Charged Lepton LFV Decays, Majorana CP-Violating Phases, Leptogenesis and $(\beta\beta)_{0\nu}$–Decay

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The Role of LFV Decays: $\mu \rightarrow e + \gamma$

For $M_1 \ll M_2 \ll M_3$, $M_3 \gtrsim 5 \times 10^{15}$) GeV,

$M_{SUSY} \sim (100 - 600)$ GeV (LHC), e.g.,

$$m_0 = m_{1/2} = 250 \text{ GeV}, \quad A_0 = a_0 m_0 = -100 \text{ GeV},$$

$BR(\mu \rightarrow e + \gamma) < 1.2 \times 10^{-11}$ implies:

terms $\sim M_3$ in $|(\mathbf{Y}_\nu^\dagger L \mathbf{Y}_\nu)_{21}|$ – **suppressed**.

One possible solution - the form of $\mathbf{R}$.

IH (QD) spectrum:

$$\mathbf{R} \simeq \begin{pmatrix} \cos\omega & \sin\omega & 0 \\ -\sin\omega & \cos\omega & 0 \\ 0 & 0 & 1 \end{pmatrix} . \tag{1}$$

The terms $\sim M_2$ in $|(\mathbf{Y}_\nu^\dagger L \mathbf{Y}_\nu)_{21}|$ – **dominant**.

Leptogenesis, IH spectrum: $M_1 \gtrsim 7 \times 10^{12}$ GeV, $\omega-$complex.

$M_2 \gtrsim 5 \times 10^{13}$ GeV: predicted $BR(\mu \rightarrow e + \gamma) \gg 10^{-11}$

Two possibilities:

- $M_{SUSY} \sim (600 - 2000)$ GeV, ($m_{1/2} \gg m_0$, e.g, $m_0 = 300$ GeV, $m_{1/2} = 1400$ GeV, $a_0 m_0 = 0$)

- $M_{SUSY} \sim (100 - 600)$ GeV, but $\mathbf{Y}_{\nu 21} = 0$, or $\mathbf{Y}_{\nu 22} = 0$

A. $\mathbf{Y}_{\nu 21} = 0$:

$$\tan\omega = e^{-i\alpha/2}\ \tan\theta_{12}.$$

B. $\mathbf{Y}_{\nu 22} \cong 0$, neglecting s_{13}:

$$\tan\omega = -e^{-i\alpha/2}\ \cot\theta_{12}.$$

Leptogenesis: $\omega-$complex; thus $\alpha \neq 0, \pi$, CP-violating values

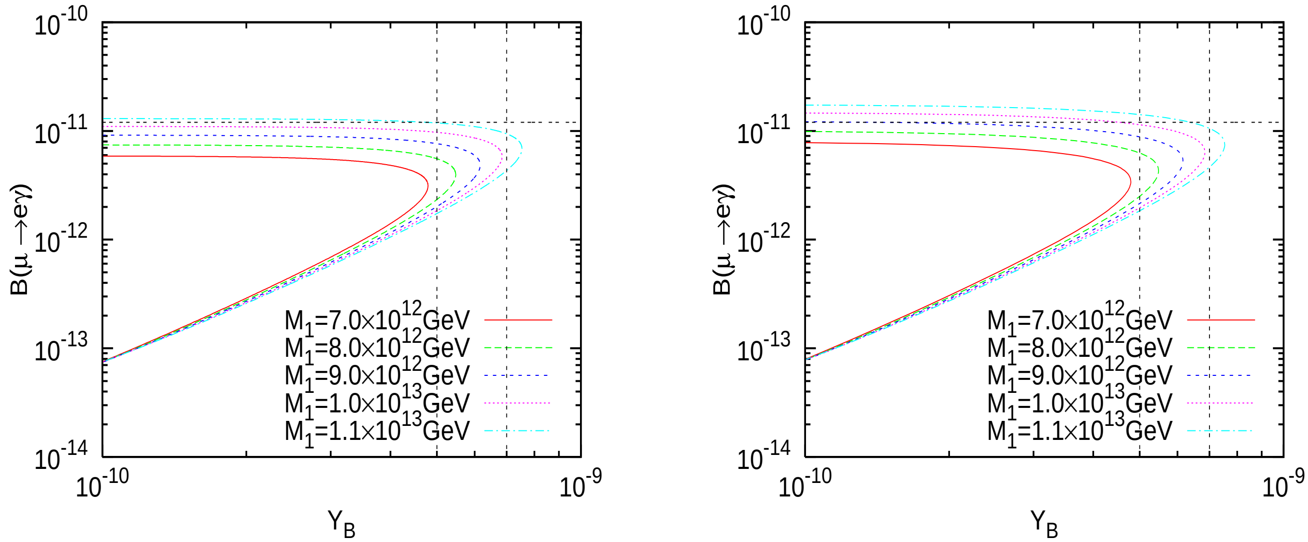
B. $\mathbf{Y}_{\nu 22} = 0$, including s_{13}:

$$\tan\omega = -\frac{c_{12} - s_{12}s_{13}e^{-i\delta}}{s_{12} + c_{12}s_{13}e^{-i\delta}}\ e^{-i\alpha/2}$$

IH spectrum:

