PREFACE

Our book aims to give students a broad perspective of current understandings of the basic structures of matter as scientists have probed ever deeper levels from atoms, to the nucleus, on to leptons, quarks, and gluons, along with the necessary introductory quantum mechanics. We have interwoven the material with its historical development and challenging future directions. Beyond a broad understanding of atomic, nuclear, and particle physics, we want students early in their studies to appreciate the uncertain path of success and failure, opportunities seized and opportunities missed and the roles of chance and intuition by scientists in the unfolding human drama of scientific discovery. By working through some of the issues and struggles that occurred in the development of modern physics, students better understand the material as well as learn how science works. Several significant historical developments are presented that are not found in any textbooks.

We also believe that it is important for students as early as possible to begin to think about some of the current intellectual challenges of these fields and to glimpse the ever-increasing power of new techniques and facilities to probe these and future challenges. Thus, examples of very recent developments and future plans are described to excite students by allowing them to see how the techniques and ideas of atomic, nuclear, and particle physics have been used and are being used to attack important problems in other basic and applied areas of physics, chemistry, and biology on to major societal problems in medicine, energy resources, new tailor-made materials and environmental pollution, and in areas of wide cultural and historical interest such as dating the Shroud of Turin, the levels of civilization revealed by the compositions of ancient artifacts, and the cause of the extinction of the dinosaurs.

A questioning spirit is at the heart of scientific discovery. Many discoveries began by someone asking "Why is that so?" or "How could we do that differently?" Thus, throughout the book students are encouraged to reflect on problems and to ask questions. One of the important traits of great scientists is the ability to identify, out of the many open questions and problems, the significant ones whose answers would truly make a difference.

The text is an outgrowth of our many years of teaching courses in atomic physics, in nuclear and particle physics and in modern physics, our research in these fields, and our strong interest in the history of physics and the philosophy of science. The book can be used in these different courses by sophomore students to beginning graduate students for a one-semester or a full-year course by emphasizing different chapters and different material within a chapter. Only an introductory calculus-based physics course is a necessary prerequisite. Students in biology,

chemistry, engineering, medicine, and other fields in addition to physics will find the material very helpful in their work. We hope students will come to share the challenges and excitement we experience in seeking to understand the basic structures of matter at the atomic, nuclear, and particle levels.

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Because of the simplicity in stating many equations in electricity and magnetism, we have more often used the Gaussian (CGS) system rather than the SI (MKS) units. The conversion of factors between the two systems of electrical units are given in an appendix. Again, for ease in solving problems, energies are given in electron-volts up to GeV (10^9 eV). Several constants which are composed of different fundamental constants are given to facilitate the working of various practical problems. Other appendices are given to provide more detailed deriva-tions, examples of the applications of the principles to different areas of research, and useful tables.

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