ARTICLE IN PRESS

Progress in Particle and Nuclear Physics ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

Progress in Particle and Nuclear Physics

journal homepage: www.elsevier.com/locate/ppnp

Review

The Standard Model and Higgs physics

Ezio Torassa

INFN, Sez. di Padova, Italy

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Standard model
Higgs boson
LEP
Tevatron
LHC
Future colliders

ABSTRACT

The Standard Model is a consistent and computable theory that successfully describes the elementary particle interactions. The strong, electromagnetic and weak interactions have been included in the theory exploiting the relation between group symmetries and group generators, in order to smartly introduce the force carriers. The group properties lead to constraints between boson masses and couplings. All the measurements performed at the LEP, Tevatron, LHC and other accelerators proved the consistency of the Standard Model. A key element of the theory is the Higgs field, which together with the spontaneous symmetry breaking, gives mass to the vector bosons and to the fermions. Unlike the case of vector bosons, the theory does not provide prediction for the Higgs boson mass. The LEP experiments, while providing very precise measurements of the Standard Model theory, searched for the evidence of the Higgs boson until the year 2000. The discovery of the top quark in 1994 by the Tevatron experiments and of the Higgs boson in 2012 by the LHC experiments were considered as the completion of the fundamental particles list of the Standard Model theory. Nevertheless the neutrino oscillations, the dark matter and the baryon asymmetry in the Universe evidence that we need a new extended model. In the Standard Model there are also some unattractive theoretical aspects like the divergent loop corrections to the Higgs boson mass and the very small Yukawa couplings needed to describe the neutrino masses. For all these reasons, the hunt of discrepancies between Standard Model and data is still going on with the aim to finally describe the new extended theory.

© 2018 Elsevier B.V. All rights reserved.

Contents

E-mail address: ezio.torassa@pd.infn.it.

https://doi.org/10.1016/j.ppnp.2018.01.003
0146-6410/© 2018 Elsevier B.V. All rights reserved.

Please cite this article in press as: E. Torassa, The Standard Model and Higgs physics, Progress in Particle and Nuclear Physics (2018), https://doi.org/10.1016/j.ppnp.2018.01.003.

---

1. Introduction

1.1. Electroweak history

The weak interaction was discovered by Antoine Henry Becquerel in 1896 [1] when he found that a nucleus may decay into a different nucleus plus a β ray. Wolfgang Pauli in 1930 [2] postulated the existence of a new particle, the neutrino, to make possible the momentum and energy conservation despite the continuous distribution of energy of the β particles. Subsequently, in 1932, the neutron was discovered by James Chadwick [3] and the decay of a nucleus was interpreted as the decay of a neutron inside the nucleus:

$$n \to p + e^- + \overline{\nu}_e \tag{1}$$

The description of the weak interactions was proposed by Enrico Fermi in 1934 [4]. Fermi assumed that the emission of a electron–neutrino pair was analogous to the electromagnetic emission of a photon. Since the electromagnetic interaction of a charged particle is given by:

$$\mathcal{L}_{\text{e.m.}} = eA_\mu \overline{\psi} \gamma^\mu \psi \tag{2}$$

where ψ is the field describing the charged particles, A_μ the electromagnetic field and $\overline{\psi} = \psi^\dagger \gamma^0$, the Fermi ansatz for the Lagrangian of the neutron decay was:

$$\mathcal{L}_{\text{weak}} = G_F(\overline{\psi_e}\gamma_\mu \psi_\nu)(\overline{\psi_p}\gamma^\mu \psi_n) \tag{3}$$

where G_F is the Fermi coupling constant. The main problem of the Fermi theory is its non-renormalizability. The renormalizability rule for a theory is to have positive dimensions in mass for every coupling:

$$[g_i] \geq 0 \quad \text{for any } i \tag{4}$$

The dimensions of $\mathcal{L}$, ψ, A_μ in natural units ($L = T = M^{-1}$) are:

$$[\mathcal{L}] = 4 \qquad [\psi] = 3/2 \qquad [A_\mu] = 1 \tag{5}$$

the resulting dimension for e in Eq. (2) is 0, for G_F in Eq. (3) is -2. The problem can be solved introducing an intermediate vector boson. The idea was proposed by Julian Schwinger in 1957 [5] and extended to a neutral vector boson by Sidney Bludman in 1958 [6] and Sheldon Glashow in 1961 [7] deriving the Fermi interaction from the SU(2) symmetry. The description of the electroweak theory including the electromagnetic and weak interactions is due to Sheldon Glashow, Steven Weinberg and Abdus Salam [7–9].

Please cite this article in press as: E. Torassa, The Standard Model and Higgs physics, Progress in Particle and Nuclear Physics (2018), https://doi.org/10.1016/j.ppnp.2018.01.003.

Download English Version:

https://daneshyari.com/en/article/8200882

Download Persian Version:

https://daneshyari.com/article/8200882

Daneshyari.com