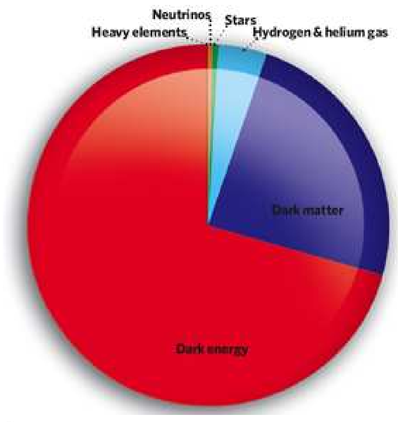
The right-handed sneutrino as thermal dark matter in U(1) extensions of the MSSM

G. Bélanger*, J. Da Silva* and A. Pukhov†, in preparation

*Laboratoire d'Annecy-le-Vieux de Physique Théorique, France
†Skobeltsyn Institute of Nuclear Physics, Moscow State University, Russia

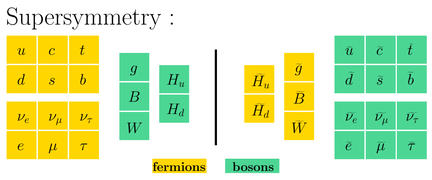
Context

• Dark matter :



CMB, rotation curves, Bullet cluster, ...
⇒ more interesting candidates : WIMPs

• Supersymmetry :



Hierarchy problem, unification of the couplings, ...
⇒ new particles interacting weakly with standard particles

⇒ Dark matter candidates in supersymmetric models

Candidates

Assuming R-parity :

• 2 WIMPs candidates in the MSSM : good (χ_1^0) and bad ($\tilde{\nu}_L$, because of direct detection constraints)

• Dirac RH neutrino ⇒ Can $\tilde{\nu}_R$ be good candidate when it couples to new vector, scalar field, adding a new abelian gauge group ?

The UMSSM

• Symmetry group : $SU(3)_c \times SU(2)_L \times U(1)_Y \times U'(1)$
Coupling constants associated : g_3, g_2, g' and $g'_1 = g_1 = \sqrt{\frac{5}{3}}g'$

• Breaking of E_6 group ⇒ $U'(1)$ is a combination of U_χ and U_ψ with charge associated :

$$Q' = \cos\theta_{E_6} Q_\chi + \sin\theta_{E_6} Q_\psi, \qquad \theta_{E_6} \in [-\pi/2, \pi/2]$$

Higgs sector

• New chiral supermultiplet S ⇒ new v.e.v. ⇒ μ problem resolved as in the NMSSM : $\mu = \frac{\lambda v_s}{\sqrt{2}}$

• 1 CP odd Higgs A^0, 5 CP even Higgs : $H^\pm$, h_1, h_2 and h_3

• Singlet-like Higgs mass near Z_2 mass

• With radiative corrections + pure UMSSM terms ⇒ good increase of m_{h_1}

Gauge sector

• New vector supermultiplet ⇒ new gauge boson : B'

• Physical abelian gauge bosons : Z_1 and Z_2, stem from $Z^0 = -\sin\theta_W B + \cos\theta_W W^3$ and $Z' = B'$:

$$Z_1 = Z^0 \cos\alpha_Z + Z' \sin\alpha_Z$$
$$Z_2 = -Z^0 \sin\alpha_Z + Z' \cos\alpha_Z$$

• $M_{Z_1}^2 \neq M_{Z^0}^2 = \frac{g'^2+g_2^2}{4}v^2$ and $M_W = \cos\theta_W M_{Z^0}$ ⇒ small α_Z

Gauginos sector

• 6 neutralinos in the basis $(\widetilde{B}, \widetilde{W}^3, \widetilde{H}_d^0, \widetilde{H}_u^0, \widetilde{S}, \widetilde{B'})$, χ_1^0 DM in UMSSM studied in arXiv:0811.2204v2 [hep-ph] (J. Kalinowski et al.)

