Preface to the Second Edition

Much has happened since the appearance of *Supersymmetry and String Theory: Beyond the Standard Model* in 2006. The LHC, after a somewhat bumpy start, has performed spectacularly, discovering what is almost certainly the Higgs particle of the simplest version of the Standard Model in 2012, reproducing and improving a broad range of other Standard Model measurements and excluding significant swathes of the parameter space of proposed ideas for Beyond the Standard Model (BSM) physics.

There have also been important observational and experimental developments in astrophysics and cosmology. The Wilkinson Microwave Anisotropy Probe (WMAP), the Planck satellite and a variety of other experiments have greatly improved our understanding of the cosmic microwave radiation background. We have more reliable measures of the dark matter and dark energy densities and a good measurement of the spectral index, n_s. It is likely that we will soon have some information on, and possibly a measurement of, the scale of inflation coming from studies of B-mode polarization. At the same time, direct and indirect searches for weakly interacting massive particle (WIMP) dark matter have significantly constrained the space of masses and couplings. However, there remain, as of the time of writing, some intriguing anomalies. Furthermore, axion searches have made significant progress and are probing significant parts of the plausible parameter space.

On the theoretical side there have been a number of developments. Within the study of the Standard Model, there has been enormous progress in QCD computations; indeed, these have played an important role in the Higgs discovery. Lattice gauge theorists have continued to make strides in computation of quantum chromodynamics (QCD) quantities, such as quark masses, while embarking on the study of theories relevant to issues in BSM physics. Within supersymmetric models, metastable dynamical supersymmetry breaking has emerged as both an interesting feature of supersymmetric dynamics and a possible mechanism for supersymmetry realization in nature. Other important new ideas include general gauge mediation.

But perhaps the most important theoretical development has been the response to the Higgs discovery, as well as BSM (particularly supersymmetry) exclusions. The observed Higgs mass is compatible with supersymmetry only if the superpartners are quite heavy (tens of TeV) or under special circumstances. Many other BSM ideas face similar challenges. This has sparked a search for alternatives and also a rethinking of notions of naturalness. The big questions are:

1. Is there some form of new physics that accounts for the hierarchy between the weak and other scales, which is perhaps difficult to see or which occurs at a scale somewhat above the current LHC reach?

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2. Are our ideas about naturalness somehow misguided? Would a more refined viewpoint point to some energy scale slightly higher than a TeV, which might be accessible to future LHC experiments or some higher-energy accelerator? This has focused renewed attention on ideas such as little Higgs models and Randall–Sundrum models, as well as the possibility that the scale of supersymmetry breaking is simply higher.
3. The possibility that simple-minded notions of naturalness may not be correct has increased interest in the landscape hypothesis.

In this present edition of this book I have attempted to incorporate these developments and to provide some possible directions for investigations of BSM physics. Additions include:

1. new sections on the Higgs discovery;
2. discussion of developments in perturbative QCD computations;
3. expanded discussion of lattice gauge theory, with an emphasis on results of the simulations for quantities such as quark masses;
4. updated discussion of dark matter experiments;
5. updated discussion of the neutrino mass matrix;
6. updated discussion of inflation in light of WMAP, Planck and other experiments;
7. more extensive discussion of solutions to the hierarchy problem outside supersymmetry, especially the little Higgs and Randall–Sundrum models;
8. sections on metastable dynamical supersymmetry breaking that include the Intriligator, Shih and Seiberg models but treat the issue quite generally;
9. an introduction to general gauge mediation;
10. more extensive discussion of the landscape, hypothesis and its connection to and possible implications for notions of naturalness;
11. replacement of the previous "Coda" by a discussion of possible future directions in light of the first four years of LHC, dark matter searches, cosmological observations and theoretical developments.

I have also taken the opportunity to correct many errors in the first edition. I am grateful to the many readers who have pointed these out. I am sure that errors will remain, and I have only myself to blame for these.

Michael Dine

Santa Cruz, California

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