A modern monograph on the physics of disordered systems

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Usp. Fiz. Nauk. **155**, 733–734 (August 1988)

Electron-Electron Interactions in Disordered Systems. Eds. A. L. Efros and M. Pollak. North-Holland, Amsterdam; Oxford; New York; Tokyo, 1985. 690 pp. (Modern Problems in Condensed Matter Science. V.10/Gen. Eds. V. M. Agranovich and A. A. Maradudin).

The physics of disordered systems is at present not only one of the most rapidly developing fields of solid state physics, but also one of the most fashionable ones attracting greater and greater effort. Under conditions when the number of publications is continuously growing and new ideas arise on the basis of those already published the need for well-qualified reviews and monographs is very great and is far from being satisfied. Therefore the appearance of the book under review which is devoted to the electronic properties of disordered conductors is most welcome.

In fact this book is a collective monograph devoted to the most contemporary achievements in this field and written by persons whose efforts made these achievements possible.

The book begins with a brief introduction written by Neville Mott, one of the founders of this field of science, and this marks the connection between the achievements of the 1960s and the very latest advances in physics of disordered systems.

The first two articles of the volume are devoted to weak localization—a new field of the theory of impure metals created very recently and which has given a brilliant explanation of old experimental riddles: the anomalous magnetoresistence, the anomaly in the zero shift in tunnel characteristics, etc. The long article of B. L. Al'tshuler and A. G. Aronov contains a detailed and very clear exposition of this entire theory, including not only the theory of the electron-electron interaction in metals with a short electron mean free path, but also the theory of quantum phenomena for noninteracting particles. This results in a remarkable unification of the description of properties of impure metals. In presenting the theory the authors do not simply comment on calculations, but also present a physical picture of the phenomenon and obtain results with the aid of easily understandable estimates. If one takes into account that this article contains a detailed discussion of experiments, one may say that it is very useful reading material both for theoreticians and experimenters. Apparently, generally speaking, as of today it is the best review of weak localization.

The subject of the article by H. Fukuyama is the same—electron-electron interaction in the regime of weak localization. In a number of points it successfully complements the article by Al'tshuler and Aronov. But here the presentation is a more formal one, and occasionally the author simply presents the disagreements existing in the literature. While the book was in the process of publication a number of these disagreements had been resolved, and it would be useful to add the necessary supplements in the Russian translation. A book is not an article and it will be read not just for a year.

The article by R. F. Milligan, T. F. Rosenbaum, R. N. Bhatta and G. A. Thomas is a review of experimental papers devoted to the investigation of the metal-dielectric transition in the impurity band of semiconductors. This, by now well-established, field has recently undergone extensive development owing primarily to the work of these authors. Combining the modern technology of preparation of samples and the technique of ultralow temperatures with the high intelligence and cleverness of the experimenters produced an important result: it was proved that at the point of transition the conductivity does not undergo a discontinuity, but tends smoothly to zero. The article contains results of investigation of semiconductors in the critical range of concentrations of impurities with the aid of a large number of methods: conductivity and Hall effect, optics and spectroscopy of Raman scattering, deformations and EPR, NMR, tunnel spectroscopy, measurement of heat capacity, etc., etc. On the whole, such a review does not have any analogs in the world literature and is extremely valuable.

Three articles—by M. Pollak and M. Ortuni, A. L. Efros and B. I. Shklovskiĭ and H. Kamimura—are devoted to Coulomb effects within the regime of a disordered dielectric, when the electron states are localized. The Soviet reader will derive particular pleasure from reading the article by Efros and Shklovskiĭ the creators of our own literary tradition in the field of the physics of disordered systems. We have obtained a new presentation of theory of the Coulomb gap in the spectrum and of its influence on the transport and thermodynamic properties of a disordered conductor. A new point is the theory of the absorption of a high frequency field. The review pleases one by its clarity, logic and picturesqueness of presentation of a problem which is on the whole a very difficult one. The review by Pollak and Ortuni is also very good in itself, and for us in particular by the fact that it provides a presentation of the Pollak theory of multielectron hops and its relation to experiment. Kamimura's article is specifically devoted to the effect of the interaction on the properties of the dielectric phase near the metal-dielectric transition and is the one most closely related to the experimental review by Milligan *et al.*

E. M. Gershenzon, A. M. Mel'nikov and R. I. Rabinovich have written for this volume an excellent review of the papers devoted to the properties of doubly charged states of shallow donors D^-. Depending on the donor concentration the states can be isolated ones, form molecular complexes and become delocalized generally. The article preserves a good balance between theory and experiment, and its inclusion in the book must be acknowledged as a success for the editors.

