natural 125 GeV Higgs boson in deflected mirage mediation

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1.Introduction

recent experiments and naturalness

- discovery of a Higgs boson with mass 125GeV

  heavy top squark or **large A-term of top squark**

- naturalness suggests small μ, m_{h_u}

successful EWSB condition

$$m_Z^2 \sim -2|\mu|^2 - 2m_{h_u}^2$$

How to induce small μ and large A-term ?

→ **large wino mass** at the GUT scale [1]

- RG running induces both of them
- mirage mediation leads large wino mass
- some UV models induce gauge mediation

2.deflected mirage mediation (DMM)

- **mixed** modulus / anomaly / gauge mediation[2]
- can solve or ameliorate **little hierarchy** (e.g. TeV mirage[3])
- **landscape** of mediation mechanism

GUT

soft parameters

$$M_a(M_{\rm GUT}) = m_0\left[1+\frac{g_0^2}{16\pi^2}b'_a\alpha_m\ln\frac{M_p}{m_{3/2}}\right]$$

$$a^{ijk}(M_{\rm GUT}) = m_0\left[(3-n_i-n_j-n_k)-\frac{1}{16\pi^2}\left[y^{ljk}\gamma_l{}^i+{\rm cyclic}\right]\alpha_m\ln\frac{M_p}{m_{3/2}}\right]$$

$$m^2{}_i{}^j(M_{\rm GUT}) = {m_0}^2\left[(1-n_i)\delta_i{}^j-\frac{2\theta_i{}^j}{16\pi^2}\alpha_m\ln\frac{M_p}{m_{3/2}}-\frac{\dot\gamma_i^j}{(16\pi^2)^2}\left(\alpha_m\ln\frac{M_p}{m_{3/2}}\right)^2\right]$$

Mess $W_{\rm GMSB} = W_1(X) + X\Psi\overline{\Psi}$ causes gauge mediation $\Psi, \overline{\Psi}: \ 5, \bar5$ of SU(5)

$$\Delta M_a(M_{\rm mess}) = -m_0 N_{\rm mess}\frac{g_a^2(M_{\rm mess})}{16\pi^2}\alpha_m(1+\alpha_g)\ln\frac{M_p}{m_{3/2}}$$

$$\Delta m^2{}_i{}^j(M_{\rm mess}) = {m_0}^2\sum_a 2c_a(\Phi_i)N_{\rm mess}\frac{g_a^4(M_{\rm mess})}{(16\pi^2)^2}\left[\alpha_m(1+\alpha_g)\ln\frac{M_p}{m_{3/2}}\right]^2\delta_i{}^j$$

EW

3.Higgs naturalness in DMM

mediation parameters

$m_0 \cdots$ size of moduli mediation

$\alpha_m \cdots$ anomaly/moduli

$\alpha_g \cdots$ gauge/anomaly

$\tan\beta = 15$

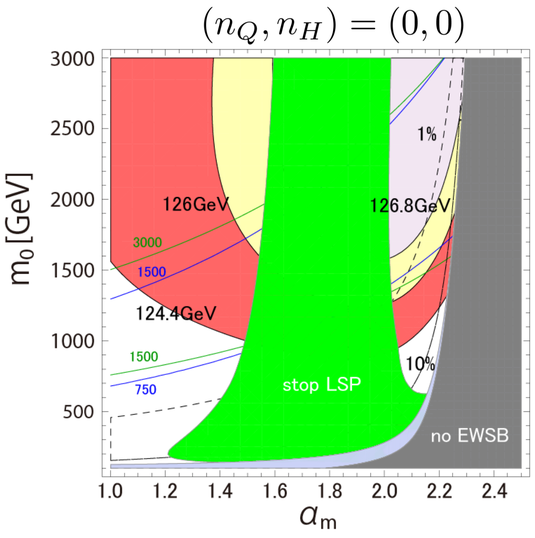
$n_Q, n_H \cdots$ modular weights

$N_{\rm mess} \cdots \sharp$ of messenger pairs

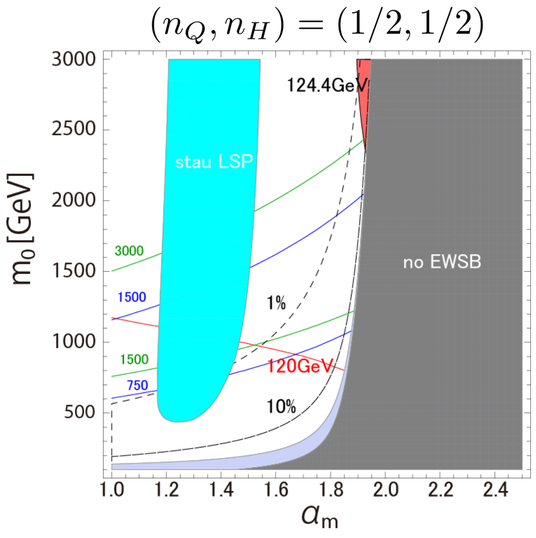
$M_{\rm mess} \cdots$ messenger scale

3.1 pure mirage mediation ($N_{\rm mess} = 0$)

