WMAP constraints on Dark Matter and Yukawa unification with massive neutrinos

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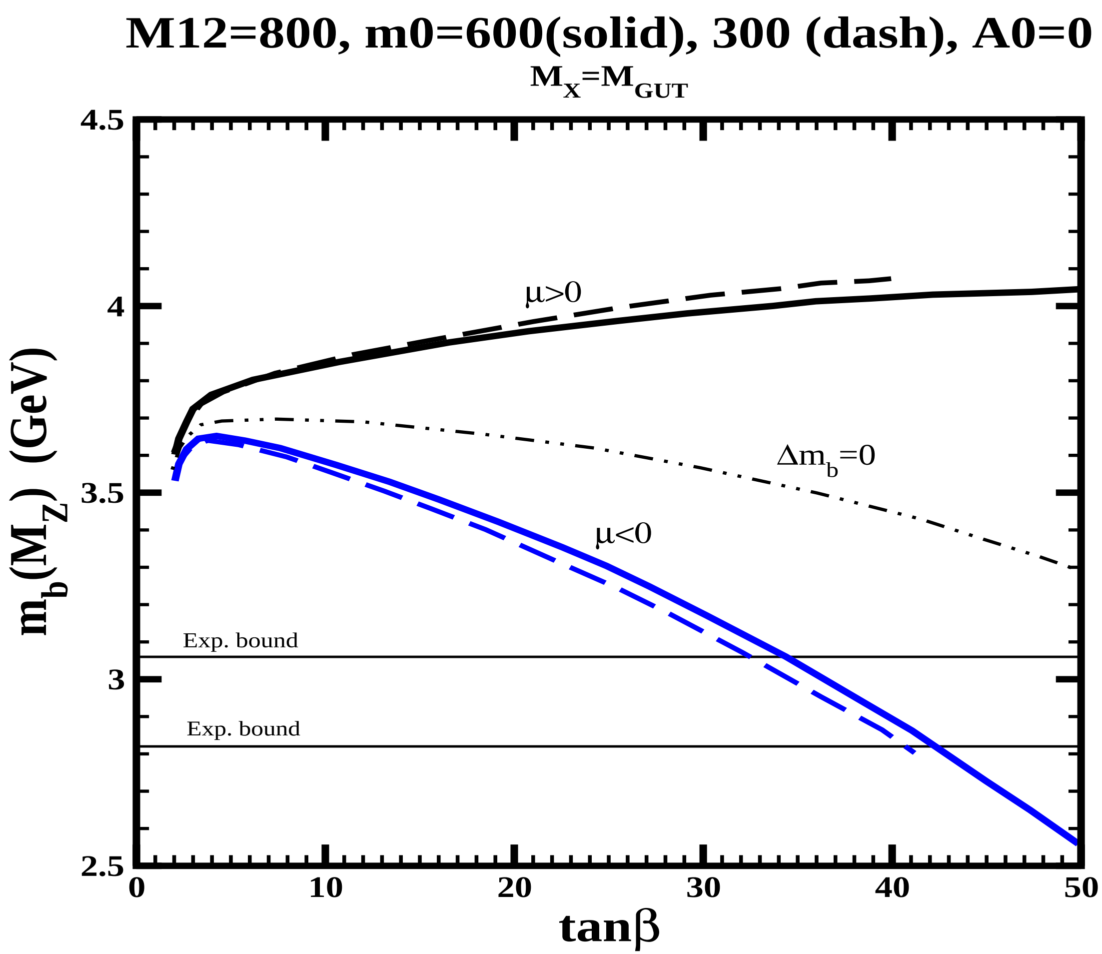
Summary

- SUSY $SU(5)$ and the m_b
- Massive neutrinos
- SUSY $SU(5)$ with massive neutrinos
  1. b mass
  2. Dark Matter
- Conclusions

$b - \tau$ unification and m_b

With no lepton mixing ($m_\nu = 0$)



NEUTRINO FLAVOUR OSCILLATION

- Neutrino data: By now convincing for $m_\nu \neq 0$ and physics beyond SM
- What do we know?

Atmospheric problem	Solar problem
$\Delta m^2_{atm} = \left(2.6^{+0.4}_{-0.7}\right) \times 10^{-3}$ eV^2	$\Delta m^2_{sol} = \left(8.1^{+0.5}_{-0.5}\right) \times 10^{-5}$ eV^2
$\sin^2 2\theta_{atm} > 0.90$	$\sin^2 2\theta_{sol} = \left(0.86^{+0.05}_{-0.06}\right)$

- Questions:
  1. How do massive neutrinos affect Yukawa unification? Do they alter the predictions for the bottom mass?
  2. What are the implications for DM?

