Nonstandard Higgs decays in the E_6SSM

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Outline

- Introduction
- Exceptional SUSY model
- Inert charginos and neutralinos
- Exotic Higgs decays
- Conclusions

Based on:

J. Hall, S. F. King, R. Nevzorov, S. Pakvasa and M. Sher, in preparation;
S. F. King, S. Moretti and R. Nevzorov, Phys. Lett. B 650 (2007) 57;
S. F. King, S. Moretti and R. Nevzorov, Phys. Rev. D 73 (2006) 035009;
S. F. King, S. Moretti and R. Nevzorov, Phys. Lett. B 634 (2006) 278.

Introduction

- SUSY leads to a partial unification of the SM gauge interactions with gravity within SUGRA models.
- But MSSM being incorporated in supergravity or GUTs suffers from the μ problem. Indeed

$$W_{SUGRA} \simeq W_0(h_m) + \mu(h_m)(\hat{H}_d \hat{H}_u) + h_t(\hat{Q}\hat{H}_u)\hat{u}^c + h_b(\hat{Q}\hat{H}_d)\hat{d}^c + ...,$$

where $\mu(h_m) \sim M_{Pl}$ or $\mu(h_m) = 0$.

- The correct pattern of EW symmetry breaking requires

$$\mu(h_m) \sim 100 - 1000\,\text{GeV}\,.$$

- In the superstring inspired E_6 models gauge symmetry forbids any bilinear terms in W allowing interaction

$$W_{E_6} = \lambda \hat{S}(\hat{H}_d \hat{H}_u) + \ldots\,.$$

- At high energies E_6 may be broken to

$$E_6 \to SU(3)_C \times SU(2)_W \times U(1)_Y \times U(1)' \,,$$

$$U(1)' = U(1)_\chi \cos\theta + U(1)_\psi \sin\theta \,,$$

where $E_6 \to SO(10) \times U(1)_\psi, \quad SO(10) \to SU(5) \times U(1)_\chi.$

- $\theta = \arctan\sqrt{15}$ corresponds to $U(1)_N$ symmetry under which right-handed neutrinos have zero charge.
- Only in this exceptional SUSY model (E_6SSM) right–handed neutrino may be superheavy shedding light on the origin of lepton mass hierarchy.
- At the EW scale field S acquires VEV breaking $U(1)_N$ and providing natural solution of the μ–problem

$$\mu_{eff} = \lambda < S > \ .$$

Exceptional SUSY model

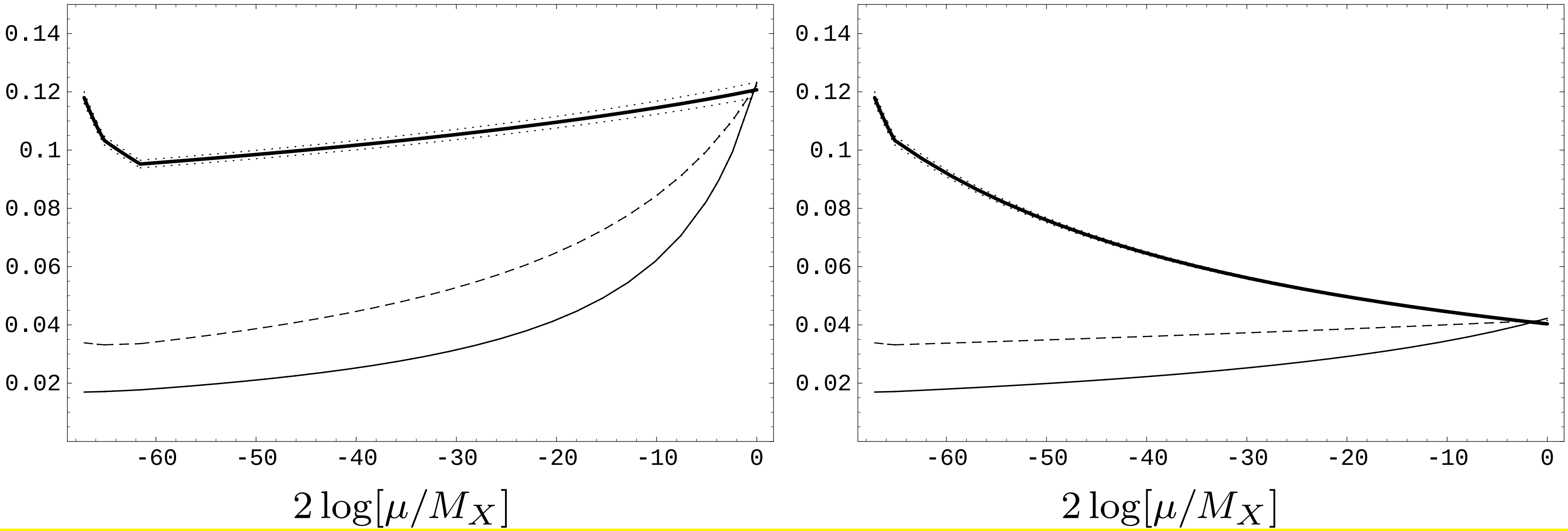
- To ensure anomaly cancellation the particle content of the E$_6$SSM is extended to include three complete 27_i representations of E_6.
- In addition the spectrum of the E$_6$SSM is supplemented by $SU(2)$ doublet and anti-doublet from extra $27'$ and $\overline{27'}$ (L_4 and $\overline{L}_4$) to preserve gauge coupling unification in the one–loop approximation.
- Together with survivors the particle content of the E$_6$SSM becomes

