Origin of Dark Matter

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Statistics of Network Activities

118 publications!

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Highlight 1: $e^\pm$ “Excesses”

PAMELA

![Graph showing positron fraction vs. energy](image-url)
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**PAMELA**

![Graph showing positron fraction vs. energy (GeV)]

**Fermi/LAT**

![Graph comparing positron fraction at various energies]
Remarks on “Excesses”

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  Supposed to be due to solar modulation – but production of $e^+$
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G. Tarle, Talk at PPC09.

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- Fermi/LAT large $E$ excess is only about 1 *systematic* standard deviation! In this data set, deficit at lower $E$ is nearly as likely as excess at high $E$. 
To explain this through WIMP annihilation, need:

E.g. Cirelli, Kadastik, Raidal, Strumia: arXiv:0809.2409

\[ m_\chi \gtrsim 1 \text{ TeV} \] (Fermi/LAT syst. error?)
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Examples:
Kohri, McDonald, Sahu: arXiv:0905.1312
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Constraints and other explanations

- **Fermi/LAT diffuse $\gamma$ flux**: Cirelli, Panci, Serpico: arXiv:0912.0663; Papucci, Strumia: arXiv:0912.0742 Only annihilation into $\mu^+\mu^-$ or $\ell^+\ell^-\ell^+\ell^- \ (\ell = e, \mu)$ is allowed, and only if DM density not too strongly peaked at galactic center!
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- Many other constraints have been discussed in 2008/9; e.g. BBN Hisano, Kawasaki, Kohri, Nakayama: arXiv:0810.1892; CMB Galli, Iocco, Bertone, Melchiorri: arXiv:0905.0003; $\nu$ bounds Hisano, Kawasaki, Kohri, Nakayama: arXiv:0812.0219

My conclusion

The “background prediction” is based on an over–simplified model. Our galaxy is not a homogeneous cylinder! This model has sufficiently many parameters to reproduce some data, (e.g. the B/C ratio) but there’s no guarantee that other predictions of this model are accurate.
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- Clearcut identification of Dark Matter using charged cosmic rays or photons requires refined modelling of entire cosmic ray spectrum!
Highlight 2: Direct WIMP Detection

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- Modulation amplitude in 2-6 keV ee window (in counts/d/kg/keV):
  0.020 ± 0.003 in 1995-2001;
  0.0107 ± 0.0019 in 2003-2007;
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- No effort made to isolate nuclear recoil events
Light WIMPs (cont’d)

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-Quite difficult to find models giving required large scattering cross sections
Highlight 3: WIMPs and Stars

Network members explored relations between DM and traditional astrophysics!

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- **Effect of WIMP annihilation in stars:** Significant only for $S$–wave annihilation!
- **Pop–III stars:** effect small? Ripamonti et al.: arXiv:0903.0346
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- 5 GeV non–annihilating (e.g. “asymmetric”) WIMPs with very large scattering cross section might conceivably affect helio–seismology. Frandsen, Sarkar: arXiv:1003.4505
Highlight 4: Local DM Density:

Network members derived new, improved estimates of the “local” DM density!

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Upshot:

$$\rho_{\text{DM}}^{\text{here}} = (0.39 \pm 0.08) \frac{\text{GeV}}{\text{cm}^3}$$
Highlight 5: Sterile keV neutrinos

Network members constrained simplest warm Dark Matter model.

Simplest model (thermal production, no asymmetry) declared excluded in Lesvos rapporteur talk: lower bound on $m_{\nu_s}$ from Ly–$\alpha$ “forest” incompatible with upper bound from X–ray searches ($\nu_s \rightarrow \nu \gamma$) Palazzo et al.: arXiv:0707.1495
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  - Altogether: $2 \text{ keV} \leq m_{\nu_s} \leq 50 \text{ keV}$ allowed! Boyarsky, Lesgourgues, Ruchayskiy, Viel: arXiv:0812.3256 and arXiv:0812.0010; Acero, Lesgourgues: arXiv:0812.2249
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- But: needs additional “new physics”
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- People have been constructing complicated models, and will continue to do so, but simple ones are still fine.
- Experiment may give clues soon: LHC, Xenon–100, AMS–02, …