Preface

Studies of superconductivity theory are among the most fruitful and promising trends in the theoretical physics of condensed matter, since superconductivity remains one of the most interesting research areas in physics.

The goal of this book is to give a representation of certain modern aspects of superconductivity. We discuss important aspects of the theory of superconductivity, such as the nature of high-T_c superconductivity, two-gap superconductivity, room-temperature superconductivity, mesoscopic superconductivity, the pairing state and the mechanism of cuprate high-T_c superconductivity.

In Chap. 1, we consider the field-theoretical method of superconductivity and discuss the basic idea of superconductivity and the elaboration of the Ginzburg–Landau and Bardeen–Cooper–Schrieffer theories in the frame of many-particle quantum field theory.

In Chap. 2, we consider the structures of high-T_c superconductors, phase diagrams and the problem of pseudogaps, and analyze the mechanisms of superconductivity. We present general arguments regarding the pairing symmetry in cuprate superconductors and investigate their thermodynamical properties within the spin-fluctuation mechanism of superconductivity, by using the method of functional integrals.

Chapter 3 concentrates on two-band and multiband superconductivity. We consider the physical properties of the superconductor MgB_2 and use our two-band model to explain the two coupled superconductor gaps of MgB_2. To study the effect of the increasing T_c in MgB_2, we use the renormalization-group approach and phase diagrams. In the field of superconductivity we meet the problem-maximum, which consists in the creation of room-temperature superconductors. We consider this problem in our book and make some recommendations on the search for these superconductors.

Chapter 4 deals with the problem of mesoscopic superconductivity. We consider the two-band superconductivity in ultrasmall grains, by extending the Richardson exact solution to two-band systems, and develop the theory of interactions between nanoscale ferromagnetic particles and superconductors. The properties of nanosize two-gap superconductors and the Kondo effect in superconducting ultrasmall grains are investigated as well.

We also consider the ideas of quantum computing and quantum information in mesoscopic circuits. The theory of the Josephson effect is presented, and its applications to quantum computing are analyzed.

This book deals with a wide scope of theoretical and experimental topics in superconductivity, and has been written for advanced students and researchers in that field.

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