$$3\times 27_i + L_4 + \overline{L}_4 = 3\Big[Q_i,\, u^c_i,\, d^c_i,\, L_i,\, e^c_i\Big] + 3(D_i,\, \overline{D}_i) +$$
$$+3(H^u_i) + 3(H^d_i) + 3(S_i) + 3(N^c_i) + L_4 + \overline{L}_4\,.$$

  - D_i and $\overline{D}_i$ are exotic quarks.
  - H^d_i and H^u_i are either Higgs or inert Higgs fields.

- In the E_6SSM two–loop corrections to $\alpha_i(\mu)$ are large and could spoil gauge coupling unification.
- However it was argued that within the E_6SSM gauge coupling unification can be achieved for any value of $\alpha_3(M_Z)$ which is in agreement with current data [S.F.King, S.Moretti, RN, Phys.Lett.B 650 (2007) 57].

Two–loop RG flow of $\alpha_i(\mu)$ in the E_6SSM and MSSM



- To prevent rapid proton decay the invariance under some discrete symmetry should be imposed.
- To suppress baryon number violating and flavour changing processes one can postulate Z_2^H symmetry under which all superfields except $H_d \equiv H_{1,3}$, $H_u \equiv H_{2,3}$ and $S \equiv S_3$ are odd.
- The Z_2^H symmetry reduces the structure of Yukawa interactions to:

$$W_{\mathrm{E_6SSM}} \simeq \lambda\hat{S}(\hat{H}_u\hat{H}_d) + \lambda_{\alpha\beta}\hat{S}(\hat{H}^d_\alpha\hat{H}^u_\beta) + \kappa_i\hat{S}(\hat{D}_i\hat{\overline{D}}_i) + f_{\alpha\beta}\hat{S}_\alpha(\hat{H}_d\hat{H}^u_\beta$$

$$+\tilde{f}_{\alpha\beta}\hat{S}_\alpha(\hat{H}^d_\beta\hat{H}_u) + h^E_{4j}(\hat{H}_d\hat{L}_4)\hat{e}^c_j + \mu'(\hat{L}_4\hat{\overline{L}}_4) + \frac{1}{2}M_{ij}\hat{N}^c_i\hat{N}^c_j$$

$$+h_{4j}(\hat{H}_u\hat{L}_4)\hat{N}^c_j + h_{ij}(\hat{H}_u\hat{L}_i)\hat{N}^c_j + W_{MSSM}(\mu = 0)\,,$$

where $\alpha, \beta = 1, 2$ and $i = 1, 2, 3$.

  - $\hat{H}_u$, $\hat{H}_d$ and $\hat{S}$ play the role of Higgs superfields.