Neutrino mass effects

RGE: $M_X \longrightarrow M_R$

$$16\pi^2 \frac{d}{dt}\lambda_t = \left(6\lambda_t^2 + \lambda_N^2 - G_U\right)\lambda_t$$

$$16\pi^2 \frac{d}{dt}\lambda_N = \left(4\lambda_N^2 + 3\lambda_t^2 - G_N\right)\lambda_N$$

$$16\pi^2 \frac{d}{dt}\lambda_b = \left(\lambda_t^2 - G_D\right)\lambda_b$$

$$16\pi^2 \frac{d}{dt}\lambda_\tau = \left(\lambda_N^2 - G_E\right)\lambda_\tau$$

SU(5) GUTs

- SUSY $SU(5)$ RH superpotential

$$\mathcal{W}_X = T^T \lambda_u T H + T^T \lambda_d \bar{F} \bar{H} + \bar{F}^T \lambda_\nu S H + S^T M_R S$$

- With the matter content: $\bar{F}$=5=$(D_R^c,\ L)$, T=10=(Q, U_R^c, E_R^c).

Yukawa textures in some basis:

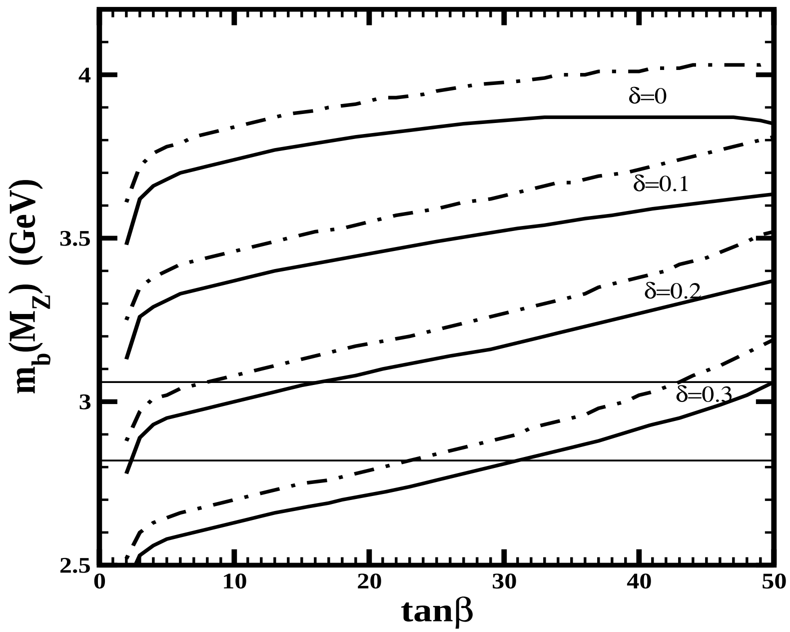
$$m_\ell^0 = m_0 \begin{pmatrix} 0 & x \\ 0 & 1 \end{pmatrix}, \quad m_{\rm D}^0 = m_0 \begin{pmatrix} 0 & 0 \\ x & 1 \end{pmatrix}$$

The unification condition

$$\frac{m_b^0}{1+x^2} = \frac{m_\tau^0}{1-x^2} \rightarrow m_b^0 = m_\tau^0 \left(1 - \underbrace{2x^2}_{\delta} + O(\delta^2) \right)$$

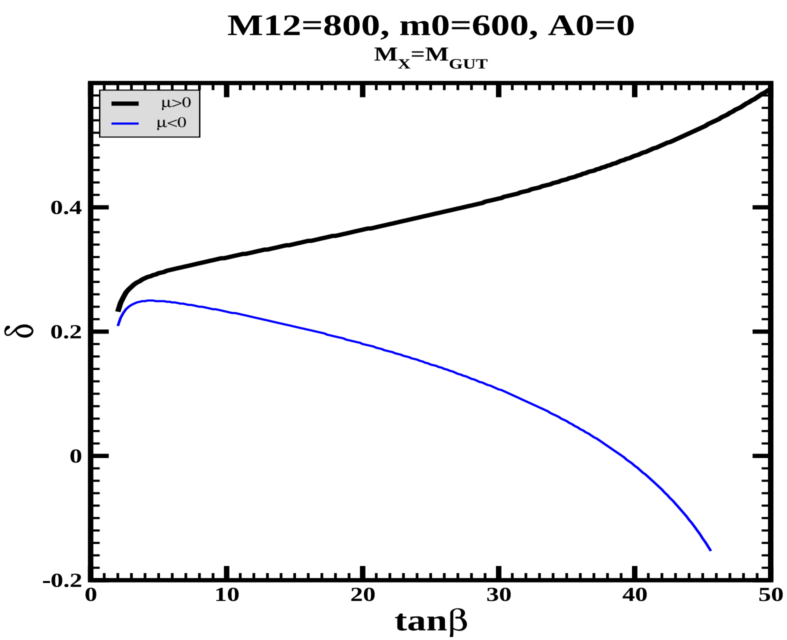
Lepton Mixing Effects

Considering lepton mixing ($\delta \neq 0$), $b - \tau$ unification possible for both signs of μ and a large range of $tan\beta$



Bottom mass in terms of tanβ for different values of δ.