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The last article of the volume is the review by L. P. Gor'kov entitled "Disorder and interactions in a system of quasi-one-dimensional electrons." This section of another science—one-dimensional physics—is very naturally combined with the remaining contents of the volume. The merits of the article itself are brevity, clarity and the great number of new original results. Apparently, this is the first review article on one-dimensional localization, where the effect appears not as a mathematical phenomenon, but as a defining property of an entire class of real substances whose properties are here discussed.

In conclusion the book must be judged as a great achievement of the authors and the editors, and must be warmly recommended to the reader. Unfortunately, the book itself was a long time in production, and its Russian translation will reach the reader with an even greater delay. Inevitably part of the material will become outdated. This can be seen even now, and by the time the Russian translation appears the number of incongruities will increase. This can be avoided by including in the translation supplements or editorial notes.

A school on the electronic structure of solids

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Usp Fiz. Nauk **155**, 735–736 (August 1988)

Ed. M. Yussouff. *Electronic Band Structure and Its Applications.* Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1987, 440 pp.

The book under review is a collection of lectures and reports presented at the international school on electronic structure of solids which took place in India in the fall of 1986. The collected materials are not homogeneous in their quality. Some lectures are reviews of the activity of well-known western groups over a period of several years, some are essays on the urgent problems of band theory, some are simply scientific reports. Because of this, considerable attention will be devoted to some materials in this review, a lesser amount to others, and some will simply be listed.

The lecture by O. K. Andersen, O. Jepsen, and M. Soba is entitled "Linear Methods of Calculating Band Structure." It occupies almost 60 pages and is devoted to a presentation of the current state of the method of linear MT-orbitals (LMTO), including the theory of transformations of the MT-orbitals and the method of LMTO-strong coupling. For those who are acquainted with the well-known Trieste lecture by O. K. Andersen (O. K. Andersen, O. Jepsen, and D. Glötzel, *Highlights of Condensed Matter*, North Holland, N. Y., 1985) we note, that this lecture is, in fact, a reworking of the Trieste lecture. Although during the past two years the ideological content has not undergone much change, a much more precise and clear presentation of the ideology of the modern LMTO method has been achieved. To those wishing to study this method one can recommend specifically this lecture as being suitable for today.

The lecture by S. G. Louis is a review of the extensive activity of the author together with M. S. Hibertsen on calculating quasi-particle spectra in semiconductors "from first principles," including the investigation of corrections to the theory of the density functional. This review contains to some extent all the work of this group except for the latest papers (1987) on calculations of the dielectric susceptibility of semiconductors.

The third lecture of a review nature is the one by R. Zeller. It presents results obtaining by Dederichs, Zeller and other representatives of the Ülich Institute of Solid State Physics in calculating the electronic structure of impurities, particularly of magnetic ones, in transition metals. We note that in this lecture, as in the preceding one, very little is said concerning the technique of the corresponding calculations—the emphasis is on the results of the work.

While the lectures referred to above are, as has already been said, reviews of the work of the corresponding groups, the lectures by R. Heidok ("The method of recursions"), by A. Bensil ("The Modern Theory of Disordered Alloys") and by H. Neddermeyer ("Photoemission in Metals") are much closer to lectures in the direct sense of this word, i.e., they have rather an educational aim—to give an idea of the subject to a person who is not a specialist literally in the given field. Quite brief (10–30 pages), but sufficiently exhaustive, these lectures are very interesting to read.

Particular mention should be made of the report by W. E. Pickett "The Relationship of the Theory of the Density Functional to the Problem of Heavy Fermions." A well-known theoretician and at the same time an excellent specialist in the field of band calculations, he gives a clear concept of what can and what cannot be provided by the modern technique of one-electron calculations for the understanding and description of heavy-fermion systems. This article, or rather, essay, will be interesting and useful to a wider circle of readers—both to "band specialists," involved in calculations "from first principles," and also to "abstract theoreticians" involved in constructing model theories of heavy-fermion systems. In my opinion it would be useful to translate this article.

I shall list several other articles of a more special nature: M. Yussouff—"A Rapid Self-Consistent KKR method." O. Gunnarsson, R. O. Jones, and K. Schönhammer—"Formalism of the Density Functional: V_{XC}, discontinuities, local density approximation." S. Demanja—"Hydrogen in transi-