Advanced University Physics

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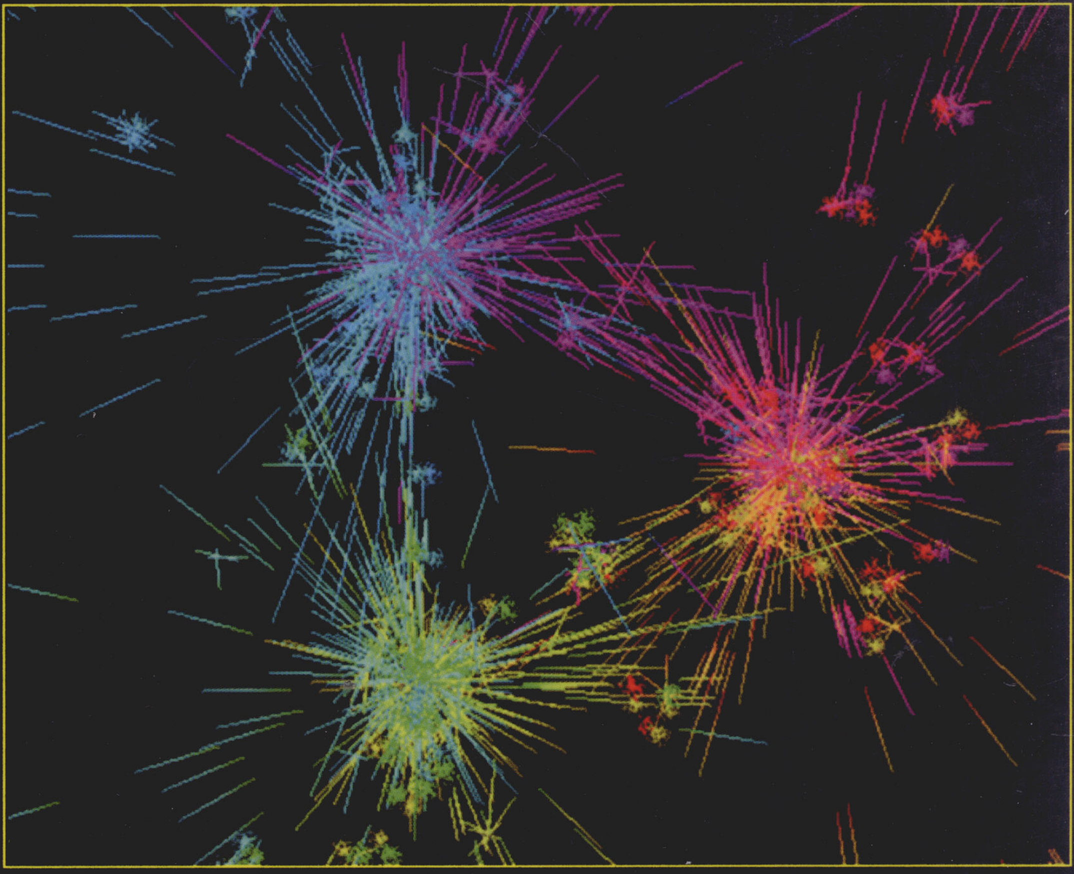

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ADVANCED UNIVERSITY PHYSICS

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ADVANCED UNIVERSITY PHYSICS

To our wives

Sue and Jennifer

PREFACE

The purpose of this book is to bridge the gap between the mainly descriptive treatment of phenomena, given in compendium University texts, and the highly theoretical accounts found in graduate level texts. The former seldom satisfy the serious student or the teacher, while the latter can often be intimidating without an appropriate introduction. The present book is intended to be used as a realistic introduction to both macroscopic and microscopic physics, at an intermediate level allowing the reader to step from empirical books to advanced texts.

There are several good textbooks which contain suitable advanced material for each particular branch of physics, but no one book covers the entire syllabus in a unified way. The texts that are recommended for specialized topics devote considerable space to the development of the necessary background and the application of the derived results to further topics. The present book avoids this and presents a concise, condensed sequence of physical principles linking *macroscopic* mechanical, thermal and electrical phenomena to their *microscopic* quantum origin, statistical description and atomic structure. It is written firstly as a book for *learning* and *revising* where the advanced undergraduates will find a coherent summary and the logical connections with earlier work to supplement and support more specialized books. In addition it also provides a reference material for professional physicists in both university and industry, who may find it useful for *recapping* aspects of physics related to their specialist activity.

