Preface

At the end of 1950s and in early 1960s there was a kind of "revolution" in the theory of condensed matter (at that time called mostly the theory of solid state and quantum liquids) which was due to the use of methods, developed a decade earlier in quantum field theory, mainly the method of Feynman diagrams. Since that time diagrammatic methods became the foundation of this section of theoretical physics, and the knowledge of these is absolutely necessary for any professional working in this field.

A number of good books are devoted to rather detailed exposition of the general aspects of these methods, such as the introduction of diagrammatic formalism for different types of interactions [Abrikosov A.A., Gorkov L.P., Dzyaloshinskii I.E. (1963); Lifshits E.M., Pitaevskii L.P. (1980)]. Of course, most of these books contain also discussion of some specific applications of these methods to concrete physical problems. At the same time, up to now there are almost no books, where the reader can find the detailed description of calculations and methodical "know how" for specific problems, at the beginner level (like graduate or postgraduate students)[1]. During the last decades a great number of problems were solved (or analyzed) using Feynman diagram technique and the results are scattered in the numerous original papers, reviews and books.

The aim of these lectures is precisely the demonstration of the power of diagram technique as applied to the solution of different problems of condensed matter theory, most of which became a kind of "gold reserve" of this theory a long time ago, while different concepts and methodical

[1]The author knows only one such attempt [Levitov L.S., Shitov A.V. (2003)], which remained unpublished for a long time, and finally was published only in Russian. A comprehensive review of the applications of field theory methods to different problems of solid state theory and the theory of quantum liquids is contained in [Mahan G.D. (1981)], but it is in fact a review for a professional, not a textbook.

developments constitute a part of a working "folklore" of modern theorists. Our choice of problems is based both on their importance and personal interests of the author. Some of these problems are not "finally" solved up to now, so that further development of the results of almost any section of this book may be the starting point of a serious theoretical study. Actually, we limit ourselves only to the selected problems of electronic theory of solids, dropping any discussion of Bose-liquids, most problems of the theory of magnetism, as well as the theory of critical phenomena, where diagrammatic methods are also quite important. It should be clearly understood that the material discussed in every chapter of this book can be a part of a separate lecture course, and we do not pretend to give a self-contained review of any of these parts of the modern theory. Some of the more special and technical parts of the text are given in smaller point size and can be dropped during the first reading.

It is obvious, that the application of quantum field theory methods to the theory of condensed matter is not limited to diagrammatic methods only. In particular, there was a great temptation to pay some attention to the functional integrals or renormalization group. But finally a decision was made to limit discussion only to diagrammatic approaches and problems, which can be solved within more or less standard perturbation theory, dropping almost all modern aspects of the theory of strongly correlated systems. This was due to a wish to make these lectures more or less "compact", as well as to demonstrate the "richness" of results, which can be obtained on this way.

To understand these lectures it is necessary to know the basic notions of Feynman diagram technique, approximately within the limits of chapters II and III of the notorious "AGD" book [Abrikosov A.A., Gorkov L.P., Dzyaloshinskii I.E. (1963)], where anybody can find a presentation, which remains unsurpassed up to now[2].

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M.V. Sadovskii
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[2]In fact the material presented in this book is used by the author as a *second* part of the lecture course, taught at the Ural State University in Ekaterinburg. The first part of this course is actually based on these chapters of "AGD".