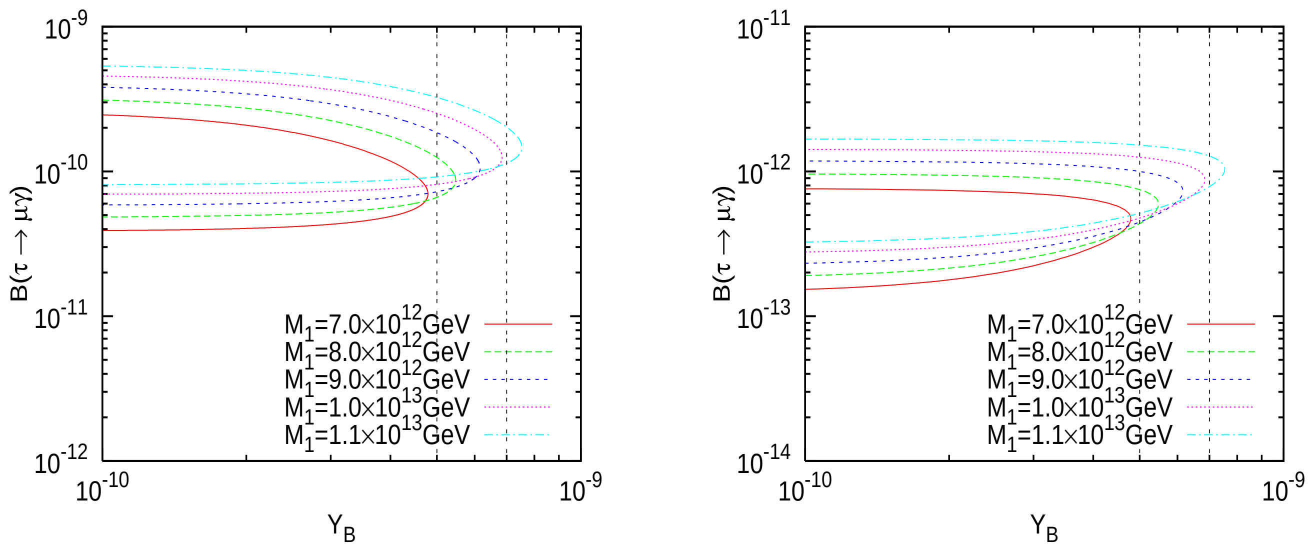
$$|<m>|\ \cong \sqrt{\Delta m^2_{13}}\left|\cos^2\theta_{12} + e^{i\alpha}\ \sin^2\theta_{12}\right|$$

S.T. Petcov, T. Shindou and Y. Takanishi, 2006



$(Y_\nu)_{21} = 0$ $(Y_\nu)_{22} \approx 0$

Figure 1: B($\mu \to e\gamma$) for $s_{13} = 0$ as a function of Y_B. The SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



$(Y_\nu)_{21} = 0$ $(Y_\nu)_{22} \approx 0$

Figure 2: B($\tau \to \mu\gamma$) for $s_{13} = 0$ as a function of Y_B. The mass of next lightest heavy neutrino is taken as $M_2/M_1 = 10$, and the SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.

