The Fermi Surface. W. A. HARRISON AND M. B. WEBB, Editors. Pp. 356, John Wiley & Sons, Inc., New York, 1960. Price $10.00.

Proceedings of the International Conference on Fermi Surfaces held at Cooperstown, New York, in August, 1960, are made available in this book which reports, in thirty-one prepared papers and two summary talks, the remarkable advance that has taken place in the past two years in our understanding of electronic properties of metals.

For many years solid-state physics has been taught, of necessity, in a way which a conscientious teacher must regard as unsatisfactory and even misleading, for the successful methods of calculation and associated concepts (bands, zones, Fermi surface, etc.) have been based not on first principles, but on the independent-particle approximation. As an example of the kind of analysis usually given, consider Sommerfeld's famous calculation of the electronic specific heat of a metal.

One term in the energy of the electron system is their mutual Coulomb interaction, which amounts typically to about 2 ev per electron. But this term enormously complicates the mathematical problem—so it is simply ignored. What we do calculate is the small change in energy with temperature due to varying degeneration about the Fermi surface. At the temperatures (about 1°K), where the electronic specific heat $C_e=\gamma T$ can be disentangled experimentally from the Debye lattice contribution $C_d=\alpha T^3$, this amounts to about 10^{-8} ev per electron. In other words, we throw away a term which is typically about 10^8 times larger than the one we keep. But we get tolerably good agreement with experiment!

In one of the best recent textbooks on solid-state physics, this "explanation" of electronic specific heats is hailed as one of the finest accomplishments of quantum statistics. From one standpoint, of course, the fact that the free-electron theory gives the right answer here is the one and only justification it needs. But from the standpoint of a true theoretical physicist, whose aim is not merely to calculate but also to understand, this success of the free-electron theory has been almost as embarrassing as if it had turned out completely wrong.

In spite of their extremely shaky theoretical foundations, the aforementioned concepts of solid-state physics have for three decades met with one success after another in their ability to account for experimental facts. By their use, for example, the design of new solid-state electronic devices has been reduced almost to a routine engineering problem. I remember vividly a remark made by Professor E. P. Wigner in his lectures on solid-state theory at Princeton in 1948; that the success of the band theory must be regarded as "a major miracle." The book under review presents us with another major miracle, the success of the notion of the Fermi surface (which at first glance seems meaningless as soon as one considers interaction between the electrons) in accounting for a whole series of new precision experiments.

The conference heard reports on three or more experiments for each of the following effects: the de Haas-van Alphen effect, galvanomagnetic effects, cyclotron resonance, anomalous skin effect, magnetoacoustic effect, and transport properties. Different experiments measure different geometrical properties of the Fermi surface, and it emerges as a very real thing, full of enough intricate detail to delight anyone who likes to make plaster-and-wire models for demonstration purposes.

As if to emphasize the excellent timing of this conference, in addition to this wealth of new experimental evidence, there were some impressive advances in theory to report. Indeed, the work of J. M. Luttinger, J. C. Ward, and W. Kohn has almost snatched away the major miracle by showing that an adaptation of methods first developed in quantum field theory enables one to treat the interparticle interaction to arbitrarily high order in perturbation theory. To the extent that perturbation theory itself is valid (a matter not quite settled, since it is conceivable that an exact solution might contain terms of such an analytical nature that power series expansions do not exist), they find that interactions merely alter the shape of the Fermi surface without changing the enclosed volume. Most important is simply the qualitative conclusion that a Fermi surface exists; i.e., even in the presence of interactions, at absolute zero temperature there is a surface in momentum space across which sharp discontinuities in occupation numbers exist. The theoretical foundations are no longer shaky!

Professor Luttinger's opening talk gave a brief summary of this theoretical work—unfortunately much too brief to show how these important results emerge from first principles. In the meantime, however, two papers by Luttinger have appeared [Phys. Rev. **119**, 1153 (1960); **121**, 1251 (1961)] which give full details of the calculation, as applied to equilibrium properties in Fermi systems and to the de Haas-van Alphen effect. A word of advice to teachers of solid-state physics who would like to adapt these exciting new developments into their courses, but who are not experts in quantum field theory: read first the paper by J. M. Luttinger and J. C. Ward [Phys. Rev. **118**, 1417 (1960)] which explains the basis of these methods in very simple and readable form. This reviewer has been able to make good use of these papers in his statistical mechanics and solid-state theory courses.

Even for courses at the undergraduate level, the book contains a great deal of valuable material concerning experimental methods and results, which serve to make the ideas of solid-state physics much less abstract. From this standpoint, about the only criticism one could make is that, like all conference reports, the book is far from self-contained. For example, the terms "de Haas-van Alphen effect" and "magnetoacoustic effect" are nowhere defined. However, most of the authors supply adequate references, something which is particularly necessary since existing textbooks give treatments of these effects which range from sketchy to nonexistent.

Finally, the report on this conference by W. A. Harrison and R. W. Schmitt [Phys. Today, **14**, 20 (1961)] will serve as a very useful adjunct to the book.

E. T. Jaynes
Washington University