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国外物理名著系列 13

（影印版）

Statistical Mechanics

(2nd Edition)

统计力学

（第二版）

F.Schwabl

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《国外物理名著系列》(影印版)专家委员会名单

(按姓氏笔画排序)

国外物理名著(影印版)系列序言

对于国内的物理学工作者和青年学生来讲，研读国外优秀的物理学著作是系统掌握物理学知识的一个重要手段。但是，在国内并不能及时、方便地买到国外的图书，且国外图书不菲的价格往往令国内的读者却步，因此，把国外的优秀物理原著引进到国内，让国内的读者能够方便地以较低的价格购买是一项意义深远的工作，将有助于国内物理学工作者和青年学生掌握国际物理学的前沿知识，进而推动我国物理学科研和教学的发展。

为了满足国内读者对国外优秀物理学著作的需求，科学出版社启动了引进国外优秀著作的工作，出版社的这一举措得到了国内物理学界的积极响应和支持，很快成立了专家委员会，开展了选题的推荐和筛选工作，在出版社初选的书单基础上确定了第一批引进的项目，这些图书几乎涉及了近代物理学的所有领域，既有阐述学科基本理论的经典名著，也有反映某一学科专题前沿的专著。在选择图书时，专家委员会遵循了以下原则：基础理论方面的图书强调“经典”，选择了那些经得起时间检验、对物理学的发展产生重要影响、现在还不“过时”的著作（如：狄拉克的《量子力学原理》）。反映物理学某一领域进展的著作强调“前沿”和“热点”，根据国内物理学研究发展的实际情况，选择了能够体现相关学科最新进展，对有关方向的科研人员和研究生有重要参考价值的图书。这些图书都是最新版的，多数图书都是 2000 年以后出版的，还有相当一部分是 2006 年出版的新书。因此，这套丛书具有权威性、前瞻性和应用性强的特点。由于国外出版社的要求，科学出版社对部分图书进行了少量的翻译和注释（主要是目录标题和练习题），但这并不会影响图书“原汁原味”的感觉，可能还会方便国内读者的阅读和理解。

“他山之石，可以攻玉”，希望这套丛书的出版能够为国内物理学工作者和青年学生的工作和学习提供参考，也希望国内更多专家参与到这一工作中来，推荐更多的好书。

杨国桢

中国科学院院士

中国物理学会理事长

2007 年 3 月 20 日

A theory is all the more impressive the simpler its premises, the greater the variety of phenomena it describes, and the broader its area of application. This is the reason for the profound impression made on me by classical thermodynamics. It is the only general physical theory of which I am convinced that, within its regime of applicability, it will never be overturned (this is for the special attention of the skeptics in principle).

Albert Einstein

To my daughter Birgitta

Preface to the Second Edition

In this new edition, supplements, additional explanations and cross references have been added in numerous places, including additional problems and revised formulations of the problems. Figures have been redrawn and the layout improved. In all these additions I have pursued the goal of not changing the compact character of the book. I wish to thank Prof. W. Brewer for integrating these changes into his competent translation of the first edition. I am grateful to all the colleagues and students who have made suggestions to improve the book as well as to the publisher, Dr. Thorsten Schneider and Mrs. J. Lenz for their excellent cooperation.

Munich, December 2005 *F. Schwabl*

Preface to the First Edition

This book deals with statistical mechanics. Its goal is to give a deductive presentation of the statistical mechanics of equilibrium systems based on a single hypothesis – the form of the microcanonical density matrix – as well as to treat the most important aspects of non-equilibrium phenomena. Beyond the fundamentals, the attempt is made here to demonstrate the breadth and variety of the applications of statistical mechanics. Modern areas such as renormalization group theory, percolation, stochastic equations of motion and their applications in critical dynamics are treated. A compact presentation was preferred wherever possible; it however requires no additional aids except for a knowledge of quantum mechanics. The material is made as understandable as possible by the inclusion of all the mathematical steps and a complete and detailed presentation of all intermediate calculations. At the end of each chapter, a series of problems is provided. Subsections which can be skipped over in a first reading are marked with an asterisk; subsidiary calculations and remarks which are not essential for comprehension of the material are shown in small print. Where it seems helpful, literature citations are given; these are by no means complete, but should be seen as an incentive to further reading. A list of relevant textbooks is given at the end of each of the more advanced chapters.

In the first chapter, the fundamental concepts of probability theory and the properties of distribution functions and density matrices are presented. In Chapter 2, the microcanonical ensemble and, building upon it, basic quantities such as entropy, pressure and temperature are introduced. Following this, the density matrices for the canonical and the grand canonical ensemble are derived. The third chapter is devoted to thermodynamics. Here, the usual material (thermodynamic potentials, the laws of thermodynamics, cyclic processes, etc.) are treated, with special attention given to the theory of phase transitions, to mixtures and to border areas related to physical chemistry. Chapter 4 deals with the statistical mechanics of ideal quantum systems, including the Bose–Einstein condensation, the radiation field, and superfluids. In Chapter 5, real gases and liquids are treated (internal degrees of freedom, the van der Waals equation, mixtures). Chapter 6 is devoted to the subject of magnetism, including magnetic phase transitions. Furthermore, related phenomena such as the elasticity of rubber are presented. Chapter 7 deals with the theory of phase transitions and critical phenomena; following a general overview, the fundamentals of renormalization group theory are given. In addition, the Ginzburg–Landau theory is introduced, and percolation is discussed (as a topic related to critical phenomena). The remaining three chapters deal with non-equilibrium processes: Brownian motion, the Langevin and Fokker–Planck equations and their applications as well as the theory of the Boltzmann equation and from it, the H-Theorem and hydrodynamic equations. In the final chapter, dealing with the topic of irreversiblility, fundamental considerations of how it occurs and of the transition to equilibrium are developed. In appendices, among other topics the Third Law and a derivation of the classical distribution function starting from quantum statistics are presented, along with the microscopic derivation of the hydrodynamic equations.

The book is recommended for students of physics and related areas from the 5th or 6th semester on. Parts of it may also be of use to teachers. It is suggested that students at first skip over the sections marked with asterisks or shown in small print, and thereby concentrate their attention on the essential core material.

This book evolved out of lecture courses given numerous times by the author at the Johannes Kepler Universität in Linz (Austria) and at the Technische Universität in Munich (Germany). Many coworkers have contributed to the production and correction of the manuscript: I. Wefers, E. Jörg-Müller, M. Hummel, A. Vilfan, J. Wilhelm, K. Schenk, S. Clar, P. Maier, B. Kaufmann, M. Bulenda, H. Schinz, and A. Wonhas. W. Gasser read the whole manuscript several times and made suggestions for corrections. Advice and suggestions from my former coworkers E. Frey and U. C. Täuber were likewise quite valuable. I wish to thank Prof. W. D. Brewer for his faithful translation of the text. I would like to express my sincere gratitude to all of them, along with those of my other associates who offered valuable assistance, as well as to Dr. H. J. Kölsch, representing the Springer-Verlag.

Munich, October 2002 *F. Schwabl*

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