Sneutrino cold dark matter in extended MSSM models[1]

Chiara Arina

University of Turin

43rd Rencontres de Moriond

[1] **C.Arina and N.Fornengo**, *Sneutrino cold dark matter, a new analysis: relic abundance and detection rates*, JHEP11(2007)029, arXiv:0710.0553 [hep-ph]

MSSM conserving R-parity

$(\tilde{\nu}, \tilde{e}^-)_L$	$(\nu, e^-)_L$
$\tilde{e}^-_R$	e^-_R

$\tilde{\nu}$ CDM

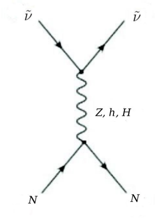
- LSP $\rightarrow$ stable
- neutral
- WIMP

$$W_{\rm MSSM} = \epsilon_{ij}(\mu \hat{H}^1_i \hat{H}^2_j - Y_l \hat{H}^1_i \hat{L}_j \hat{R})$$

$$V_{\rm soft} = (M^2_L)\, \tilde{L}^*_i \tilde{L}_i + [\epsilon_{ij}(\Lambda_l H^1_i \tilde{L}_j \tilde{R}) + \text{h.c.}]$$

$\Omega h^2 \propto < \sigma_{ann} v >^{-1}$

$$< \sigma_{ann} v > \rightarrow \begin{cases} \tilde{\nu}\bar{\tilde{\nu}} & \rightarrow & f\bar{f}, ZZ, W^+W^-, hh\ldots \text{ annihilation} \\ \tilde{\nu}\tilde{e}_L & \rightarrow & \nu e, ZW^-, \ldots \\ \tilde{e}_L\bar{\tilde{e}}_L & \rightarrow & f\bar{f}, ZZ, W^+W^-, hh\ldots \text{ coannihilation} \end{cases}$$



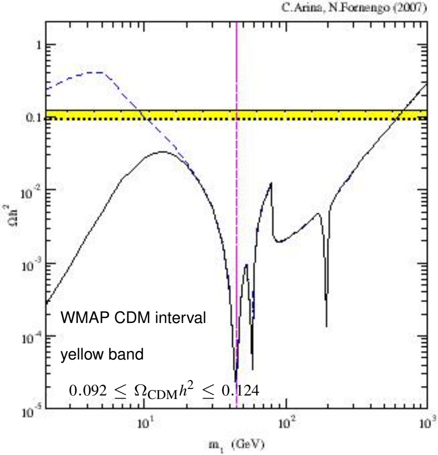
Direct detection $\rightarrow$ elastic scattering on nuclei

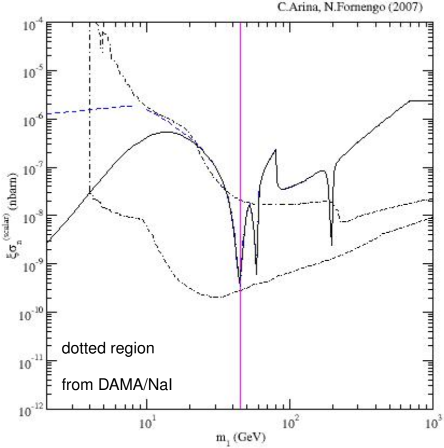
Scalar interaction through Z and Higgs t-channel exchange

$$\sigma_{\mathcal{N}} = \sigma_Z + \sigma_{h,H}$$

$\xi \sigma^{(scalar)}_{nucleon}$ $\quad \xi = \min(1, \frac{\Omega_{\tilde{\nu}} h^2}{\Omega_{CDM} h^2})$

Ωh^2 and $\xi\sigma^{(scalar)}_{nucleon}$ vs. sneutrino mass in the MSSM





- dips $\longrightarrow$ Z and Higgs (h,H,A,$H^\pm$) poles; sharp drop $\longrightarrow$ W^+W^- threshold
- $\tilde{\nu}$-Z coupling huge $\longrightarrow$ low relic abundance and high detection rate
- Extensions of the MSSM in relation with neutrino physics reduce $\tilde{\nu}$-Z coupling

Inclusion of a right–handed neutrino superfield $\hat{N}$

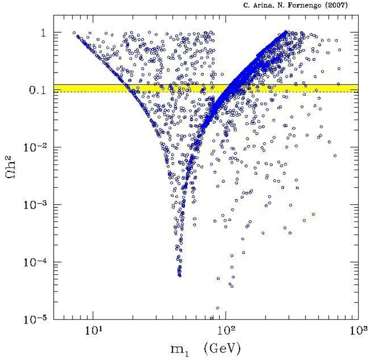
$$W_{LR} = \epsilon_{ij}(\mu \hat{H}^1_i \hat{H}^2_j - Y_l \hat{H}^1_i \hat{L}_j \hat{R} + Y_\nu \hat{H}^2_i \hat{L}_j \hat{N})$$