- At the physical vacuum $\langle H_d\rangle = \frac{v_1}{\sqrt{2}}$, $\langle H_u\rangle = \frac{v_2}{\sqrt{2}}$, $\langle S\rangle = \frac{s}{\sqrt{2}}$, where $v^2 = v_1^2 + v_2^2 = (246\, GeV)^2$ and $\tan\beta = v_2/v_1$.
- At the tree level CP is preserved in the Higgs sector of the E$_6$SSM so that the Higgs spectrum contains
  - one pseudoscalar m_A^2 ,
  - two charged states $m_{H^\pm}^2 = m_A^2 + O(M_Z^2)$,
  - three scalars $m_{h_3}^2 = m_A^2 + O(M_Z^2)$, $m_{h_2}^2 = M_{Z'}^2 + O(M_Z^2)$.
- The upper limit on the lightest Higgs mass m_{h_1} in the E$_6$SSM is considerably larger than in the MSSM and NMSSM.
- In the two–loop approximation the upper bound on m_{h_1} does not exceed $150 - 155$ GeV.

- The Z_2^H symmetry can only be approximate since it ensures that the lightest exotic quark is stable.
  - If D–quarks were stable they would be confined in heavy hadrons which relative concentrations would be 10^{-10} per nucleon.
  - The experimental limits on the abundances of such stable relics vary from 10^{-15} to 10^{-30} per nucleon [T.K. Hemmick et al., Phys.Rev.D 41 (1990) 2074.]
- There are two different ways to impose an appropriate Z_2 symmetry leading to the baryon and lepton number conservation which imply

– exotic quarks are diquarks, i.e. $B_{D,\overline{D}} = \mp 2/3$;

– exotic quarks are leptoquarks, i.e. $B_{D,\overline{D}} = \pm 1/3,\ L_{D,\overline{D}} = \pm 1$.

- The terms which allow D and $\overline{D}$ to decay are given by

$$W_1 = g^{Q}_{ijk} D_i (Q_j Q_k) + g^{q}_{ijk} \overline{D}_i d^c_j u^c_k \, .$$

if exotic quarks are diquarks and

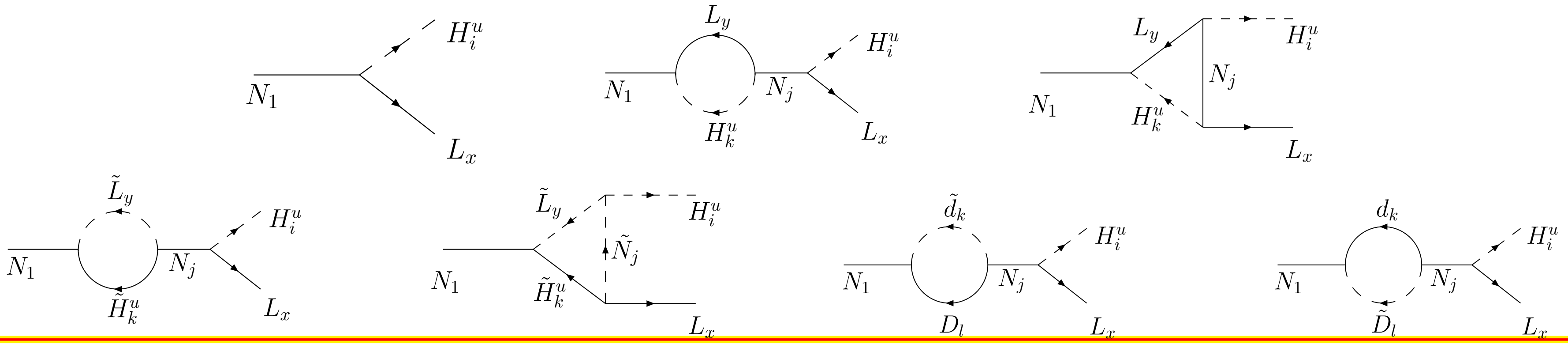
$$W_2 = g^{E}_{ijk} e^c_i D_j u^c_k + g^{D}_{ijk} (Q_i L_j) \overline{D}_k \, ,$$

if exotic quarks are leptoquarks.