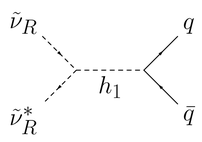
Sparticles sector

• Addition of UMSSM terms in the squared mass matrix : $\Delta_f = \frac{1}{2}g_1'^2 Q'_f (Q'_{H_d} v_d^2 + Q'_{H_u} v_u^2 + Q'_S v_s^2)$

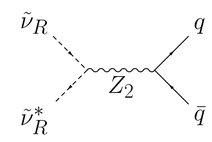
Interactions

Parameter space regions with $\Omega_{WIMP}h^2 \approx 0.1$ ⇒ need to increase the annihilation cross section :

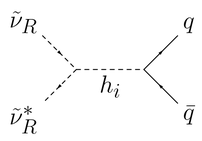
• WIMP mass near $m_{h_1}/2$:



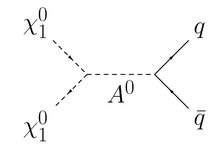
• WIMP mass near $M_{Z_2}/2$:



• WIMP mass near $m_{h_i}/2$, h_i singlet-like Higgs :



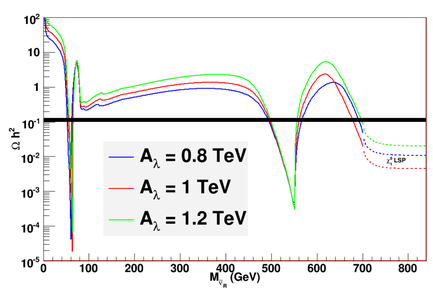
• Coannihilation processes (mainly $\widetilde{S}$ and $\widetilde{B'}$)

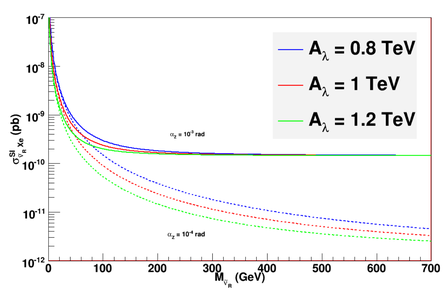


Example for $U(1)_\psi$ model ($\theta_{E_6} = \pi/2$)

• Relevant parameters : $M_{\tilde{\nu}_R}$, μ, A_λ, M_{Z_2}, α_Z

• Example with soft terms at 1 TeV, $M_1 = 1$ TeV, $M_2 = 2M_1$, $M_{Z_2} = 1.1$ TeV, $\mu = 1$ TeV and $\alpha_Z = 10^{-3}$ rad : $m_{h_1} = 119.2$ GeV :





Example of relic density and direct detection cross section profiles

Global scan

Constraints :

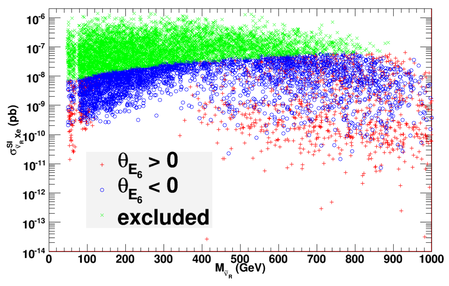
• Relic density at 3σ with $\Omega_{WIMP}h^2 = 0.1123 \pm 0.0035$

• Higgs mass limit for doublet-like Higgs : $m_{h_1} \geq 114.4$ GeV

• LEP constraints on sparticles masses implemented in the micrOMEGAs code

• Spin independent direct detection cross section (The XENON100 Collaboration, arXiv:1104.2549v1 [astro-ph.CO])

Preliminary results



• Interesting WIMP mass from 50 GeV to TeV-scale

• Besides the interactions shown, constraints respected for annihilation into W pairs through Higgs exchange arround $M_{\tilde{\nu}_R}$ = Some hundreds of GeV ($\theta_{E_6} < 0$)

Conclusion

• **RH sneutrino is a viable dark matter candidate**

• This model can be tested with other experimental results : indirect detection, flavour physics, ...