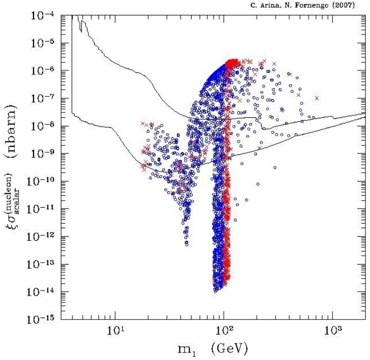
$$V_{\rm soft} = (M^2_L)\, \tilde{L}^*_i \tilde{L}_i + (M^2_N)\, \tilde{N}^* \tilde{N} - [\epsilon_{ij}(\Lambda_l H^1_i \tilde{L}_j \tilde{R} + \Lambda_\nu H^2_i \tilde{L}_j \tilde{N}) + \text{h.c.}]$$

$$\tilde{\nu}_1 = -\sin\theta\; \tilde{\nu}_L + \cos\theta\; \tilde{N}$$

mixing with the sterile right-handed sneutrino $\tilde{N}$

induces a reduction of $\sin^2\theta$ in the $\tilde{\nu}$-Z coupling



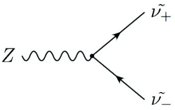


Explicit lepton number violating term from a 5-dim operator $\mathcal{L} = g/M_\Lambda(\epsilon_{ij}L_iH_j)(\epsilon_{kl}L_kH_l) + \text{h.c.}$

$$V_{\rm mass} = \left[m_L^2 + \frac{1}{2}m_Z^2\cos(2\beta)\right]\tilde{\nu}_L^*\tilde{\nu}_L + \frac{1}{2}m_B^2(\tilde{\nu}_L\tilde{\nu}_L + \tilde{\nu}_L^*\tilde{\nu}_L^*)$$

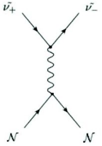
$$\begin{cases} \tilde{\nu}_+ = \frac{1}{\sqrt{2}}(\tilde{\nu}_L + \tilde{\nu}_L^*) \\ \tilde{\nu}_- = \frac{-i}{\sqrt{2}}(\tilde{\nu}_L - \tilde{\nu}_L^*) \end{cases}$$

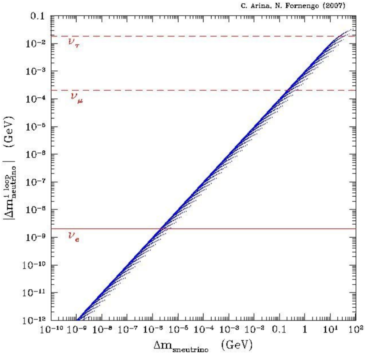
$$\Delta m^2 \equiv m_+^2 - m_-^2 = 2m_B^2$$



Z coupling off-diagonal

Inelastic Scattering $\Delta m < \frac{\beta^2 m_- m_{\mathcal{N}}}{2(m_- + m_{\mathcal{N}})}$

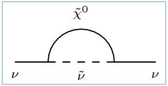




Strong constraints from neutrino physics

One-loop neutrino mass corrections

$\Delta m_\nu^{1loop} \propto \Delta m$

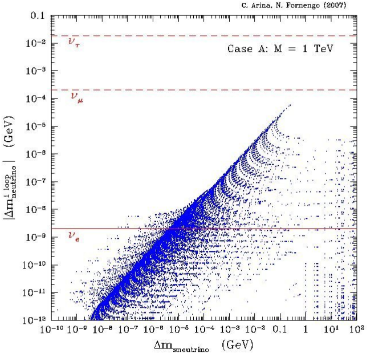


See-saw model with $M = 1$ TeV

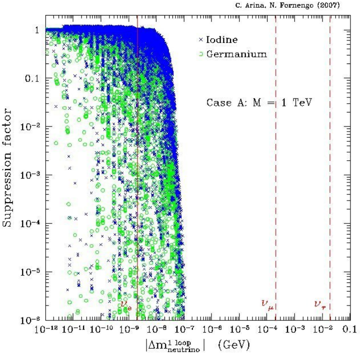
$$W_{Maj} = \epsilon_{ij}(\mu \hat{H}_i^1 \hat{H}_j^2 - Y_l \hat{H}_i^1 \hat{L}_j \hat{R} + Y_\nu \hat{H}_i^2 \hat{L}_j \hat{N}) + \frac{1}{2} M \hat{N}\hat{N}$$

$$V_{\text{soft}} = (M_L^2)\, \tilde{L}_i^* \tilde{L}_i + (M_N^2)\, \tilde{N}^* \tilde{N} - [(m_B^2) \tilde{N}\tilde{N} + \epsilon_{ij}(\Lambda_l H_i^1 \tilde{L}_j \tilde{R} + \Lambda_\nu H_i^2 \tilde{L}_j \tilde{N}) + \text{h.c.}]$$