- Since Z_2^H symmetry violating operators give rise to FCNC processes ($K^0 - \overline{K}^0$ oscillations, $\mu \to e^- e^+ e^-$ and etc.) the corresponding Yukawa couplings are expected to be small ($\lesssim 10^{-4} - 10^{-3}$).
- In the E$_6$SSM lepton asymmetry can be dynamically generated via the decay of N_1^c and then gets converted into baryon asymmetry due to sphaleron interactions.

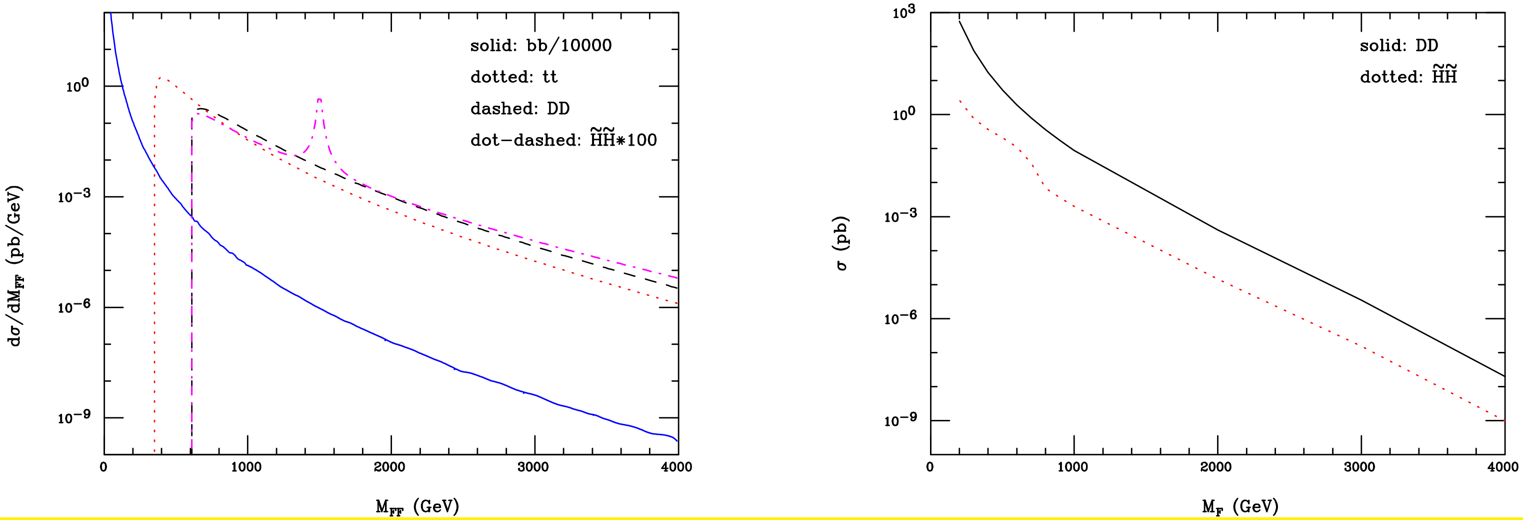
- New exotic particles predicted by the E_6SSM contribute to the generation of lepton asymmetry.
- In the E_6SSM the substantial lepton CP asymmetries can be induced even for $M_1 \simeq 10^6$ GeV that may allow to avoid gravitino problem [S.King,R.Luo,D.Miller,RN, JHEP 12 (2008) 042].
- New particles may be produced at future colliders.
- At the LHC the Z' boson can be discovered if it has a mass below $4 - 4.5$ TeV [A.Leike, Phys.Rept. 317 (1999) 143; J.Kang, P.Langacker, Phys.Rev.D 71 (2005) 035014].

Diagrams that contribute to the generation of lepton asymmetry



- If exotic quarks are light their production cross section at the LHC can be comparable with $\sigma(pp \to t\bar{t} + X)$.
- Assuming that D and $\overline{D}$ couple most strongly with the third family quarks and leptons light exotic quark will result in the enhancement of the cross sections of
  - $pp \to t\bar{t}b\bar{b} + E_T^{miss} + X$ if exotic quarks are diquarks;
  - $pp \to t\bar{t}l\bar{l} + E_T^{miss} + X$ if new quark states are leptoquarks.