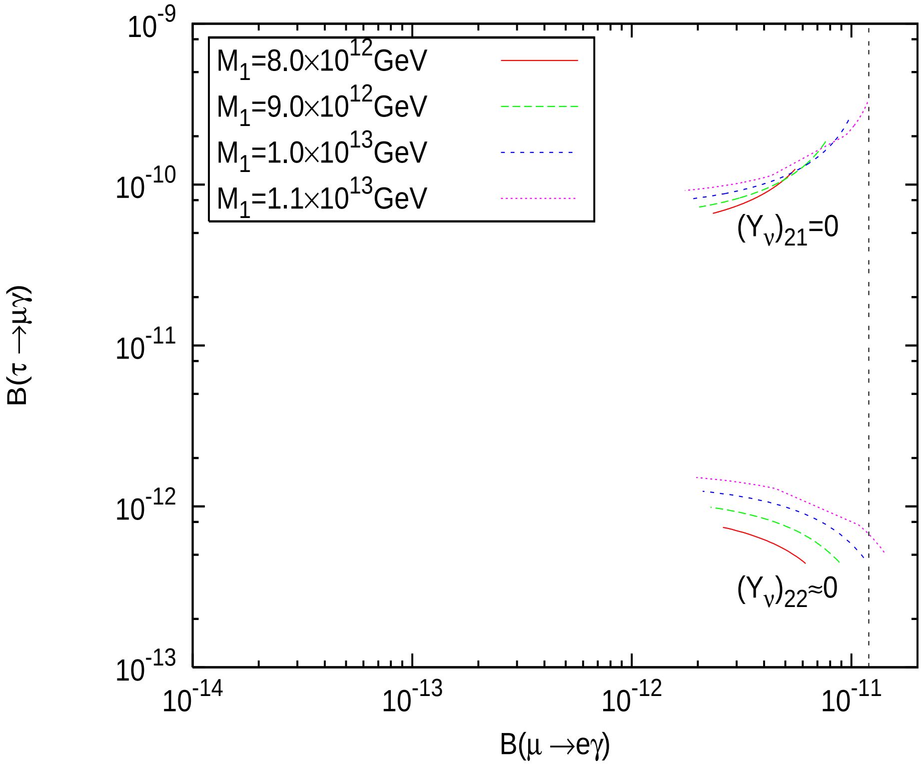
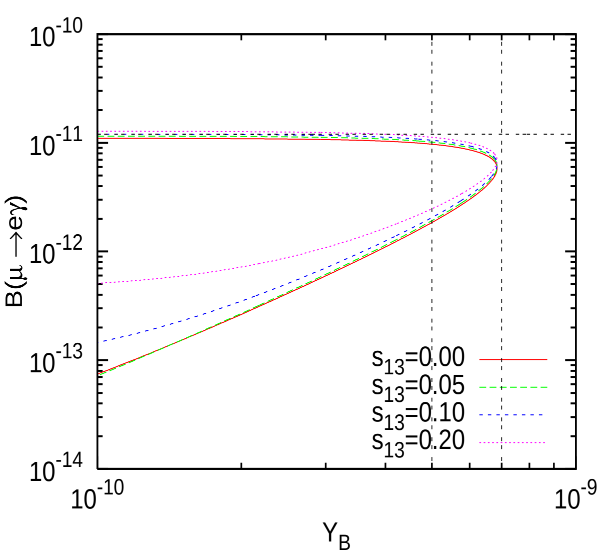
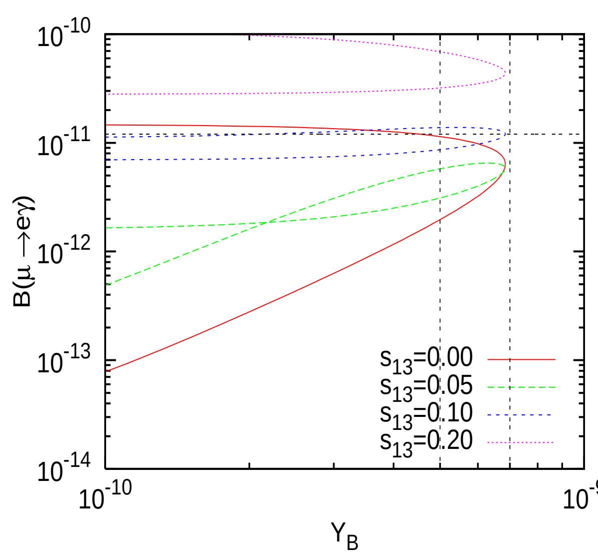


Figure 3: The correlation between $\mu \to e\gamma$ and $\tau \to \mu\gamma$. $M_2/M_1 = 10$, $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$ are taken. The constraint on Y_B, $5.0 \times 10^{-10} \leq Y_B \leq 7.0 \times 10^{-10}$ is taken into account.

