Preface to the First Edition

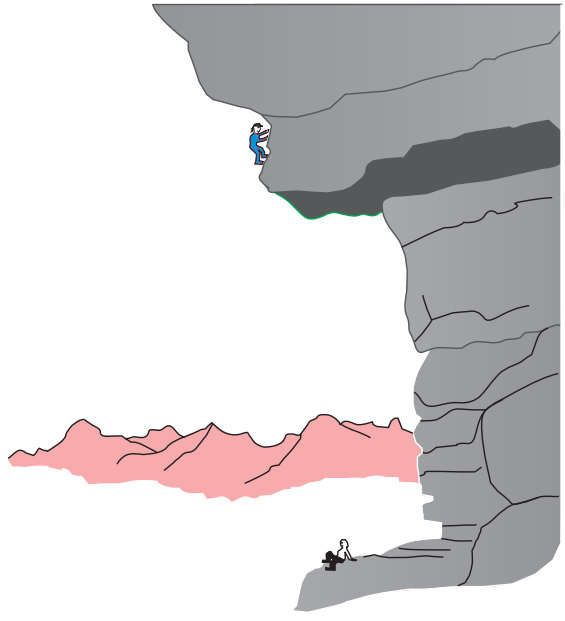
Subatomic Physics, the physics of nuclei and particles, has been one of the frontiers of science since its birth in 1896. From the study of the radiations emitted by radioactive nuclei to the scattering experiments that point to the presence of subunits in nucleons, from the discovery of the hadronic interactions to the realization that the photon possesses hadronic (strong) attributes, and that weak and electromagnetic forces may be intimately related, subatomic physics has enriched science with new concepts and deeper insights into the laws of nature.

Subatomic Physics does not stand isolated; it bears on many aspects of life. Ideas and facts emerging from studies of the subatomic world change our picture of the macrocosmos. Concepts discovered in subatomic physics are needed to understand the creation and abundance of the elements, and the energy production in the sun and the stars. Nuclear power may provide most of the future energy sources. Nuclear bombs affect national and international decisions. Pion beams have become a tool to treat cancer. Tracer and Mössbauer techniques give information about structure and reactions in solid state physics, chemistry, biology, metallurgy, and geology.

Subatomic Physics, because it reaches into so many areas, should not only be accessible to physicists, but also to other scientists and to engineers. The chemist observing the Mössbauer effect, the geologist using a radioactive dating method, the physician injecting a radioactive isotope, or the nuclear engineer designing a power plant have no immediate need to understand isospin or inelastic electron scattering. Nevertheless, their work may be more satisfying and they may be able to find new connections if they have a grasp of the basic principles of subatomic physics. While the present book is mainly intended as an introduction for physicists, we hope that it will also be useful to other scientists and to engineers.

Subatomic Physics deals with all entities smaller than the atom; it combines nuclear and particle physics. The two fields have many concepts and features in common. Consequently, we treat them together and attempt to stress unifying ideas, concepts and currently unsolved problems. We also show how subatomic

physics is involved in astrophysics. The level of presentation is aimed at the senior undergraduate or first-year graduate student who has some understanding of electromagnetism, special relativity, and quantum theory. While many aspects of subatomic physics can be elucidated by hand waving and analogies, a proper understanding requires equations. One of the most infuriating sentences in textbooks is "It can be shown..." We would like to avoid this sentence but it is just not possible. We include most derivations but use equations without proof in two situations. Many of the equations from other fields will be quoted without derivation in order to save space and time. The second situation arises when the proper tools, for instance Dirac theory of field quantization, are too advanced. We justify omission in both situations by an analogy. Mountain climbers usually like to reach the unexplored parts of a climb quickly rather than spend days walking through familiar terrain. Quoting equations from quantum theory and electrodynamics corresponds to reaching the starting point of an adventure by car or cable car. Some peaks can only by reached by difficult routes. An inexperienced climber, not yet capable of mastering such a route, can still learn by watching from a safe place. Similarly, some equations can only be reached by difficult derivations, but the reader can still learn by exploring the equations without following their derivations. Therfore, we will quot some relations without proof, but we will try to make the result plausible and to explore the physical consequences. Some more difficult parts will be denoted with bullets (•); these parts can be omitted on first reading.



Preface to the Third Edition

Subatomic Physics has continued to make rapid strides since the 2nd. Edition was published in 1991 (by Prentice-Hall). New particles have been found; the distributions of electric charge and magnetism within the proton have been found to be significantly different; neutrinos have been found to have masses and undergo oscillations, and the standard model needs to be accordingly modified; CP violation has been established to be compatible with the Cabibbo-Kobayashi-Maskawa matrix; chiral and effective field theories have been developed, lattice QCD has made enormous strides. Nuclear structure far from the region of stability has started to been studied, relativistic heavy ions have opened new doors and understanding, and astrophysics and cosmology have provided us with a much improved understanding of the world around us. Data has become much more precise. Although there is a perception that physics has changed from being a unified science to a series of subfields that ignore each other, here we find the opposite: in the last twenty years there has been much progress at the intersection between atomic, nuclear, particle, and astro physics.

In the new edition we have updated all the material trying to expose the excitment that we feel about progress in the last two decades. We have reorganized chapters to make the material more clear, we have written new sections where new discoveries justified it, and we have trimmed parts of the 2nd Edition to allow us to incorporate new material. We have included new problems and, on the basis of comments we have received on the previous editions, we have starred problems which require the student to find library material. Overall there is more material in this edition than in the previous ones and we do realize that this is too much to be covered in a single quarter or semester. We nevertheless believe that this gives some freedom for the instructor to concentrate on the areas of choice. In addition, it gives the students the possibility of using the additional material to explore it on their own.

Hans Frauenfelder, who was one of the authors of the first two editions (1976, 1991) has been out of the field long enough to ask not to participate in the present work.