The value of δ computed for the experimental central value of m_b in terms of tanβ.



SU(5) RGE effects

The running of the soft terms from a higher scale (M_X) to M_{GUT} introduce non universalities on the soft terms :

- $M_x \longrightarrow M_{GUT}$

$$W_{\mathrm{SU(5)}} \;=\; \frac{1}{4}\, f_u^{ij}\; 10_i\; 10_j\; H + \sqrt{2}\, f_d^{ij}\; 10_i\; \overline{5}_j\; \overline{H} + f_\nu^{ij}\; 1_i\; \overline{5}_j\; H$$

$$f_u^{ij} = f_u^{\delta},$$

$$f_d^{ij} = V_{CKM}^{*}\, \lambda_d^{\delta}\, V_{KM}^{\dagger}$$

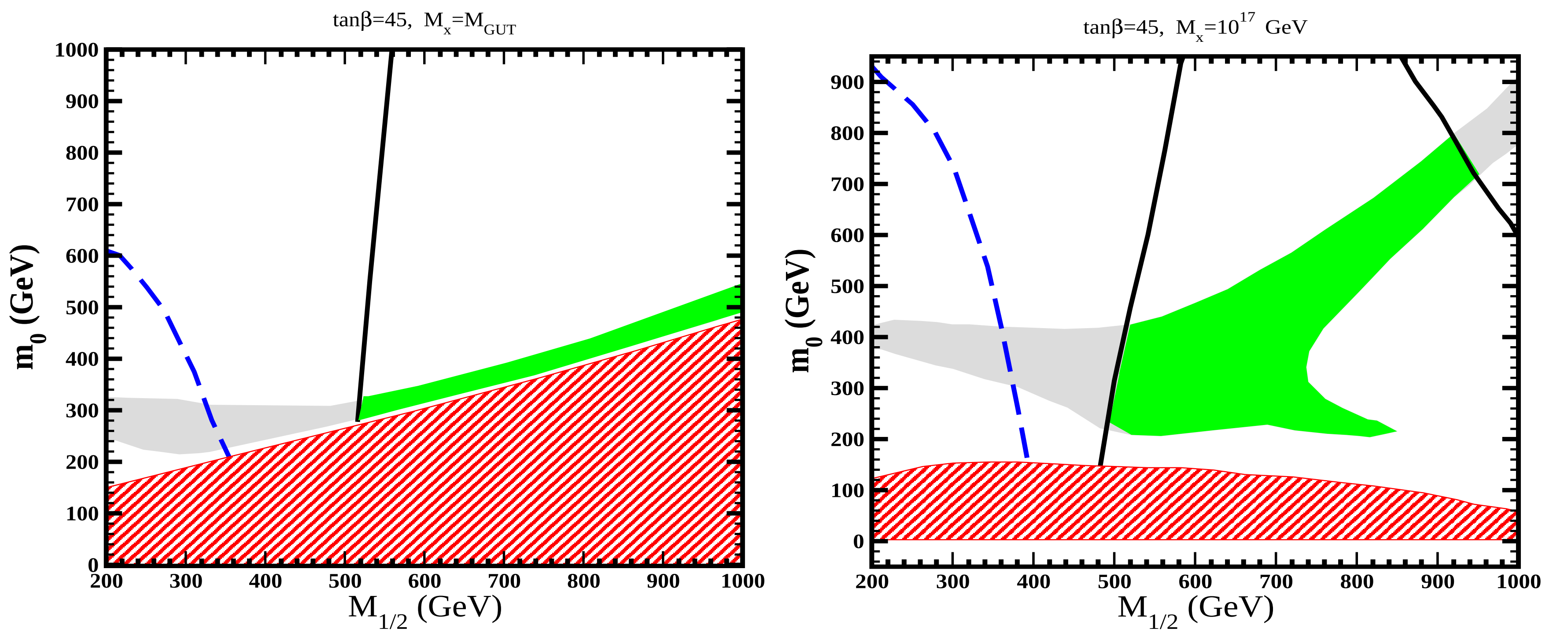
The soft terms:

$$m_{10}\; \widetilde{10} * \widetilde{10} + m_5\; \widetilde{5} * \widetilde{5}\; + \;\cdots$$

$$\widetilde{\ell}_R \text{ in } 10's \longrightarrow m^2_{\widetilde{\ell}_R} = V_{\mathrm{CKM}}^{\dagger}\, m_{10}^2\, V_{\mathrm{CKM}}$$