The text is designed to encourage the student of physics, engineering or materials science to use it continually, and to make it the basis of his or her course. A rigorous treatment is applied to each topic by starting from first principles and deriving the basic laws and the significant consequences. We assume that the mathematical background of the student includes at least a year's course in calculus and we aim to develop the student's facility with applied mathematics by gradually increasing the mathematical sophistication as the chapters progress and by the use of several *Appendices.*

The book is divided into two parts, although this division is not formal. The first part deals with *macroscopic* physics and the second part (starting with Chapter 28) is concerned with *microscopic* physics. We start with a discussion of the basic concepts of momentum, energy and angular momentum (Chapters 2 and 3) followed by two chapters on special relativity. Since we have supposed that much of this is familiar to the reader, the treatment is rather abbreviated in some sections. Chapter 6, which is dedicated to the continuum limit of mechanics, is intended to establish a connection with thermodynamics, whose basic laws and applications to continuum systems are discussed in Chapters 7 to 10.

The basic principles of electromagnetism, starting from the fundamental experimental observations and building up to Maxwell's equations, are introduced in Chapters 11 to 14, allowing the properties of electromagnetic waves to be deduced. The generality of concepts and techniques concerning waves is emphasized in Chapters 15 to 22, where we use the wave equation to discuss wave propagation and the phenomena of interference, coherence and diffraction. The techniques of Fourier analysis are employed where necessary. Chapters 23 to 26 deal with the transverse nature of electromagnetic waves and optical phenomena in anisotropic media. Chapter 27 describes the macroscopic phenomena of absorption and dispersion and demonstrates the need for a microscopic description.

In approaching microscopic physics, we first present the generalized mechanics appropriate to many-particle systems (Chapter 28) and then introduce the principles and methods of statistical mechanics and thermodynamics (Chapters 29 to 31). Thermal radiation (Chapter 32) and the phenomena and hypotheses related to wave-particle duality (Chapter 33) are discussed with the aim of making the transition to quantum physics more transparent. The postulates of quantum mechanics lie at the heart of microscopic physics (Chapter 34). They are used as the basis of our discussion of orbital angular momentum and one-electron atoms using the Schrödinger picture (Chapters 35 to 37), the spinning electron in the matrix formalism (Chapters 38 and 39), multielectron atoms as systems of identical particles (Chapters 40 and 41) and the semi-classical theory of radiation (Chapter 42).

A description of the systems of atoms and the crystal lattice (Chapters 43 and 44) prepares the reader to cope with the problems of solid state physics. Here we cover free electrons in metals (Chapter 45), electronic energy bands, semiconductor physics and physical electronics (Chapters 46 to 48), lattice dynamics (Chapter 49), magnetism and superconductivity (Chapters 50 and 51). The last two chapters on nuclear structure and dynamics show how classical and quantum concepts find applicability in the domain of very short distances.

Teachers should appreciate that each chapter is a suitable core for a university lecture course at the second, third or fourth year level. We have tried to provide a coverage of the subject matter, using simple models yet still allowing contact with the behaviour of real phenomena, real substances and aspects of present-day research. Several relevant *Examples* are included in every chapter. However needs differ and each University department will probably find itself teaching material which is not in the text. Some specialist topics reserved for graduate courses are added as *Notes*. Various *Applications* are discussed for the purpose of illustrating the core topics. All formulae are presented in SI form and should be used with SI units. Rather than scattering the references among the text, some titles of books are collected at the end of each chapter, with no intention other than to provide supplementary reading.

Parts of the manuscript have been read by Professors M.Gunn, E.J.S.Lage, D.Iordache and A.Lupascu, Doctors N.Appleyard, T.J.Jackson and A.Dorobantu. They are to be thanked for numerous improvements and corrections. We, of course, are responsible for all errors, omissions and faults of presentation which, despite our best efforts, will no doubt remain. We also thank the editors at Gordon and Breach Science Publishers for their continuing support and encouragement.

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CONTENTS