of solid-solid nucleation theory and comparison with experimental observations," which is well supplied with up-to-date literature references. The book concludes with Sekerka and Wang on "Moving Phase Boundary Problems," a mathematically formidable contribution (for this reader!) that includes analytical solutions to planar and nonplanar problems. These are of prime importance in establishing the kinetics of a wide range of engineering processes, as the authors observe.

The new article by Johnson, at about 100 pages, is the longest article in the book, and it is enhanced by micrographs showing changes in the morphology of the γ phase in some nickel-based alloys, arising from the elastic stress distribution. An excellent introduction is given to the basics of the subject (starting with an introduction to tensors), including the characterization of elastic deformation, the deformation gradient tensor, and the strain tensor, as well as the formulation of constitutive equations. This is followed by a lucid account of the basics of elastic stress and strain distributions for misfitting particles. A consideration of the thermodynamics of stressed systems, and of phase equilibria generally (not shirking ternary phase diagrams), leads to a final section on microstructural evolution that includes a presentation of some computer simulations of the phenomena.

A significant bonus to the impecunious student reader is the authorization provided by the publishers for the articles to be photocopied for personal use (subject to the payment of a nominal fee). I can, however, imagine this book of somewhat fragile binding looking a little the worse for wear when a generation or two of enthusiastic graduate students have had their way with it on their photocopiers!

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