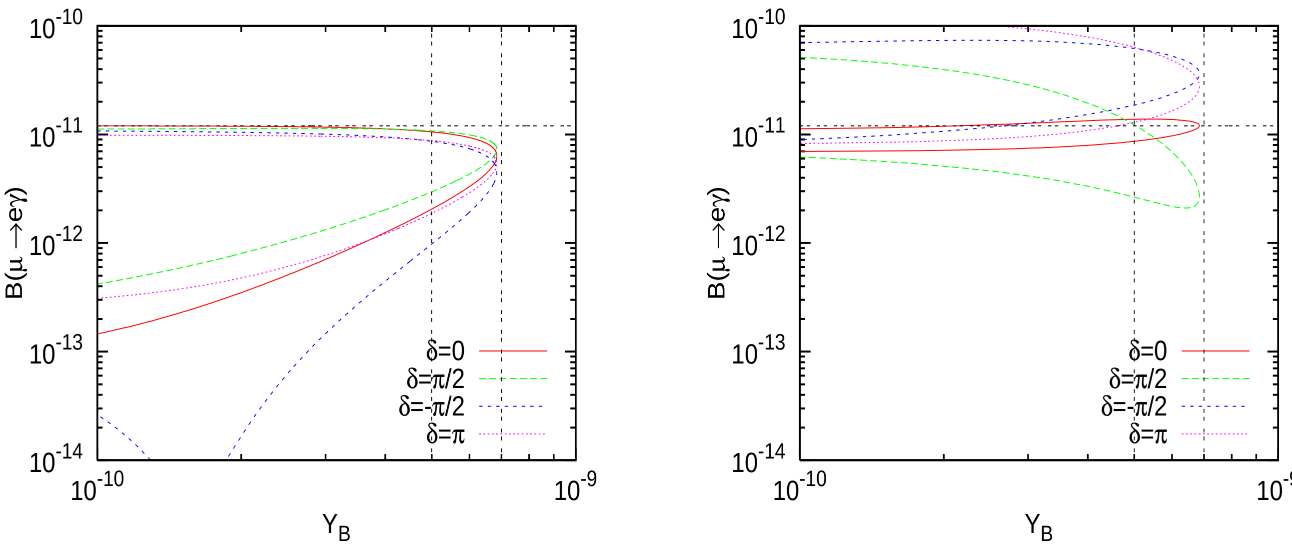


$(Y_\nu)_{21} = 0$



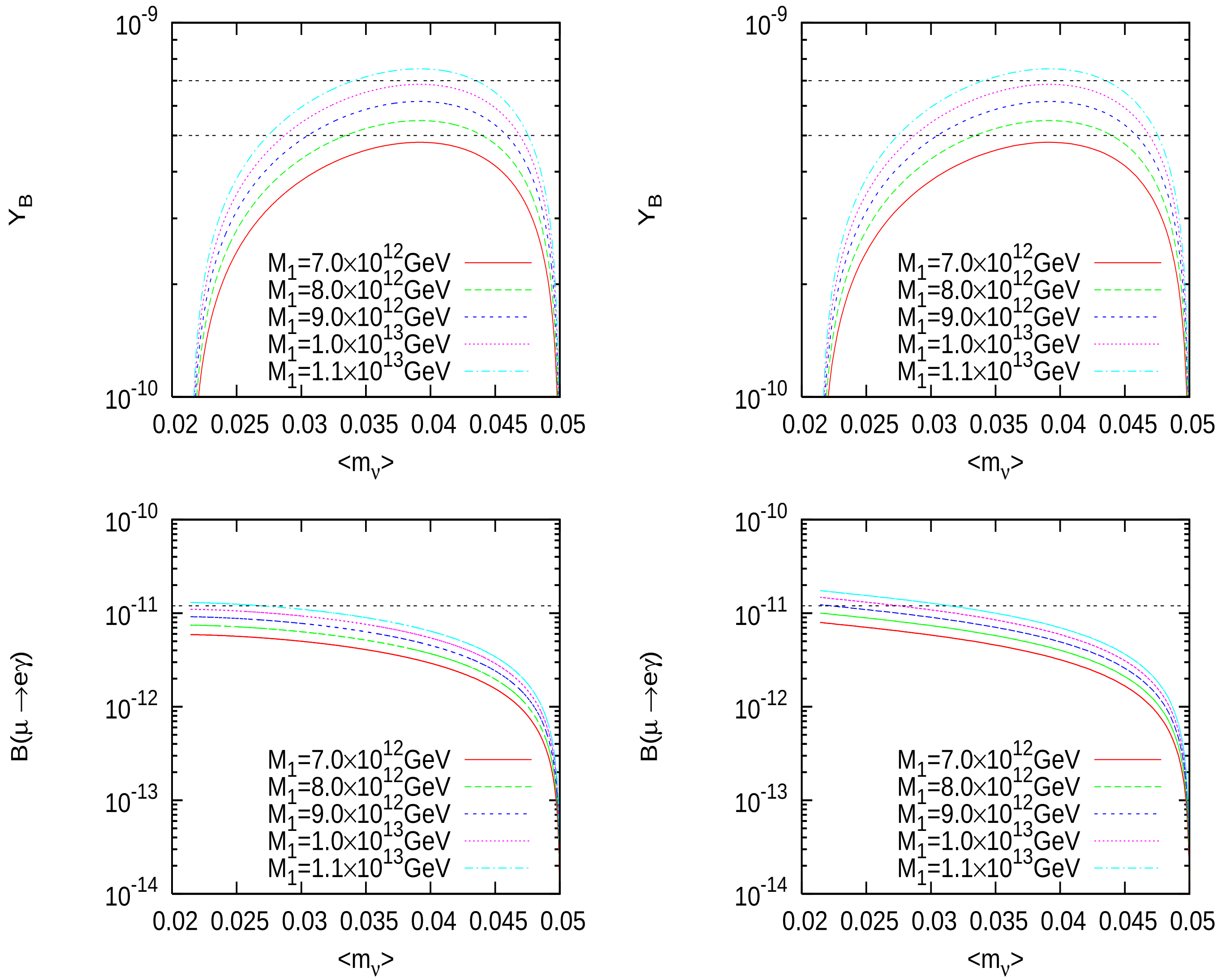
$(Y_\nu)_{22} \approx 0$

Figure 4: B($\mu \to e\gamma$) for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. The Dirac CP phase is taken as $\delta = 0$ and the SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