Cross sections for pair production of exotic particles at the LHC



Inert charginos and neutralinos

- In our analysis we assume that Z_2^H symmetry violating couplings are small and can be neglected so that neutralino and Inert neutralino states as well as chargino and Inert chargino states do not mix.
- In the field basis $(\tilde{H}_2^{d0},\, \tilde{H}_2^{u0},\, \tilde{S}_2,\, \tilde{H}_1^{d0},\, \tilde{H}_1^{u0},\, \tilde{S}_1)$ the mass matrix of the Inert neutralino sector takes a form

$$M_{IN} = \begin{pmatrix} A_{22} & A_{21} \\ A_{12} & A_{11} \end{pmatrix} ,$$

$$A_{\alpha\beta} = -\frac{1}{\sqrt{2}} \begin{pmatrix} 0 & \lambda_{\alpha\beta} s & \tilde{f}_{\beta\alpha} v \sin\beta \\ \lambda_{\beta\alpha} s & 0 & f_{\beta\alpha} v \cos\beta \\ \tilde{f}_{\alpha\beta} v \sin\beta & f_{\alpha\beta} v \cos\beta & 0 \end{pmatrix} ,$$

- In the basis of Inert chargino interaction states $(\tilde{H}_2^{u+},\, \tilde{H}_1^{u+},\, \tilde{H}_2^{d-},\, \tilde{H}_1^{d-})$ the corresponding mass matrix is given by

$$M_{IC} = \begin{pmatrix} 0 & C^T \\ C & 0 \end{pmatrix}, \qquad C_{\alpha\beta} = \frac{1}{\sqrt{2}}\lambda_{\alpha\beta}\, s\,.$$

- We require
  - all Inert charginos to be heavier than 100 GeV to satisfy LEP constraints;
  - s to be large enough to avoid lower experimental bound on $M_{Z'} \gtrsim 860$ GeV ($s \gtrsim 2400$ GeV);
  - the validity of perturbation theory up to the GUT scale that constrains the allowed range of all Yukawa couplings.

- Our numerical analysis indicates that
  - the lightest and second lightest Inert neutralinos are always light ($m_{\chi_1,\chi_2} \lesssim 60-65\,$GeV);
  - two lightest Inert neutralinos are predominantly Inert singlinos;
  - four other Inert neutralinos, which are basically linear superpositions of neutral components of Inert Higgsinos, are normally heavier than $100\,$GeV;
  - the lightest and second lightest Inert neutralinos may have rather small couplings to Z-boson so that they could escape detection at LEP;
  - the couplings of the two lightest Inert neutralinos to the SM-like Higgs boson are always large if they have appreciable masses.

- In order to clarify the obtained results let us consider a simple scenario when

$$\lambda_{\alpha\beta} = \lambda_\alpha\,\delta_{\alpha\beta}\,, \qquad f_{\alpha\beta} = f_\alpha\,\delta_{\alpha\beta}\,, \qquad \tilde{f}_{\alpha\beta} = \tilde{f}_\alpha\,\delta_{\alpha\beta}\,.$$

- In the considered case the mass matrix of Inert neutralinos becomes block diagonal while the masses of the Inert charginos are given by

$$m_{\chi^\pm_\alpha} = \frac{\lambda_\alpha}{\sqrt{2}}\,s\,.$$

- In the limit when $\lambda_\alpha\,s \gg \tilde{f}_\alpha\,v,\; f_\alpha\,v$ the mass matrix of the Inert neutralinos can be approximately diagonalised.
- The masses of four heaviest Inert neutralino states are

$$\left|m_{\chi^\pm_\alpha} - \frac{\tilde{f}_\alpha f_\alpha v^2 \sin 2\beta}{4m_{\chi^\pm_\alpha}}\right|, \qquad \left|-m_{\chi^\pm_\alpha} - \frac{\tilde{f}_\alpha f_\alpha v^2 \sin 2\beta}{4m_{\chi^\pm_\alpha}}\right|.$$

