Quantum theory

Quantum Theory of the Solid State. By Joseph Callaway. Part A: Pp. x+1–370+10. Part B: Pp. xiii+371–824. (Academic: New York and London, July 1974.) $29.50; £14.75.

THIS work is in two parts, the first containing an account of the formalism required to study solids and the second concerned with more specific problems. The book is at a level suitable for students with a good background in quantum mechanics and some knowledge of the experimental facts of the solid state.

Part A is divided into four chapters, the first on lattice dynamics being followed by magnetism at a phenomenological level. Chapters 3 and 4 can be viewed together as an introduction to the group theory, followed by the calculational methods needed to find the electron states (and from the symmetry standpoint the phonon states) in periodic crystals. Part B then treats impurities, the effect of external electric and magnetic fields on solids and transport phenomena. In the final chapter there is an introduction to many-body theory.

Professor Callaway, of course, has made important contributions over a wide area of solid state physics and the book reflects his deep understanding of his subject. I wonder, however, a little about his ordering of the material. For, although many-body theory is treated in depth only in the last chapter, on p. 22 we have the creation and annihilation operators, and on p. 41, also in the first chapter, the van Hove correlation function appears in its full quantum mechanical form. Nevertheless, even for the reader who does not struggle too hard with the more advanced detail in Chapter 1, there is a good deal of basic solid state physics concerned with phonons which can be learned from it. The references, which are at the end of each chapter, number about 60 on phonons. Three refer to work later than 1971 but the rest are from 1969 and earlier.

Chapter 2 begins with the Heisenberg Hamiltonian along with some discussion of how the exchange parameters can be calculated from first principles. Molecular field theory is then discussed at some length, followed by an account of antiferromagnetism. The spin wave problem is then tackled using the Heisenberg Hamiltonian, with the dependence of spin waves on an external magnetic field given some attention. The extensive and helpful (though pretty advanced) discussion of spin waves is followed by a discussion of neutron scattering from magnetic crystals. The Ising model is then given a good deal of prominence, 15 pages or so being devoted to it. Phase transitions in ferromagnets are then treated, at about the same length. The discussion is scholarly, but in my opinion rather more advanced than is consistent with the author's remarks in the preface about the level of students it is written for.

In the chapter on symmetry, one of the nice features is the attention given to crystal field effects. The reader will probably find Chapter 3 on symmetry and Chapter 4 on band theory a good deal easier than the first two chapters. The chapter on energy bands has all the clarity one would expect from such an expert in the field; however, quite a bit of the discussion is available already in good sources. The discussion of the tight-binding method, which Professor Callaway has used to very good effect on the transition metals, is very helpful here. Finally, the central question of the way the crystal potential is to be constructed is discussed from the standpoint of density functional theory; Dirac-Slater exchange theory and gradient corrections to it are summarised.

Part B begins with the impurity problem, Wannier and also t matrix methods being dealt with in some detail. A nice account of the optical theorem is to be found here. Effective mass theory, local moments, the coherent potential approximation and the Kondo effect are other topics treated. A chapter of about 100 pages then follows on crystals in external fields, including optical properties, and magnetic field phenomena, such as low field diamagnetism and the de Haas-van Alphen effect. Transport theory is discussed at length and the last chapter represents a useful introduction to many-body theory. Itinerant electron magnetism is treated in a very clear manner in this chapter, along with Landau Fermi liquid theory. Green's functions and diagrammatic analysis are also developed here.

The only general criticism I would want to level concerns the ordering of the material. The first two chapters might have been better placed after the consideration of symmetry and band theory. More discussion of many-body theory would have been helpful earlier in the book.

Without doubt, this is a valuable addition to the literature which I found very stimulating to read. The problems at the end of each chapter are helpful in assessing one's grasp of the material as one goes along, though some are pretty difficult.

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Sound through the sea floor

Physics of Sound in Marine Sediments. Edited by Loyd Hampton. Pp. xii+567. (Plenum: London and New York, 1974.) $39.00.

THIS publication is a collection of 20 papers presented as the proceedings of one of four symposia organised by the Office of Naval Research to review current research activities and to discuss possible future trends in the subject of sound propagation in marine sediments. Edited by Loyd Hampton, the papers describe the research efforts of many of the world's leading authorities on a subject which is of increasing importance as the commercial exploitation of the natural resources that lie on, or beneath, the sea floor continues to expand into less accessible areas.

This collection of papers is presented quite informally and is therefore comprehensible to those not too familiar with all of the aspects of a relatively diverse field. The volume highlights the difficulties involved in obtaining accurate geophysical, acoustic and mechanical data from sediments in their natural environment. Such data have perhaps, not been given sufficient priority in the past, but the advent of large structures that are to be placed on the sea floor may change that situation. Current static loading tests may soon prove inadequate in solving settlement problems in the high energy environments that exist at sea. A possible alternative may be to consider the interrelationships between the required parameters and such physical properties as sound propagation, electrical resistivity and radioactivity. Acoustic properties will probably prove to be the most useful in this respect because of the fundamental relationships involving mechanical and physical properties of materials. With knowledge of these relationships, acoustic measurements could combine with the normal methods of site investigation which use standard acoustic techniques to provide more accurate interpretation as well as dynamic loading information. Continuous monitoring of the acoustic properties of sediments may also allow the measurement of the long term changes in sediment fabric and of the effects of severe weather conditions on sediment structure.

The presentation of the papers is of a general high standard, but as many authors are involved it is often necessary to compare data; this task would have been simplified if a standard set of units had been specified.

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