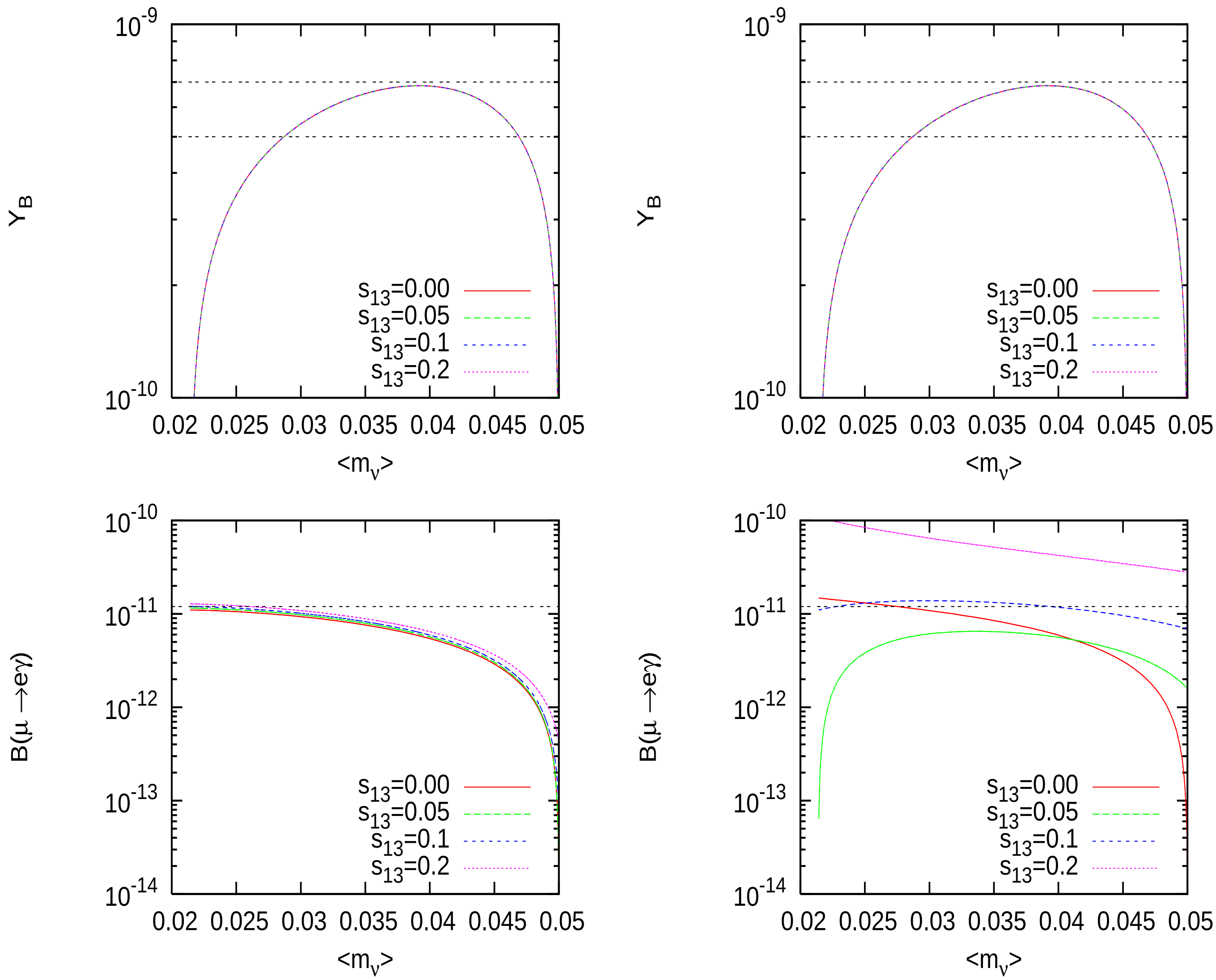
$(Y_\nu)_{21} = 0$ $\qquad$ $(Y_\nu)_{22} \approx 0$

Figure 5: $\mathrm{B}(\mu \to e\gamma)$ for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. $|s_{13}| = 0.1$ is considered and the SUSY parameters are taken as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



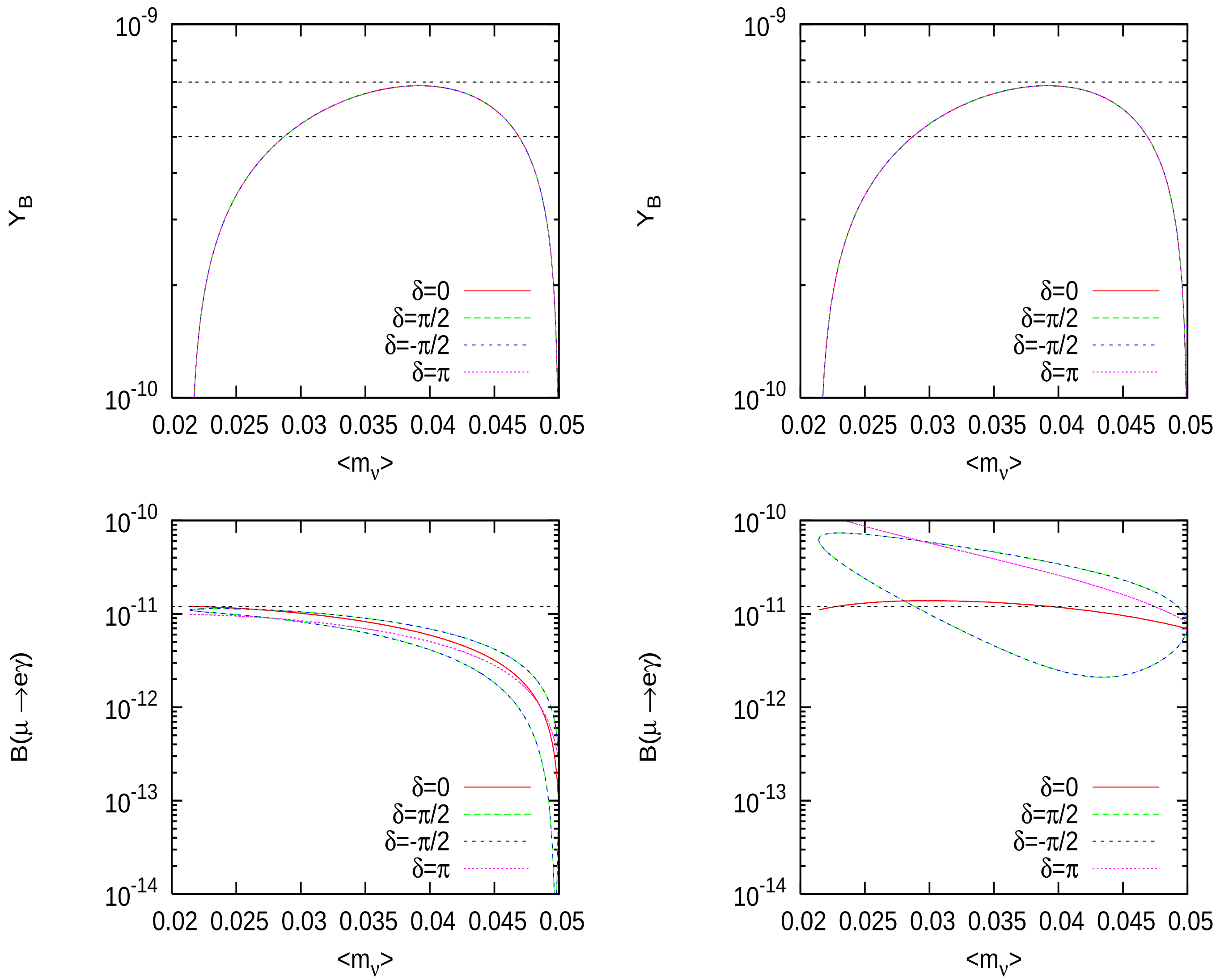
$(Y_\nu)_{21} = 0$ $(Y_\nu)_{22} \approx 0$