WMAP and Dark Matter constraints

$$\mu > 0, A_0 = 0$$



WMAP and Dark Matter constraints

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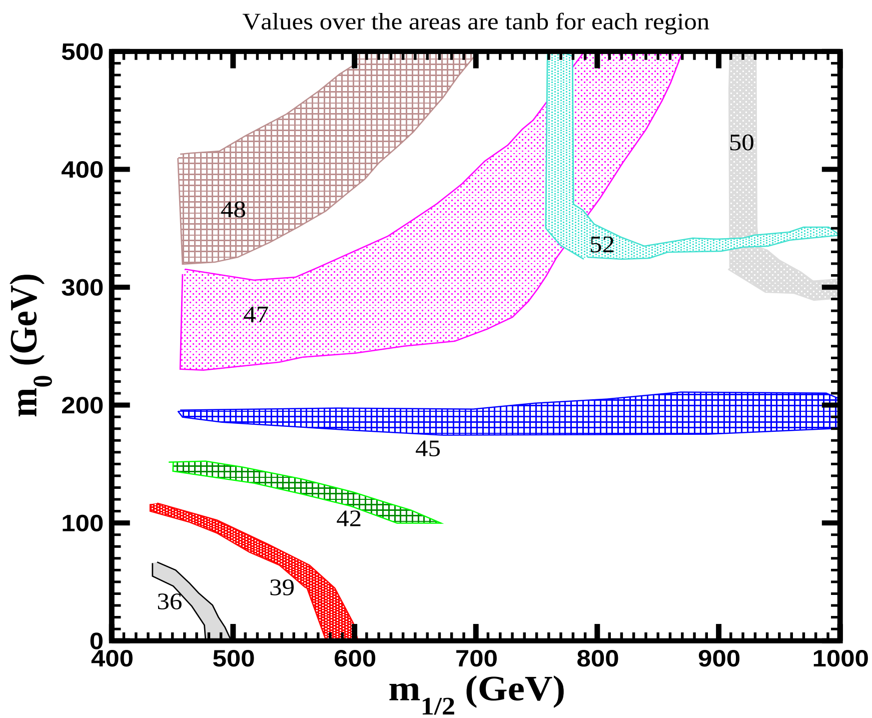

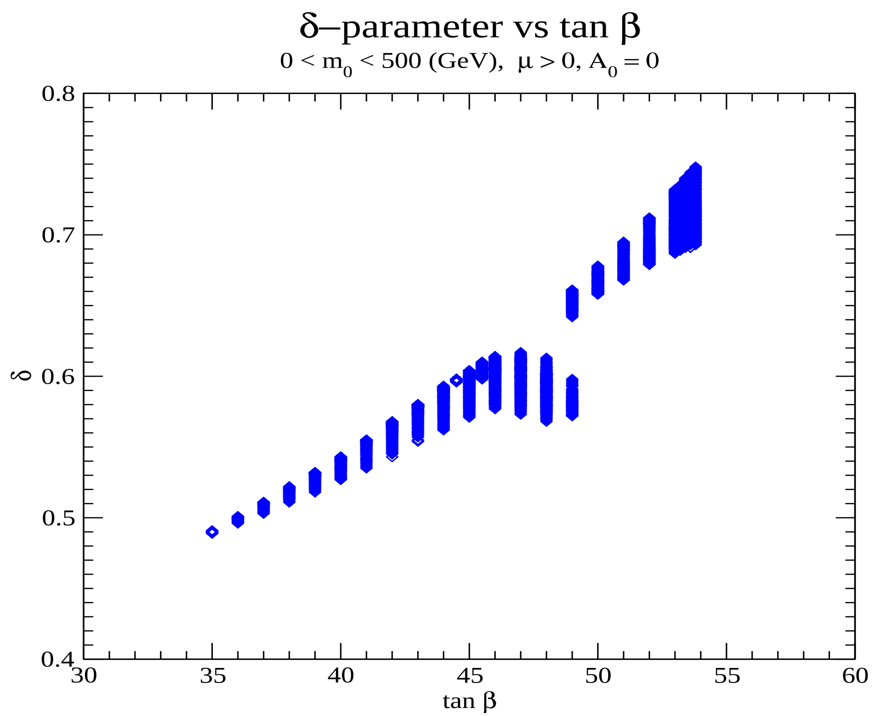

Conclusions

- To explain neutrino data we need large lepton mixing, which also affects Yukawa unification.
- The assumption of a sizeable 2-3 flavour mixing in the lepton sector
  1. allows unification for $\mu > 0$
  2. enhances the allowed range of $\tan\beta$ where $y_b - y_\tau$ unification is possible.
- Using Yukawa textures in SU(5), compatible with neutrino data, we study the WMAP favoured parameter space.