Leptonų aromatų apsikeitimas Higso bozono skilimuose dviejų Higso dubletų ir sūpuoklių modelyje

Lepton flavour changing Higgs boson decays in a two-Higgs-doublet seesaw model

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From the experimental observation of neutrino oscillations, lepton flavor violation (LFV) in the neutrino sector has been observed. However, that violation has not yet been observed in the charged-lepton sector and it is not quite certain where it is most likely to be observed first. After discovery of Higgs boson it is pertinent to ask if there could be a connection or mixing between the Higgs sector and the mechanism responsible for the nonconservation of lepton number, and to find out whether some remnant effect could show up in Higgs decays, which may be detectable at present or future colliders. We are interested in studying the decays of the Higgs boson $H \to \ell_1 \ell_2$ as a possible signal of LFV. The CMS and ATLAS Collaborations have reported current upper limits on the branching ratios of the Higgs decay to two leptons [1, 2]. The second run of the LHC, at a center of mass energy $\sqrt{s} = 13$ TeV will provide an important probe of flavour changing couplings of the Higgs boson.

We consider a two-Higgs-doublet extension of the Standard Model (SM), with three right-handed neutrino singlets and the seesaw mechanism. Is assumed that the lepton flavours are conserved in the Yukawa couplings and broken only in the Majorana mass terms of the right-handed neutrinos; this assumption is field-theoretically consistent because those mass terms have dimension three while the Yukawa couplings have dimension four. Therefore all the Yukawa coupling matrices are lepton flavour-diagonal and LFV originates solely in the non-flavour-diagonal Majorana mass matrix of the right-handed neutrinos [3].

We compute the process $H(\bar{p}_1 + p_2) \to \ell_1(\bar{p}_1)\,\ell_2(p_2)$. Here, H is supposed to be the observed neutral scalar with mass $m_H \approx 125\,\text{GeV}$. In a two-Higgs-doublet model in the Higgs basis,

$$\Phi_1 = \begin{pmatrix} G^+ \\ \left(v + X_1 + iG^0\right)/\sqrt{2} \end{pmatrix}, \quad \Phi_2 = \begin{pmatrix} C^+ \\ \left(X_2 + iX_3\right)/\sqrt{2} \end{pmatrix}, \tag{1}$$

where $v \approx 246\,\text{GeV}$ is real and $X_{1,2,3}$ (and G^0) are real fields. The field $G^+ \equiv S_1^+$ is the charged Goldstone boson; $C^+ \equiv S_2^+$ is a physical charged scalar with mass m_C. The amplitude is of the form

$$T = \overline{u}_\mu(p_2)\,(l\gamma_L + r\gamma_R)\,v_\tau(\bar{p}_1), \tag{2}$$

where T has mass dimension while l and r are dimensionless. Therefore, summing over the spins of the final fermions ℓ_1 and ℓ_2,

$$|T|^2 = \left(m_H^2 - m_{\ell_1} - m_{\ell_2}\right)\left(|l|^2 + |r|^2\right) - 4m_{\ell_1}m_{\ell_2}\,\Re(lr^*). \tag{3}$$

The partial decay width is

$$\Gamma_{\text{partial}} = |T|^2\,\frac{\sqrt{\lambda\left(m_H, m_{\ell_1}, m_{\ell_2}\right)}}{16\pi m_H^3}, \tag{4}$$

where $\lambda(x, y, z)$.

There are four diagrams generating $l = \sum_{i=1}^4 l_i$ and $r = \sum_{i=1}^4 r_i$. The first two are self-energy diagrams. The third amplitude arises from diagrams in which the external H couples to gauge bosons and/or charged scalars. In the fourth amplitude, H couples to two (either distinct or identical) neutrinos; the other intermediate particle may be either $W^\pm/G^\pm$ or $C^\pm$.

We have computed the branching ratios of the Higgs decay in to two charged leptons in the case of a two-Higgs-doublet model assuming that the observed particle with mass 125 GeV is 90% equal to the Higgs of the SM and has a 10% contribution from a second Higgs doublet. Also, we have employed several simplifying assumptions in order to reduce the parameter space of the model and demonstrate that is possible to find a region in the parameter space where the branching ratios are close to their experimental limits.

Reikšminiai žodžiai: flavour violation, Higgs boson decay, two-Higgs-doublet, seesaw mechanism

Literatūra

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