Figure 6: Predicted values of Y_B and $\mathrm{B}(\mu \to e\gamma)$ for $s_{13} = 0$. The SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



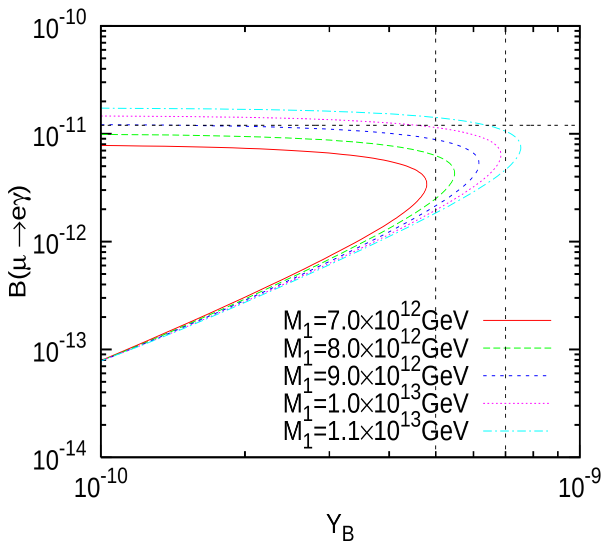
$(Y_\nu)_{21} = 0$ $(Y_\nu)_{22} \approx 0$

Figure 7: Y_B and B($\mu \to e\gamma$) for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. The Dirac CP phase is fixed as $\delta = 0$. The fixed SUSY parameters are considered: $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



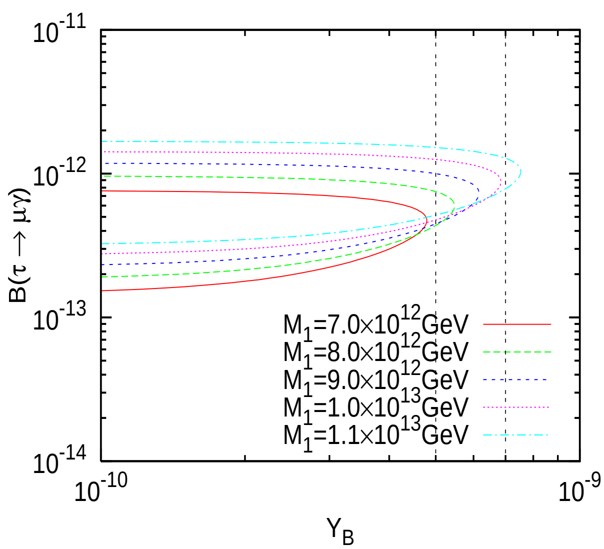
$(Y_\nu)_{21} = 0$ $(Y_\nu)_{22} \approx 0$

Figure 8: Y_B and B($\mu \to e\gamma$) for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. $|s_{13}| = 0.1$ is taken and the SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



$(Y_\nu)_{22} = 0$

Figure 9: B($\mu \to e\gamma$) for $s_{13} = 0$ as a function of Y_B. The SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



$(Y_\nu)_{22} = 0$

Figure 10: B($\tau \to \mu\gamma$) for $s_{13} = 0$ as a function of Y_B. The mass of next lightest heavy neutrino is taken as $M_2/M_1 = 10$, and the SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.

