Light Dark Matter and Neutrino Telescopes

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arXiv:1010.0553 (Phys. Lett. B695)
arXiv:1104.0679

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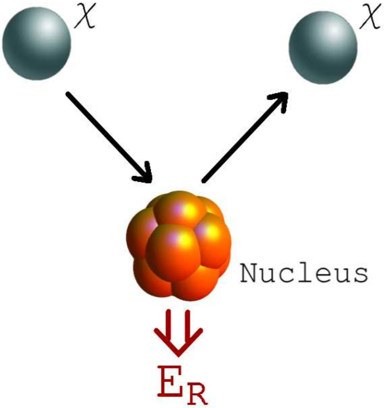
Outline

Direct Detection of WIMPs

- WIMP χ passes detector
  $\rightarrow$ liquid noble gas (Xenon...)
  $\rightarrow$ crystal (CRESST...)
- scatters off target nucleus
- $E_R \rightsquigarrow$ Light, Heat

$\downarrow$

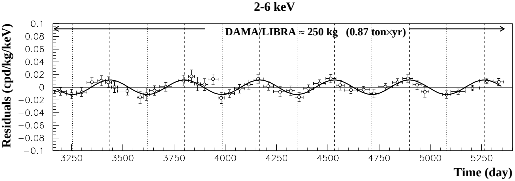
detector signal

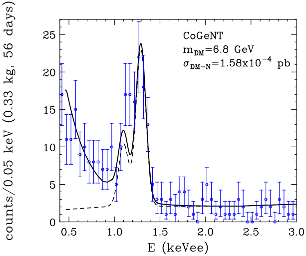


Possible Signals

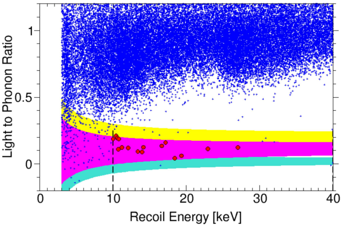
- modulation signal at **DAMA**

  Bernabei et al., Eur. Phys. J. **C67** (2010)





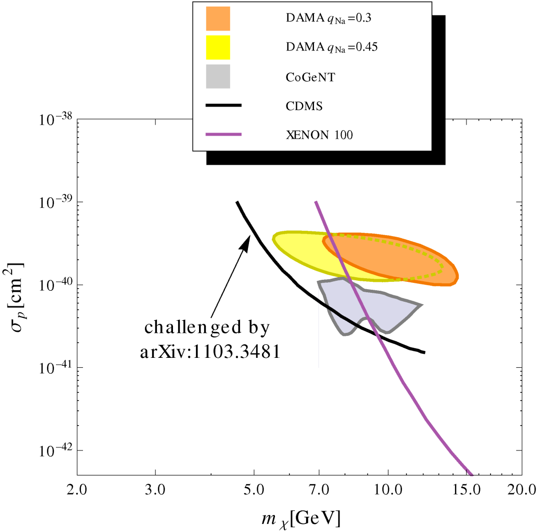
Aalseth et al., **arXiv:1002.4703** [astro-ph] (2010),
Hooper et al., **arXiv:1007.1005** [hep-ph] (2010)



Talks by Seidel and Schwetz at **IDM 2010**

- **CoGeNT**: exponential rise of events at low energies
- **CRESST:** 32 events in the oxygen band (9 expected)

Confidence Regions and Exclusion Curves



- DAMA, CoGeNT consistent for $q_{\mathrm{Na}} \gtrsim 0.45$
- strong limits
  <u>But:</u> experimental uncertainties

XENON 100, Aprile et al., Phys. Rev. Lett. **105** (2010),
CDMS, Ahmed et al., **arXiv:1011.2482** [astro-ph] (2010)

WIMP Capture in the Sun

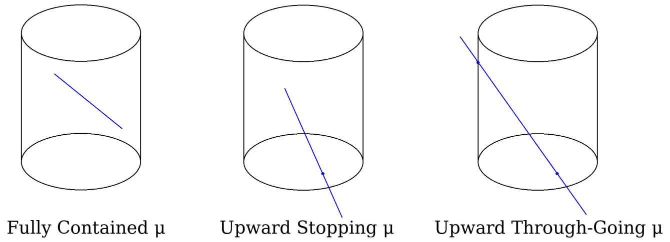
- WIMPs get trapped in the sun $C_\odot \propto \sigma_p$
- Trapped WIMPs annihilate $\rightarrow \nu$ **signal**

