

<<超对称和弦论>>

图书基本信息

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前言

As this is being written, particle physics stands on the threshold of a new era, with the commissioning of the Large Hadron Collider (LHC) not even two years away. In writing this book, I hope to help prepare graduate students and postdoctoral researchers for what will hopefully be a period rich in new data and surprising phenomena. The Standard Model has reigned triumphant for three decades. For just as long, theorists and experimentalists have speculated about what might lie beyond. Many of these speculations point to a particular energy scale, the teraelectronvolt (TeV) scale which will be probed for the first time at the LHC. The stimulus for these studies arises from the most mysterious - and still missing - piece of the Standard Model: the Higgs boson. Precision electroweak measurements strongly suggest that this particle is elementary (in that any structure is likely far smaller than its Compton wavelength), and that it should be in a mass range where it will be discovered at the LHC. But the existence of fundamental scalars is puzzling in quantum field theory, and strongly suggests new physics at the TeV scale. Among the most prominent proposals for this physics is a hypothetical new symmetry of nature, supersymmetry, which is the focus of much of this text. Others, such as technicolor, and large or warped extra dimensions, are also treated here. Even as they await evidence for such new phenomena, physicists have become more ambitious, attacking fundamental problems of quantum gravity, and speculating on possible final formulations of the laws of nature. This ambition has been fueled by string theory, which seems to provide a complete framework for the quantum mechanics of gauge theory and gravity. Such a structure is necessary to give a framework to many speculations about beyond the Standard Model physics. Most models of supersymmetry breaking, theories of large extra dimensions, and warped spaces cannot be discussed in a consistent way otherwise.

内容概要

The Standard Model has reigned triumphant for three decades. For just as long, theorists and experimentalists have speculated about what might lie beyond. Many of these speculations point to a particular energy scale, the teraelectronvolt (TeV) scale which will be probed for the first time at the LHC. The stimulus for these studies arises from the most mysterious - and still missing - piece of the Standard Model: the Higgs boson. Precision electroweak measurements strongly suggest that this particle is elementary (in that any structure is likely far smaller than its Compton wavelength), and that it should be in a mass range where it will be discovered at the LHC. But the existence of fundamental scalars is puzzling in quantum field theory, and strongly suggests new physics at the TeV scale. Among the most prominent proposals for this physics is a hypothetical new symmetry of nature, supersymmetry, which is the focus of much of this text. Others, such as technicolor, and large or warped extra dimensions, are also treated here.

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插图：The strong interactions, as their name implies, are characterized by strong coupling. As a result, perturbative methods are not suitable for most questions. In comparing theory and experiment, it is necessary to focus on a few phenomena which are accessible to theoretical analysis. By itself, this is not particularly disturbing. A parallel with the quantum mechanics of electrons interacting with nuclei is perhaps helpful. We can understand simple atoms in detail; atoms with very large Z can be treated by Hartree-Fock or other methods. But atoms with intermediate Z can be dealt with, at best, by detailed numerical analysis accompanied by educated guesswork. Molecules are even more problematic, not to mention solids. But we are able to make detailed tests of the theory (and its extension in quantum electrodynamics) from the simpler systems, and develop qualitative understanding of the more complicated systems. In many cases, we can do quantitative analysis of the small fluctuations about the ground states of the complicated system. In the theory of strong interactions, as we will see, many problems are hopelessly complicated. Low-lying spectra are hard; detailed exclusive cross sections in high-energy scattering essentially impossible. But there are many questions we can answer. Rates for many inclusive questions at very high energy and momentum transfer can be calculated with high precision. Qualitative features of the low lying spectrum of hadrons and their interactions at low energies can be understood in a qualitative (and sometimes quantitative) fashion by symmetry arguments. Recently, progress in lattice gauge theory has made it possible to perform calculations which previously seemed impossible, for features of spectra and even for interaction rates important for understanding the weak interactions.

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