Many-Body Theory of Solids: An Introduction

J. C. Inkson
331 pp. Plenum, New York, 1984.
$29.50

It is well known that, apart from a few extremely simplified cases, many-body problems cannot be solved exactly. One is therefore obliged to resort either to statistical methods or to perturbation theory, and in many cases to both. The budding physicist for this reason learns in undergraduate courses how to apply perturbation theory—nowadays in its quantum-mechanical form—while the beautiful methods of classical perturbation theory are hardly ever studied by the average physicist. Since the war it has become much easier to apply perturbation theory, because Feynman-diagram techniques enable us to keep track of the various terms in the perturbation-theory series and also make it easier to recognize large terms. Of course, it is easy to forget that these techniques do not actually solve the problem. Often, classes of diagrams less important than the diagrams retained for further consideration and possible summation are summarily dismissed. Contrary to what one is sometimes led to believe, the Feynman-diagram techniques do not prove that the large individual contributions we evaluate are not swamped by the sum of the overwhelmingly larger number of diagrams we dismiss.

Because of the great complexities of solids, it is not surprising that one has recourse to perturbation theory in theoretical solid-state physics, and it is important for the physicist who wants either to follow the literature or to solve a particular solid-state problem to be thoroughly conversant with modern diagram techniques in one form or another. The solid-state physicist needs both the zero-temperature techniques normally used in quantum theory and the finite-temperature techniques that are an extension and elaboration of the quantum-mechanical techniques. There are a few books dealing with these techniques, such as the books by R. D. Mattuck and by A. A. Abrikosov, L. P. Gor'kov and I. E. Dzyaloshinskii. The book reviewed here aims to provide a link between ordinary quantum-mechanics courses, which are not specifically intended for solid-state applications, and the specialized solid-state literature. It is based upon lecture courses given by the author at Cambridge to final-year honors undergraduates in physics and mathematics and first-year graduate students; these courses roughly correspond to first- and second-year graduate courses in the US.

Inkson introduces the basic tools and concepts of quantum mechanics, such as Green's functions and Feynman diagrams, in the first few chapters of the book. He then goes on to discuss the equation-of-motion approach to Green's function techniques—a method which he feels is physically more translucent—as applied to interacting systems, and—rather too briefly for my taste—gives a brief discussion of thermal effects. Throughout the book he stresses the physics behind the formalism and gives many applications. Each chapter includes some useful references to relevant books on research papers and a few very useful exercises.

I feel that Inkson has succeeded in producing a very useful introduction to the use of diagram techniques for many-body problems. The book can profitably be used, not by only solid-state physicists, but also by any other physicist who wants a relatively painless introduction to these techniques.

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Foundations of Laser Spectroscopy

S. Stenholm
268 pp. Wiley, New York, 1984.
$36.95

Since the invention of the laser some 25 years ago, the number of uses that spectroscopists have found for it is, to say the least, large. Not only have conventional spectroscopists benefited, but whole new fields have come into being through laser technology. The subject matter is therefore extensive. To expect to cover it comprehensively in a single, readable book is unreasonable. Stenholm, realizing that the field is a mature one with many books already published on the subject, has instead chosen to write a book that focuses on selected topics in this field. Designed as a textbook for readers with knowledge of quantum mechanics and classical electrodynamics, the work's emphasis is on applying density-matrix techniques to the derivation of the observable properties to be expected from two- and three-level systems under the influence of strong, monochromatic electromagnetic fields. In addition, the book deals with the effects of laser-field fluctuations on measured signals. This choice of emphasis allows the self-contained treatment of, for example, laser theory, saturation spectroscopy, Doppler-free spectroscopy, power broadening and multiphoton effects.

On the whole, we feel the book is valuable both as a textbook and as a reference for researchers working with lasers. In large part this value derives from the detailed and thorough derivations that allow one to follow closely the mathematical developments. In addition, the extensive examples of the application of the density matrix serve as a guide to the use of this powerful device in optical spectroscopy. Another valuable feature is a section at the end of each chapter giving a bibliography and original references pertinent to the subject matter of that chapter.

There are, however, two features of this book that prevent it from being an account of the foundations of laser spectroscopy in the broad conventional sense that most texts address. First, the heavy mathematical emphasis sometimes tends to suppress details of the physical importance of the quantities derived. Second, the book selects topics in laser spectroscopy that pertain to strong interactions between the