Unitary transformations in solid state theory

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M. Wagner. *Unitary Transformation in Solid State Physics.* North Holland, Amsterdam; Oxford; New York; Tokyo (1986) pp. 357. (Modern Problems in Condensed Matter Sciences/Gen. Eds. V. M. Agranovich and A. A. Maradudin. V. 15)

The appearance of the series of books indicated above which combines contributions of Soviet and foreign physicists should be welcomed both in its scientific and its generally humanistic aspects. It is in tune with the progressive tendencies of our time. The parallel publication of books in

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two languages is included in the basic concept of the general editors of the series. About twenty volumes have already appeared in English, unfortunately their translation into Russian is lagging.

The fifteenth volume under discussion is unique in the fact that it was written by a single author—a professor of Stuttgart University (FRG) Max Wagner. M. Wagner is well known as an author of numerous articles on solid state theory, first of all those connected with problems of vibronic interactions.

In its content Wagner's monograph is unique in world literature—it is devoted to a systematic and actively concrete presentation of the method of unitary transformations as applied to solid state problems. It contains a number of quantum-field methodologies of the theory of many-particle systems and different versions of them. Each of them has its strong and weak aspects. The "mathematical costs" (being quite varied) in utilizing these methodologies are approximately the same in extent. Quite a few monographs and textbooks of different levels are devoted to such methodologies. However the method of unitary transformations was "unlucky" in this respect. In textbooks on quantum mechanics it is usually brought up in a formal context. Its applications appear separately as methods of solving narrowly defined problems (the Frölich effective interaction of electrons, the Bogolyubov transformations, and superfluidity). As a result of this among specialists, as M. Wagner notes in his introduction, the opinion is widespread that unitary transformations are not very useful for practical solution of concrete problems. This is not so, as evidenced by the book of M. Wagner.

The presentation of the material in this book is fresh and to a large extent is related to the author's own publications and to those of his collaborators. Chapter 1 contains general information and definitions, and serves as an introduction to the theory of unitary transformations. In connection with this, perturbation theory and linear transformations are considered, as well as the possibility of utilizing the equations of motion. Chapter 2 presents in detail the most widespread transformations as applied to oscillators, to spin and two-level systems, with nonlinearities being taken into account.

Chapter 3 continues the presentation of the general theory. Systematic procedures are presented which enable in each concrete case to find transformations of maximum usefulness and to estimate quantitatively the degree of this usefulness (the "measure of nondiagonality"). This is followed by a discussion of the adiabatic evolution and the subsequent repeated application of the transformations.

After this the author returns to the simpler (Ch. 5) and more complicated (Ch. 6) applications. The breadth of the problems being treated utilizing fermion, boson and spin operators can be seen from the following list: single- and multimode Jahn-Teller vibronic situations, interaction of a quantum system with radiation, vibronic and vibrational spectra, self-trapping of excitons, radiationless transitions, resonances and antiresonances, superconductivity, ferroelectricity, the Peierls transition, the Kohn anomalies, the Hartree-Fock method, the Hubbard problem, etc. The problem of electrical conductivity is treated in an original manner in connection with the use of the so-called mobile electron basis. Here once again the unity and systematic nature of the presentation should be emphasized.

At the end of the book there is an extensive appendix in the form of summary tables of formulas for an enormous number of concrete transformations. This gives the book the character of a valuable handy reference volume for a scientist.

Wagner's entire effort is directed to a real improvement of the qualification of the reader studying the book, to an enrichment of his methodological arsenal. This goal is attained. It also should be said that the aim of the book determines the approach in which the physical properties of the systems being studied and the interpretation of the results are touched upon to the extent that is required for the understanding of the essence of the problem, for the formulation of the Hamiltonian and for an evaluation of the result obtained.

It seems to us that Wagner's monograph will be useful for a wide circle of our theoretical physicists and it is necessary to produce a Russian translation. The effect that this book can have will also depend upon the number of research workers who will have acquired it.

Translated by G. M. Volkoff