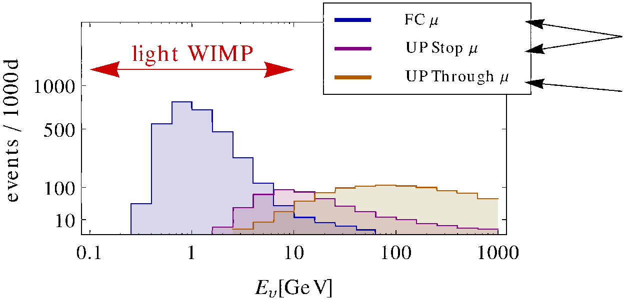
$$\Gamma_{\text{ann}} = \frac{C_\odot}{2} \qquad \text{(for equilibrium)}$$

- ν can be detected at earth (Super-Kamiokande)
- No excess of ν from the sun

  $\Longrightarrow$ Constraints on σ_p (depend on annihilation-channel)

Event Types at Super-Kamiokande



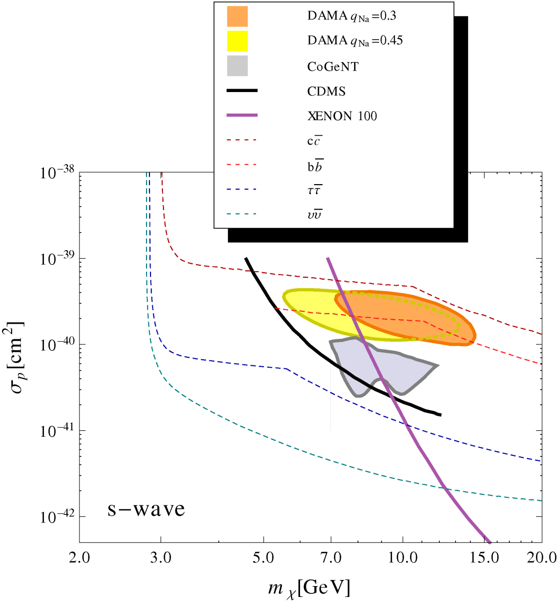


Our analysis

Super-K analysis

Desai et al., Phys. Rev. **D70** (2004)

Limits from Super-Kamiokande



CoGeNT, DAMA

- Super-K excludes $\nu\bar{\nu}$, $\tau\bar{\tau}$ channels
- WMAP disfavors $q\bar{q}$, $e\bar{e}$, $\gamma\gamma$, gg

Hütsi et al., **arXiv:1103.2766** [astro-ph]

Options

- $\mu\bar{\mu}$ channel
- velocity suppression

MSSM + Singlet

- introduce one singlet superfield

  Drees, Int. J. Mod. Phys. **A4** (1989)

$$\mathcal{W} \;=\; \mathcal{W}_{\text{MSSM}} + \lambda\, S\, H_u H_d + \frac{\mu_s}{2}\, S^2 + \frac{\kappa}{3}\, S^3$$

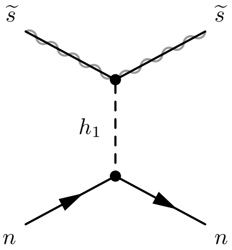
- new particles: singlino $\widetilde{s}$, singlet scalar h_s, pseudoscalar a_s

Assumption	**Effect**
all singlet mass terms $\mathcal{O}$(10 GeV)	$m_{\widetilde{s},h_s,a_s} \sim$ 10 GeV
suppressed λ	MSSM and Singlets “almost decouple” $h_1 = h_s + \varepsilon\, h$
sizeable κ	significant singlet self-interactions

Singlino Dark Matter

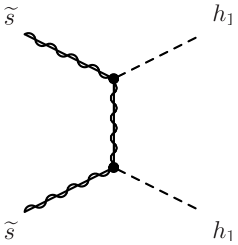
- interesting case: $m_{\widetilde{s}} \sim 7$ GeV, $m_{h_1} \sim 5$ GeV, a_s heavier

Direct Detection



$$\sigma_p \sim 10^{-40}\ \text{cm}^2$$

Relic Abundance



$$\Omega_{\widetilde{s}} h^2 \sim 0.1$$

- CoGeNT, DAMA, (CRESST) explanation ✓
- indirect detection ✓ (velocity suppression)

Conclusion

- Signals at several DM direct detection experiments might hint at light WIMPs
- Indirect detection requires the light WIMP to

  $\rightarrow$ annihilate into $\mu\bar{\mu}$, or

  $\rightarrow$ carry velocity suppression

- A simple singlet extension of the MSSM offers a promising candidate: singlino