The forces of nature

Second edition

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PREFACE

The purpose of this book is to explain the concepts underlying the spectacular recent advances in our understanding of the microcosmos – the world within the atom. It is a world inhabited by a fascinating collection of particles and forces. Although in many ways it resembles a scaled-down version of the everyday world, bizarre phenomena can occur that have no counterpart in the experience of our senses. When we probe the subatomic domain, we must be prepared for situations totally beyond our imagination, though not, one hopes, beyond our comprehension.

Very few books exist which attempt to explain modern subatomic physics at the conceptual level. The subject of quantum mechanics, in particular, is almost exclusively confined to formal textbooks. This book explains the basics of subatomic particles and their interactions without subjecting the reader to the tedium of punishing mathematics, or formal sets of rules. The emphasis is on concepts rather than facts and figures.

I have written in a style which attempts to communicate my own feelings for the subject: that it is not just a dry accumulation of data, but a human adventure without precedent. The quest to find out what the world is made of, and to uncover the forces that lie at the heart of matter, must rank as one of the most significant enterprises of mankind.

But there is more to subatomic physics than the desire to know how the microcosmos is arranged. It is also the testing ground for the two great revolutionary theories of twentieth-century science: relativity and quantum theory. Both enter into the affairs of elementary matter in a fundamental way, and the success of the revolutionary marriage has been breathtaking.

The level of presentation corresponds roughly to that of *Scientific American* or *New Scientist* and I hope will appeal to a wide range of readers, from the off-duty, non-specialist scientist, through students requiring a foundation in the topics of atomic, nuclear and elementary particle physics, quantum mechanics and field theory, to sixth formers and laymen who wish to extend their knowledge of science beyond the occasional snippet in the daily press.

Although many Greek symbols are used as names for particles, there is very little actual mathematics in this book, and none beyond ordinary secondary school algebra and arithmetic. SI units are used throughout except where subatomic distances or particle masses are concerned. There we use the more familiar fermi (10^{-15} m), abbreviated fm, for distance; masses are based on the unit Me V/c^2, or millions of electron volts ÷ (speed of light)^2, which will be abbreviated Me V.

August 1978 P.C.W.D.

PREFACE TO THE SECOND EDITION

The publication of the first edition of this book coincided with a period of rapid advance in the study of the forces of nature. On the one hand experimenters have discovered a crop of new subatomic particles, the most important being the so-called W and Z particles discovered at CERN in 1983. On the other hand theoretical ideas have moved ahead considerably. In particular the development of grand unified theories (GUTs), and the general acceptance of the Glashow–Salam–Weinberg theory of the electroweak force has focussed attention on the attractive possibility that all the forces of nature have a common origin in a still elusive 'superforce'.

The new edition of *The forces of nature* is a substantial revision of the original text to include a discussion of these major new developments. More emphasis is given to the theory of quarks and their interactions. I have also given a short section on cosmology. One of the more fascinating aspects of the way that high-energy particle physics has been changing is its increasingly detailed application to the early stages of the big bang. The physics of the very large and the very small are approaching a pleasing confluence.

As before, the material in this book is intended for the non-specialist reader as well as science students and scientists of other disciplines. It should provide ideal background reading for undergraduate courses in particle and nuclear physics or quantum physics, or simply a good read for anyone intrigued by the obviously remarkable things going on at the frontier of fundamental research.

I am greatly indebted to Stephen Huggins for many helpful comments and suggestions.

1985 P. C. W. Davies