$(n_Q, n_H) = (0,0)$



$(n_Q, n_H) = (1/2, 1/2)$



$\alpha_m \sim 2$

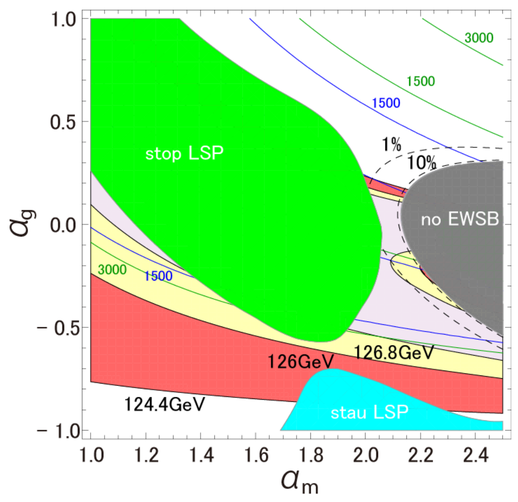
$m_0 \gtrsim 1.5{\rm TeV}$ →

degree of tuning can be relaxed above 10%

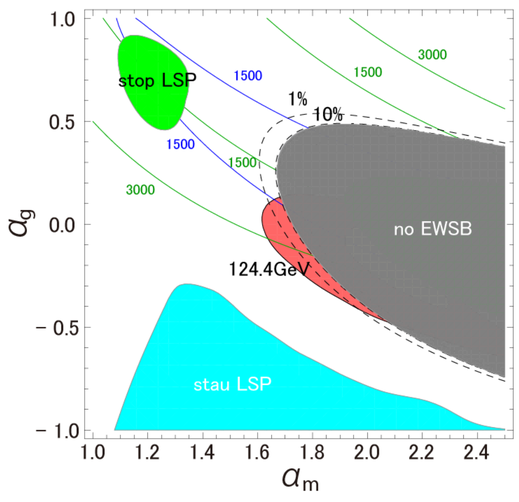
$m_h \sim 125{\rm GeV},\ m_{\tilde g} \gtrsim 1.5{\rm TeV},\ m_{\tilde t_1} \gtrsim 0.7{\rm TeV}$ (left)

3.2 deflected mirage mediation ($M_{\rm mess} = 10^{12}{\rm GeV}, N_{\rm mess} = 3$)

$m_0 = 2.0{\rm TeV},\ (n_Q, n_H) = (0,0)$



$m_0 = 3.0{\rm TeV},\ (n_Q, n_H) = (1/2, 1/2)$



$\alpha_m \sim 2, 0 \gtrsim \alpha_g \gtrsim -0.5$

appropriate α_g →

degree of tuning can be relaxed above 10%

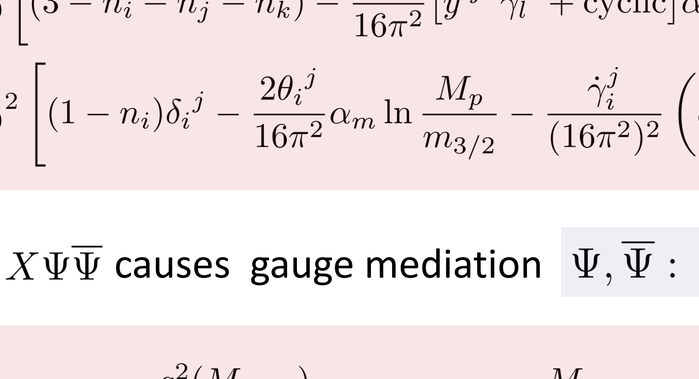
can slightly enhance the Higgs boson mass

4. typical natural mass spectrum

naturalness expects specific mass spectrum

α_m small ↓ large

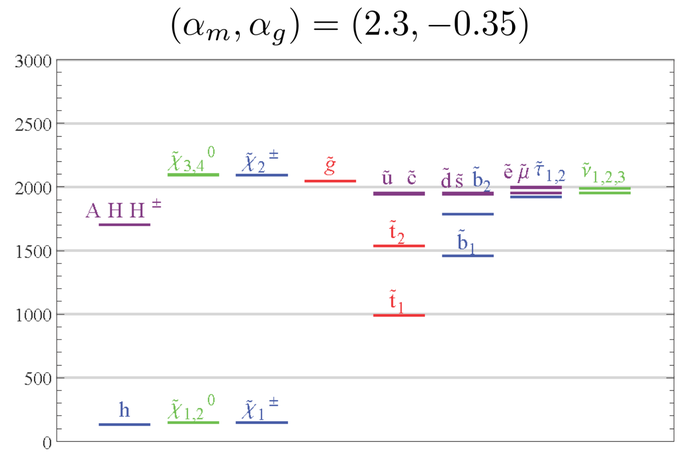
$(\alpha_m, \alpha_g) = (1.9, -0.3)$



$m_0 = 3.0{\rm TeV}$

$n_Q = n_H = 1/2$

$(\alpha_m, \alpha_g) = (2.3, -0.35)$



$m_0 = 2.0{\rm TeV}$

$n_Q = n_H = 0$

- LSP is **higgsino-like** neutralino, **top squarks** are always light
- squark and slepton masses depend on gaugino masses

5. conclusion and discussion

- naturalness needs **comparable** mixed mediation
- 125GeV Higgs boson and relaxed tuning are **compatible**
- naturalness **predicts** the specific mass spectrum

[1] H.Abe, J.K and H. Otsuka, PTEP 2013, 013B02 (2013).
[2] L.L.Everett, I.W.Kim, P.Outang and K.M.Zurek, JHEP0808, 102 (2008).
[3] K.Choi, K.S.Jeong, T.Kobayashi and K.Okumura, PRD 75, 095012 (2007).