Toward A Consistent Picture For CRESST, CoGeNT and DAMA

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Pitt- PACC Workshop
Nov. 15, 2011
Three dark matter direct detection experiments (DAMA/LIBRA, CoGeNT, and CRESST-II) have each reported signals which are not consistent with known backgrounds. The signals do resemble that predicted for a dark matter particle with mass of ~10 GeV and cross section with nucleons $\sim 10^{-41}$- $10^{-40}$ cm$^2$. These signals are also faced but null results of several other experiments. Can the signals of these experiments be explained by a single species of dark matter particle, without conflicting with the constraints of other experiments?
What’s going on with these surface events?

Optimist: A bit of a moving target is expected

Pessimist: Replace vehicle by “signals”
A theorist’s understanding of surface events

8 weeks of data, 3 months after entering Soudan
A theorist’s understanding of surface events

From Juan’s talk
Is the spectrum consistent with CDMS?

The original CoGeNT excess spectrum (that included the surface event contamination) was larger the spectrum measured at CDMS.

This is difficult to explain any way other than with detector systematics.
Is the spectrum consistent with CDMS?

Excluding these additional surface events in CoGeNT brings the two spectra into much better agreement.
CoGeNT and CRESST
Dark Matter Should Have Annual Modulation

http://www.hep.shef.ac.uk/research/dm/intro.php
DAMA (NaI) Claim

Rita Bernabeia, et. al.

Quenching factor for Na

PRELIMINARY DATA

Na recoils in NaI(Tl)

Quenching Factor (%) vs Recoil Energy (keV)

$\sigma_{\text{DM-n}}$ (cm$^2$) vs $m_{\text{DM}}$ (GeV)

- Green: $Q_{\text{Na}} = 0.40$
- Black: $Q_{\text{Na}} = 0.25$
- Red: $Q_{\text{Na}} = 0.15$
Modulation in the CoGeNT data

- We find modulation of 16±5% at the 2.7 sigma level
- The best fit to the peak is found to be at April 18±16 days
- DAMA peak is May 16±7 (2-4 keVee range) or May 26±7 (2-6 keVee range)
- N-body simulations of galaxy formation find 68% of models have a peak within 20 days of late May/early June
There is more modulation at higher energies than predicted in the standard halo model.
Independent of astrophysical uncertainties, the gray error bars are the what the DAMA signal would look like at the CoGeNT detector.

Red error bars are the CoGeNT modulation for maximum phase May 26 (~SHM).

Blue error bars are the best fit maximum phase for CoGeNT (April 18).
Overall rate versus modulation

- The simplest comparison between the overall spectra and the modulation spectra are discrepant by a factor of at least a few. What are the possibilities for reconciling this discrepancy?

- Particle Physics
  - Inelastic dark matter
  - Form Factor Dark Matter
  - Resonant Dark Matter

- Astrophysics
  - Substructure within the halo (streams)
Simulations of the Velocity Distribution of Dark Matter in Our Galaxy

Streams?

$m = 10$ GeV

165 km/s, 15% of “smooth” halo

475 km/s, 24% of “smooth” halo
Conclusions and Future Outlook

- I am going to have disagree with Neal that to zeroth order, none of the experiments agree.
- When considering reasonable uncertainties:
  - CoGeNT and CRESST have similar overall spectra.
  - CoGeNT and DAMA have similar modulation spectra.
- CoGeNT is continuing to take data (after the fire) and we look forward to seeing if the modulation signal continues to increase in significance.
- CDMS is undertaking an annual modulation analysis.
- First C4 detector to be constructed soon.