- The masses of four heaviest Inert neutralinos are set by the masses of Inert chargino states.
- The masses of two lightest Inert neutralinos are

$$m_{\chi_\alpha} \approx \frac{\tilde{f}_\alpha f_\alpha v^2 \sin 2\beta}{2m_{\chi^\pm_\alpha}}\,.$$

  - The masses of the lightest Inert neutralino states decrease with increasing $\tan\beta$ and chargino masses.
  - They are determined by the values of the Yukawa couplings $\tilde{f}_\alpha$ and f_α.
  - The requirement of validity of perturbation theory up to the GUT scale sets stringent bounds on $\tilde{f}_\alpha$ and f_α. In the simplest case

$$\tilde{f}_1 = f_1 = \tilde{f}_2 = f_2 < 0.6 - 0.65\,.$$

- Since the masses of the two lightest Inert neutralinos are determined by v the couplings of these states to the SM-like Higgs boson are set by their masses, i.e.

$$g_{h\chi_\alpha\chi_\alpha} \approx m_{\chi_\alpha}/v\,.$$

- The Lagrangian that describes interactions of the Z-boson with χ_1 and χ_2 can be written as

$$L_{Z\chi\chi} = \frac{\bar{g}}{4} Z_\mu \Bigl(\chi_\alpha \gamma_\mu \gamma_5 \chi_\beta \Bigr) R_{Z\alpha\beta}\,,$$

$$R_{Z\alpha\beta} = R_{Z\alpha\alpha}\,\delta_{\alpha\beta}\,, \qquad R_{Z\alpha\alpha} = \frac{v^2}{2m^2_{\chi^\pm_\alpha}} \Bigl(f_\alpha^2 \cos^2\beta - \tilde{f}_\alpha^2 \sin^2\beta \Bigr)\,.$$

  - Couplings $\tilde{f}_\alpha$ and f_α can be chosen so that $R_{Z\alpha\alpha}$ become rather small.
  - $R_{Z\alpha\alpha}$ are always small when Inert charginos are rather heavy or $\tilde{f}_\alpha$ and f_α are small ($m_{\chi_\alpha} \to 0$).

Exotic Higgs decays

- Since in the E_6SSM the lightest Inert neutralino has mass which is less than 60 GeV it tends to be the LSP, that forms dark matter in the Universe.
- We restrict our consideration by the scenarios that result in the dark matter density which is not greater than the observed one: $\Omega_{CDM} h^2 = 0.1099 \pm 0.0062$.
- This requires annihilation cross-section of χ_1 $\sigma(\chi_1\chi_1 \to anything)$ to be large enough.
- When $m_{\chi_1} \ll M_Z/2$ the lightest Inert neutralino has rather small couplings and $\sigma(\chi_1\chi_1 \to anything)$ is too small leading to the extremely large value of $\Omega_\chi h^2$.
- The reasonable dark matter density can be obtained for $m_{\chi_1} \sim M_Z/2$ when the s-channel annihilation through the Z-boson is the dominant annihilation channel.

- This scenario implies that two lightest Inert neutralinos have large couplings to the SM-like Higgs boson.
- As a result the lightest Higgs boson in the E_6SSM decays predominantly into $\chi_1\chi_1$ and $\chi_2\chi_2$ whereas the branching ratios of ordinary Higgs decays are small.
- Since $\chi_2 \to \chi_1 + f\bar{f}$ the decays of the lightest Higgs boson into $l^+l^- + X$ might be observed at the LHC if $m_{\chi_2} - m_{\chi_1}$ is large enough.
- The considered scenario is realized only when $\chi_1^\pm$, χ_3 and χ_4 have masses below 200 GeV and $\tan\beta$ is close to 1.5 ($\tan\beta < 2$).
- So light Inert chargino and neutralino states, which are predominantly Inert Higgsinos, can be discovered at the LHC in the nearest future.