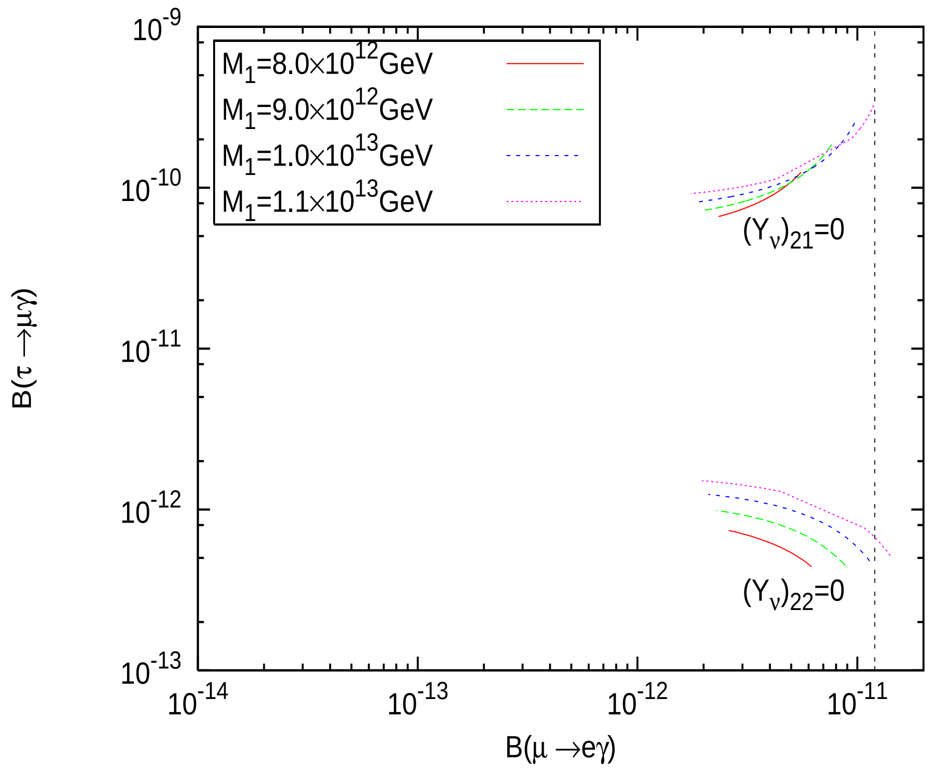
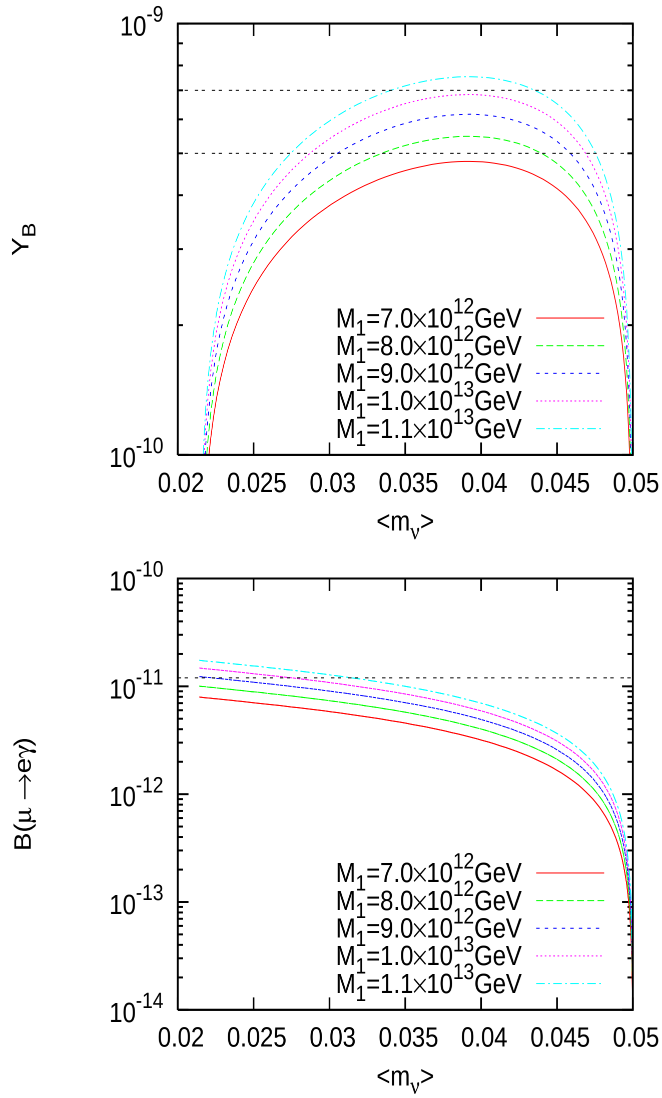


Figure 11: The correlation between $\mu \to e\gamma$ and $\tau \to \mu\gamma$. $M_2/M_1 = 10$, $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$ are taken. The constraint on Y_B, $5.0 \times 10^{-10} \leq Y_B \leq 7.0 \times 10^{-10}$ is taken into account.



$(Y_\nu)_{22} = 0$

Figure 12: Predicted values of Y_B and $\mathrm{B}(\mu \to e\gamma)$ for $s_{13} = 0$. The SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.

