
Preface

The reader is holding the second volume of a three-volume textbook on solid-state physics. This book is the outgrowth of the courses I have taught for many years at Eötvös University, Budapest, for undergraduate and graduate students under the titles *Solid-State Physics* and *Modern Solid-State Physics*.

The main motivation for the publication of my lecture notes as a book was that none of the truly numerous textbooks covered all those areas that I felt should be included in a multi-semester course. Especially, if the course strives to present solid-state physics in a unified structure, and aims at discussing not only classic chapters of the subject matter but also (in more or less detail) problems that are of great interest for today's researcher as well. Besides, the book presents a much larger material than what can be covered in a two- or three-semester course. In the first part of the first volume the analysis of crystal symmetries and structure goes into details that certainly cannot be included in a usual course on solid-state physics. The same applies, among others, to the discussion of the methods used in the determination of band structure, the properties of Fermi liquids and non-Fermi liquids, and the theory of unconventional superconductors in the present and third volumes. These parts can be assigned as supplementary reading for interested students, or can be discussed in advanced courses.

The line of development and the order of the chapters are based on the prerequisites for understanding each part. Therefore a gradual shift can be observed in the style of the book. While the intermediate steps of calculations are presented in considerable detail and explanations are also more lengthy in the first and second volumes, they are much sparser and more concise in the third one, thus that volume relies more on the individual work of the students. On account of the prerequisites, certain topics have to be revisited. This is why magnetic properties are treated in three, and superconductivity in two parts. The magnetism of individual atoms is presented in an introductory chapter of the first volume. The structure and dynamics of magnetically ordered systems built up of localized moments are best discussed after lattice vibrations, along the same lines. Magnetism is then revisited in the third volume, where the

role of electron–electron interactions is discussed in more detail. Similarly, the phenomenological description of superconductivity is presented in this volume after the analysis of the transport properties of normal metals, in contrast to them, while the microscopic theory is outlined later, in the third volume, when the effects of interactions are discussed.

Separating the material into three similar-sized volumes is a necessity in view of the size of the material – but it also reflects the internal logical structure of the subject matter. At those universities where the basic course in solid-state physics runs for three semesters working through one volume per semester is a natural schedule. In this case the discussion of the electron gas – which is traditionally part of the introduction – is left for the second semester. This choice is particularly suited to curricula in which the course on solid-state physics is held parallel with quantum mechanics or statistical physics. If the lecturer feels more comfortable with the traditional approach, the discussion of the Drude model presented in this volume can be moved to the beginning of the whole course. Nevertheless the discussion of the Sommerfeld model should be postponed until students have familiarized themselves with the fundamentals of statistical physics. For the same reason the lecturer may prefer to change the order of other chapters as well. This is, to a large extent, up to the personal preferences of the lecturer.

In presenting the field of solid-state physics, special emphasis has been laid on discussing the physical phenomena that can be observed in solids. Nevertheless I have tried to give – or at least outline – the theoretical interpretation for each phenomenon, too. As is common practice for textbooks, I have omitted precise references that would give the publication data of the discussed results. I have made exceptions only for figures taken directly from published articles. At the end of each chapter I have listed textbooks and review articles only that present further details and references pertaining to the subject matter of the chapter in question. The first chapter of the first volume contains a longer list of textbooks and series on solid-state physics.

Bulky as it might be, this three-volume treatise presents only the fundamentals of solid-state physics. Today, when articles about condensed matter physics fill tens of thousands of pages every year in *Physical Review* alone, it would be obviously overambitious to aim at more. Therefore, building on the foundations presented in this series, students will have to acquire a substantial amount of extra knowledge before they can understand the subtleties of the topics in the forefront of today's research. Nevertheless at the end of the third volume students will also appreciate the number of open questions and the necessity of further research.

A certain knowledge of quantum mechanics is a prerequisite for studying solid-state physics. Various techniques of quantum mechanics – above all field-theoretical methods and methods employed in solving many-body problems – play an important role in present-day solid-state physics. Some essential details are listed in one of the appendices of the third volume, however, I have omitted more complicated calculations that would have required

the application of the modern apparatus of many-body problems. This is especially true for the third volume, where central research topics of present-day solid-state physics are discussed, in which the theoretical interpretation of experimental results is often impossible without some extremely complex mathematical formulation.

The selection of topics obviously bears the stamp of the author's own research interest, too. This explains why the discussion of certain important fields – such as the mechanical properties of solids, surface phenomena, or amorphous systems, to name but a few – have been omitted.

I have used the International System of Units (SI), and have given the equations of electromagnetism in rationalized form. Since nonrationalized equations as well as gaussian CGS (and other) units are still widely used in the solid-state physics literature, the corresponding formulas and units are indicated at the appropriate places. In addition to the fundamental physical constants used in solid-state physics, the commonest conversion factors are also listed in Appendix A of the first volume. I deviated from the recommended notation in the case of the Boltzmann constant using k_B instead of k – reserving the latter for the wave number, which plays a central role in solid-state physics.

To give an impression of the usual values of the quantities occurring in solid-state physics, typical calculated values or measured data are often tabulated. To provide the most precise data available, I have relied on the Landolt–Börnstein series, the CRC Handbook of Chemistry and Physics, and other renowned sources. Since these data are for information only, I have not indicated either their error or in many cases the measurement temperature, and I have not mentioned when different measurement methods lead to slightly disparate results. As a rule of thumb, the error is usually smaller than or on the order of the last digit.

I would like to thank all my colleagues who read certain chapters and improved the text through their suggestions and criticism. Particular thanks go to professors György Mihály and Attila Virosztek for reading the whole manuscript. In spite of all efforts, some mistakes have certainly remained in the book. Obviously, the author alone bears the responsibility for them.

Special thanks are due to Károly Härtlein for his careful work in drawing the majority of the figures. The figures presenting experimental results are reproduced with the permission of the authors or the publishers. The challenge of translating the first and second volumes of the book from the Hungarian original was taken up by Attila Piróth. I acknowledge his work.

Finally, I am indebted to my family, to my wife and children, for their patience during all those years when I spent evenings and weekends with writing this book.

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