- Benchmark point A (All mass parameters are given in GeV):

Parameters : $\tan\beta = 1.5, \quad s = 2400, \quad \lambda = k_i = g_1' = 0.468, \quad A_\lambda = 600,$

$m_{Q,U} = M_S = 700, \quad X_t = \sqrt{6} M_S, \quad m_{h_1} \simeq 116,$

$\lambda_{22} = 0.094, \quad \lambda_{11} = 0.059, \quad \lambda_{12} = \lambda_{21} = 0,$

$f_{11} = f_{22} = \tilde{f}_{11} = \tilde{f}_{22} = 0.53, \quad f_{12} = f_{21} = \tilde{f}_{12} = \tilde{f}_{21} = 0.053.$

Spectrum: $m_{\chi_2^\pm} \simeq 159.5, \quad m_{\chi_6} \simeq 201.7, \quad m_{\chi_5} \simeq 162.0, \quad m_{\chi_4} \simeq 152.7,$

$m_{\chi_1^\pm} \simeq 100.1, \quad m_{\chi_3} \simeq 105.3, \quad m_{\chi_2} \simeq 51.77, \quad m_{\chi_1} \simeq 35.42,$

Couplings : $R_{Z\chi_1\chi_1} \simeq -0.115, \quad R_{Z\chi_1\chi_2} \simeq 0.091, \quad R_{Z\chi_2\chi_2} \simeq -0.288,$

$\Omega_\chi h^2 \simeq 0.107,$

Higgs Decay rates: $Br(h_1 \to \chi_2\chi_2) \simeq 20.3\%, \quad Br(h_1 \to \chi_1\chi_1) \simeq 76.3\%,$

$Br(h_1 \to \chi_2\chi_1) \simeq 0.25\%, \quad Br(h_1 \to b\bar{b}) \simeq 2.82\%,$

$Br(h_1 \to \tau\bar{\tau}) \simeq 0.30\%, \qquad \Gamma^{tot} \simeq 0.0817.$

- Benchmark point B (All mass parameters are given in GeV):

Parameters : $\tan\beta = 1.5, \quad s = 2400, \quad \lambda = k_i = g_1' = 0.468, \quad A_\lambda = 600,$

$m_{Q,U} = M_S = 700, \quad X_t = \sqrt{6} M_S, \quad m_{h_1} \simeq 116,$

$\lambda_{22} = \lambda_{11} = 0.001, \quad \lambda_{12} = \lambda_{21} = 0.095, \quad f_{12} = f_{21} = 0.69,$

$f_{11} = f_{22} = \tilde{f}_{11} = \tilde{f}_{22} = 0.001, \quad \tilde{f}_{12} = \tilde{f}_{21} = 0.49.$

Spectrum: $m_{\chi_2^\pm} \simeq 162.9, \quad m_{\chi_6} \simeq 208.4, \quad m_{\chi_5} \simeq 205.4, \quad m_{\chi_4} \simeq 163.0,$

$m_{\chi_1^\pm} \simeq 159.5, \quad m_{\chi_3} \simeq 159.6, \quad m_{\chi_2} \simeq 45.80, \quad m_{\chi_1} \simeq 45.44,$

Couplings : $R_{Z\chi_1\chi_1} \simeq -0.0203, \quad R_{Z\chi_1\chi_2} \simeq 0, \quad R_{Z\chi_2\chi_2} \simeq -0.0206,$

$\Omega_\chi h^2 \simeq 0.1017,$

Higgs Decay rates: $Br(h_1 \to \chi_2\chi_2) \simeq 48.0\%, \quad Br(h_1 \to \chi_1\chi_1) \simeq 49.5\%,$

$Br(h_1 \to \chi_2\chi_1) \simeq 0\%, \quad Br(h_1 \to b\bar{b}) \simeq 2.25\%,$

$Br(h_1 \to \tau\bar{\tau}) \simeq 0.24\%, \qquad \Gamma^{tot} \simeq 0.102.$

- Benchmark point C (All mass parameters are given in GeV):

Parameters : $\tan\beta = 1.5, \quad s = 2400, \quad \lambda = k_i = g_1' = 0.468, \quad A_\lambda = 600,$

$m_{Q,U} = M_S = 700, \quad X_t = \sqrt{6} M_S, \quad m_{h_1} \simeq 116,$

$\lambda_{22} = \lambda_{11} = 0.001, \quad \lambda_{12} = \lambda_{21} = 0.08, \quad f_{12} = f_{21} = 0.68,$