Inelasticity and mixing with the sterile right–handed component included

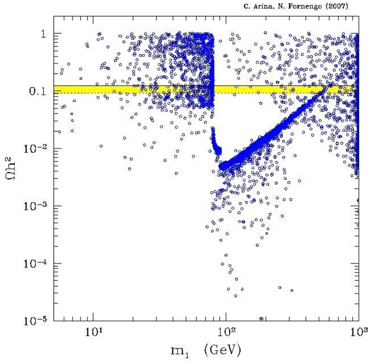


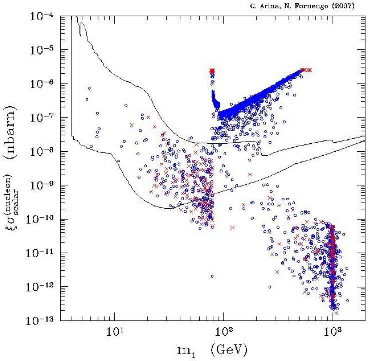
Large mass splittings allowed



Suppression of the Z inelastic scattering

Ωh^2 and $\xi\sigma^{(scalar)}_{nucleon}$ detection rate for models with $M = 1$ TeV





Conclusion and work in progress

- Sneutrinos as dominant or subdominant DM halo components ($5\,\text{GeV} < m_{\tilde{\nu}} < 1\,\text{TeV}$)
- Sneutrino configurations compatible with the direct detection bounds

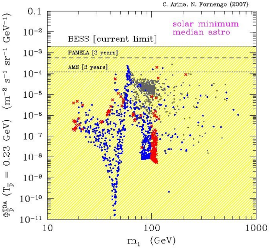
$\tilde{\nu}$ viable CDM with RH $\tilde{N}$ fields and in seesaw models

Indirect detection rates for $\bar{p}$, $\bar{D}$ in the sensitivity of incoming experiments

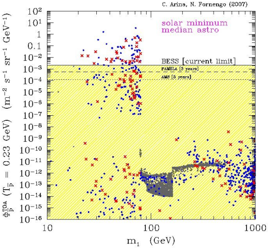
$M = 1\,\text{TeV}$ arises naturally in inverse seesaw models

Indirect detection rates for antiproton and antideuteron

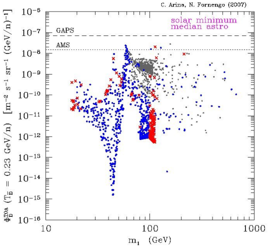
LR



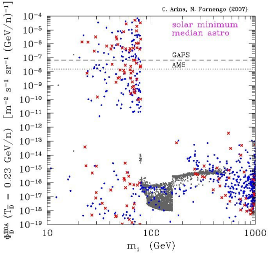
Maj $M = 1\,\mathrm{TeV}$



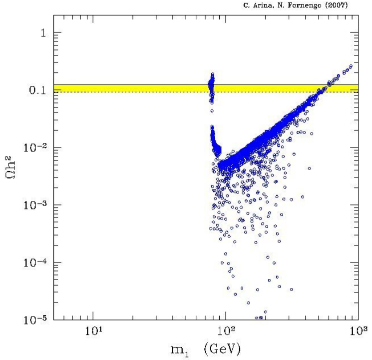
LR

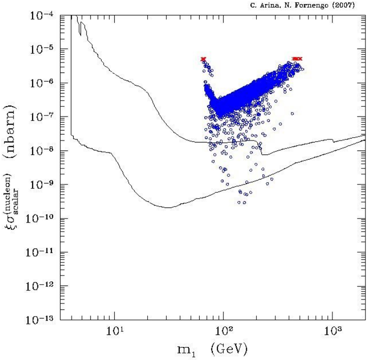


Maj $M = 1\,\mathrm{TeV}$



Ωh^2 and $\xi\sigma_{nucleon}^{(scalar)}$ detection rate for models with $M = 10^9$ GeV





- Heavy sneutrino configurations and subdominant CDM halo components
- Phenomenology only slightly changed respect to the MSSM since the Majorana mass drives the behavior of the right–handed sneutrino fields