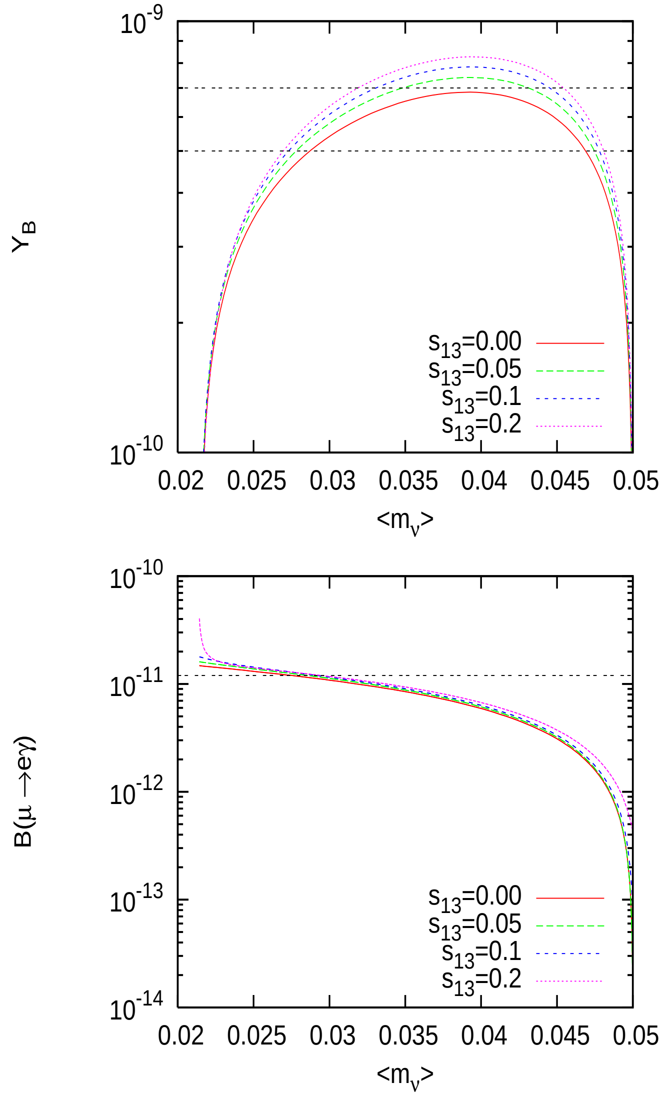
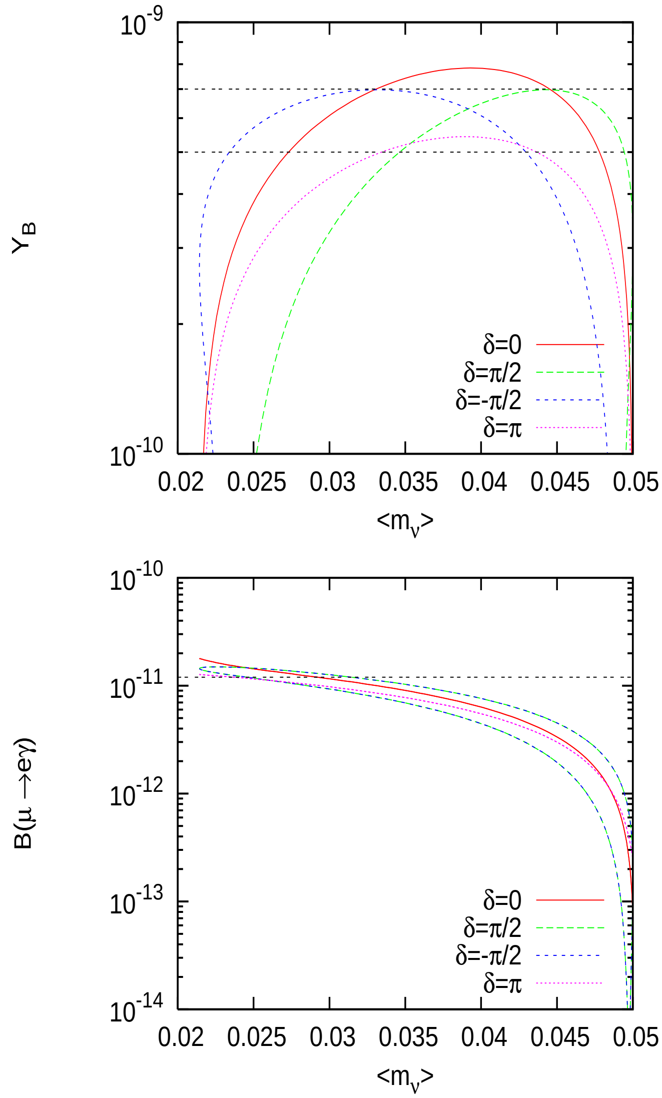


Figure 13: Y_B and $\mathrm{B}(\mu \to e\gamma)$ for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. The Dirac CP phase is fixed as $\delta = 0$. The fixed SUSY parameters are considered: $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.



$(Y_\nu)_{22} = 0$

Figure 14: Y_B and B($\mu \to e\gamma$) for $M_1 = 1.0 \times 10^{13}$GeV and $M_2/M_1 = 10$. $|s_{13}| = 0.1$ is taken and the SUSY parameters are fixed as $m_0 = m_{1/2} = 450$, $A_0 = 0$, and $\tan\beta = 5$.