$f_{11} = f_{22} = \tilde{f}_{11} = \tilde{f}_{22} = 0.04, \quad \tilde{f}_{12} = \tilde{f}_{21} = 0.49.$

Spectrum: $m_{\chi_2^\pm} \simeq 137.5, \quad m_{\chi_6} \simeq 192.9, \quad m_{\chi_5} \simeq 179.0, \quad m_{\chi_4} \simeq 137.7,$

$m_{\chi_1^\pm} \simeq 134.1, \quad m_{\chi_3} \simeq 134.1, \quad m_{\chi_2} \simeq 55.15, \quad m_{\chi_1} \simeq 44.91,$

Couplings : $R_{Z\chi_1\chi_1} \simeq -0.0214, \quad R_{Z\chi_1\chi_2} \simeq 0, \quad R_{Z\chi_2\chi_2} \simeq -0.0517,$

$\Omega_\chi h^2 \simeq 0.0312,$

Higgs Decay rates: $Br(h_1 \to \chi_2\chi_2) \simeq 13.3\%, \quad Br(h_1 \to \chi_1\chi_1) \simeq 82.5\%,$

$Br(h_1 \to \chi_2\chi_1) \simeq 0\%, \quad Br(h_1 \to b\bar{b}) \simeq 3.84\%,$

$Br(h_1 \to \tau\bar{\tau}) \simeq 0.41\%, \quad \Gamma^{tot} \simeq 0.060.$

- Benchmark point D (All mass parameters are given in GeV):

Parameters : $\tan\beta = 1.5, \quad s = 2400, \quad \lambda = k_i = g'_1 = 0.468, \quad A_\lambda = 600,$

$m_{Q,U} = M_S = 700, \quad X_t = \sqrt{6}M_S, \quad m_{h_1} \simeq 116,$

$\lambda_{22} = 0.468, \quad \lambda_{11} = 0.08, \quad \lambda_{12} = \lambda_{21} = 0.05, \quad \tilde{f}_{11} = 0.65,$

$f_{11} = f_{12} = \tilde{f}_{21} = \tilde{f}_{22} = 0.002, \quad f_{22} = \tilde{f}_{12} = 0.05, \quad f_{21} = 0.9,$

Spectrum: $m_{\chi^\pm_2} \simeq 805.0, \quad m_{\chi_6} \simeq 805.4, \quad m_{\chi_5} \simeq 805.4, \quad m_{\chi_4} \simeq 171.4,$

$m_{\chi^\pm_1} \simeq 125.0, \quad m_{\chi_3} \simeq 171.1, \quad m_{\chi_2} \simeq 46.60, \quad m_{\chi_1} \simeq 46.24,$

Couplings : $R_{Z\chi_1\chi_1} \simeq -0.0224, \quad R_{Z\chi_1\chi_2} \simeq -0.426, \quad R_{Z\chi_2\chi_2} \simeq -0.0226,$

$\Omega_\chi h^2 \simeq 0.00005,$

Higgs Decay rates: $Br(h_1 \to \chi_2\chi_2) \simeq 47.9\%, \quad Br(h_1 \to \chi_1\chi_1) \simeq 49.3\%,$

$Br(h_1 \to \chi_2\chi_1) \simeq 0, \quad Br(h_1 \to b\bar{b}) \simeq 2.56\%,$

$Br(h_1 \to \tau\bar{\tau}) \simeq 0.27\%, \qquad \Gamma^{tot} \simeq 0.0898.$

Conclusions

- The E_6SSM leads to the presence of two light Inert neutralinos with masses below 60-65 GeV that tend to be the lightest SUSY particles in the spectrum.
- The lightest Inert neutralino with mass $\sim M_Z/2$ can play the role of dark matter.
- In this case the lightest Higgs boson decays into $\chi_1\chi_1$ and $\chi_2\chi_2$ mainly while the total branching ratio of its decays into SM particles varies from 2% to 4%.
- This scenario implies the presence of relatively light Inert chargino and neutralino states with masses below 200 GeV that can be discovered at the LHC.
- In the considered case the decays of the lightest Higgs boson into $l^+l^- + X$ might play an essential role in the Higgs searches.