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DOUBLE PHOTON DECAYS OF B MESON'S IN 2HDM

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***Abstract**: B mesons double radiative decays $B \to \gamma\gamma$ are investigated in frame of two Higgs doublet model type II. The branching ratios are calculated.*

***Key words**: Standard Model, B mesons, 2HDM.*

The investigation of the B-meson's rare decays is of great interest in order to test the standard model (SM) and beyond SM (BSM) physics. In the SM the leading contribution to the two-photon decays of neutral B mesons $B_{s(d)} \to \gamma\gamma$ comes from one-loop diagrams, up-type quarks and W-bosons being particles exchanged in the loop [1]. The branching ratio of these decays is about $10^{-6(-8)}$ [1]

$$Br(B_s \to \gamma\gamma) \approx 1 \cdot 10^{-6} , \quad Br(B_d \to \gamma\gamma) \approx 3 \cdot 10^{-8} \qquad (1)$$

Whereas the current experimental limits on them are [2]

$$Br(B_s \to \gamma\gamma) < 3.1 \cdot 10^{-6} , \quad Br(B_d \to \gamma\gamma) < 3.2 \cdot 10^{-7} \qquad (2)$$

In this article we have estimated additional to the SM contribution in the two Higgs doublet model (2HDM) type II [3]. Real charged Higgs particle may contribute into $B \to \gamma\gamma$ decay in frame of 2HDM (fig.1).

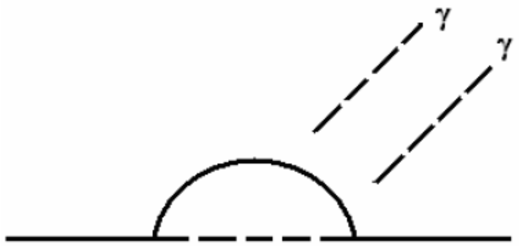

Fig. 1: $b \to s(d)\gamma\gamma$ transition in the 2HDM via charged Higgs particle (dashed intermediate line); photons are emitted from any charged particles.

The Lagrangian of interaction quarks with charged Higgs particles ($H^{\pm}$) has the following form[3]

$$L = \frac{ig}{\sqrt{2}M_W}[m_d P_L \tan\beta + m_u P_R \cot\beta] V_{ij} \bar{d}_i H u_j + h.c. \qquad (3)$$

Where $P_{L,R} = (1 \mp \gamma_5)/2$, m_u and m_d are masses of down- up- quarks, V_{ij} are elements of Cabibbo-Kobayashi-Maskava matrix, $\tan\beta = v_2 / v_1$ ($v_{1,2}$ being vacuum expectation of the Higgs bosons).

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One can write down the amplitude for the decay $B \to \gamma\gamma$ in the following form (which is correct after gauge fixing for final photons) [1]

$$T(B \to \gamma\gamma) = \varepsilon_1^{\mu}(k_1)\varepsilon_2^{\nu}(k_2)\left[Ag_{\mu\nu} + iB\varepsilon_{\mu\nu\alpha\beta}k_1^{\alpha}k_2^{\beta}\right] \qquad (4)$$

Where $\varepsilon_1^{\mu}(k_1)$ and $\varepsilon_2^{\nu}(k_2)$ are the polarization vectors of final photons with momentum k_1 and k_2 respectively. The scalar functions $A(B)$ are CP-even (odd) amplitudes for the processes $B \to \gamma\gamma$.

Using Eq. (4) we find that the branching ratio of the decay $B \to \gamma\gamma$ can be represented as

$$Br(B \to \gamma\gamma) = \frac{1}{32\pi M_B \Gamma_{tot}}\left[4|A|^2 + \frac{1}{2}M_B^4|B|^2\right] \qquad (5)$$

Let us mention that our calculations are performed in the frame of Feynman-t'Hooft gauge and we use dimension regularization technique for divergent Feynman diagrams. Only one particle reducible diagrams contain divergent parts. The divergent parts mutually cancel in the sum of amplitudes and due to GIM mechanism [4].

The direct calculation gives following expressions for the charged Higgs particles contribution into A and B scalar functions:

$$A = \frac{i\sqrt{2}m_b}{(12\pi)^2 m_{s(d)}} G_F f_B e^2 M_B^2 \sum V_{bi}V_{s(d)i}^{*}\left\{f_1(x_i) + [\cot^2\beta - \tan^2\beta \frac{m_b m_{s(d)}}{M_H^2 x_i}] f_2(x_i)\right\}$$

$$B = \frac{i\sqrt{2}m_b}{2(6\pi)^2 m_{s(d)}} G_F f_B e^2 \sum V_{bi}V_{s(d)i}^{*}\left\{f_1(x_i) + [\cot^2\beta + \tan^2\beta \frac{m_b m_{s(d)}}{M_H^2 x_i}] f_2(x_i)\right\} \qquad (6)$$

Where f_B is B–meson decay constant, and we have introduced following notation:

$$x_i = \frac{m^2(u_i)}{M_H^2}, \quad f_1(x) = \frac{-5x^3 + 8x^2 - 3x + 2x(3x-2)\ln x}{2(1-x)^3},$$

$$f_2(x) = \frac{-16x^4 + 69x^3 - 84x^2 + 31x + 6x(x^2 - 6x + 4)\ln x}{12(1-x)^4} \qquad (7)$$

Using formulae (5)-(7) one can estimate the branching ratio of the decays $B_{s(d)} \to \gamma\gamma$ (all necessary experimental data we need for this purpose are taken in [2]).

Conclusion

We have estimated charged Higgs particles contribution into $B \to \gamma\gamma$ decay. For small value of charged Higgs particle ($M_H \approx O(a\ \ few\ hundred\ GeV)$) and large $\tan\beta$ the contribution of charged Higgs particle into branching ratio of the decay $B_s \to \gamma\gamma$ is significant large (on the same level as SM estimate).This region of parameters are practically excluded by current experimental and theoretical investigations [3, 5]. Though, allowed region [3, 5] of parameters ($\tan\beta \approx 4$, $M_H \approx O(a\ \ few\ TeV)$) gives significant contribution (a few percent) into branching ratio of the decay $B_s \to \gamma\gamma$. The branching ratio 10^{-6} for B_s meson double-photon decay will be measurable in the foreseen feature.

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