

# Epilogue

## **Reductionism complete?**

The Standard Model, extended to include neutrinos carrying mass, gives a remarkably successful account of the experimental data of particle physics obtained up to 2006. Any subsequent theory must, in some sense, correspond to the Standard Model in the energy range that has so far been explored.

Many questions remain to be answered. Why is there the internal electroweak and strong group structure  $U(1) \times SU(2) \times SU(3)$ , with the three coupling constants  $g_1, g_2, g_3$ ? Is the origin of mass really to be found in the Higgs field with its two parameters: the Higgs mass and the expectation value of the Higgs field? In the electroweak sector, why are the masses of the charged leptons as they are? There are three parameters here. Another set of parameters comes with allowing neutrinos to have mass: three neutrino masses and four parameters of the mass mixing matrix (or six if it appears that neutrinos correspond to Majorana fields rather than Dirac fields). In the quark sector ten more parameters are introduced: six quark masses, and four parameters in the Kobayashi–Maskawa matrix.

Are these twenty five or twenty six parameters really independent?

Some of these questions may be answered when experimentalists have the LHC (Large Hadron Collider) at CERN, probing to higher energies and thereby to smaller distances to make progress into finding common origins of what are now diverse elements of the Standard Model. The task is to reduce twenty six parameters to one or two, say, before closing the book on the theory of matter and radiation.