

# Gauge Theory of Electroweak Interactions

Gauge fields provide new possibilities of constructing a *unified theory* of elementary-particle *interactions*. In this chapter we consider gauge models which unify electromagnetic and weak interactions. The gauge theory of strong interaction as well as theories unifying strong, electromagnetic and weak interactions will be considered later in Part IV.

The major difficulty in unifying the electromagnetic and the weak interactions originates from the basic differences in their character. Firstly, in contrast to the long-range electromagnetic interaction, the weak interaction has a finite interaction radius. The mediators of the weak interaction therefore must be massive (intermediate vector bosons), as distinct from the massless mediators of the electromagnetic interaction (photons). Secondly, unlike the electromagnetic interaction which conserves spatial parity, the weak interaction is not parity conserving.

This difficulty can be overcome by assuming the gauge fields to be the mediators of both interactions and by using spontaneous symmetry-breaking. A suitable choice of spontaneous symmetry-breaking makes one gauge field remain massless (photon) and to interact with the parity-conserving current, while the rest of gauge fields acquire a mass (intermediate bosons), their interaction not being parity conserving.

The choice of a specific realization of the model is quite arbitrary, and a large number of particular unified models for the electroweak *lepton* interactions have been analyzed in the literature. The most successful is the model suggested by Glashow, Salam and Weinberg which is referred to as the *standard* one. This model was further generalized to the case of the electroweak interaction of *quarks* by Glashow, Iliopoulos, and Maiani.

In this part, we shall obtain the Lagrangians of the standard model for electroweak interactions of both leptons and quarks. Furthermore, in the framework of the standard model, we shall present the theory of electromagnetic and weak interactions of particles. Finally, we shall dwell on the renormalizability of gauge theories and discuss unified models others than the standard one.