Sub-GeV mass dark matter with SuperCDMS

Robert Calkins

Southern Methodist University
on behalf of the SuperCDMS collaboration

February 23, 2018
SuperCDMS Soudan

- Located in Soudan Underground Lab, ≈ $\frac{1}{2}$ mile underground with 2090 M.W.E. of overburden
- Utilizes the same shielding and cryostat from CDMS-II experiment
- Collected about 2500 kg-days of raw exposure over experiment lifetime
- Data taking ended in 2015, collaboration shifting focus to SNOLAB
HV Biasing

- Phonons are created from charges passing through a crystal through Neganov-Trofimov-Luke effect
- The contribution to total phonon energy goes as $N_e/h \epsilon V_b$ : proportional to bias voltage $V_b$
- High bias voltage allows us to measure small amount of charges through phonon signal (CDMSlite mode/HV)
- Trade-off: no separate measurement of primary phonon signal, sacrifices ER/NR discrimination
• WIMPs are just one possibility

• Kinematics for light masses disfavorable, sensitivity driven by threshold

• Need new ideas and approaches to probe these low masses

\[m_\chi = 10 \text{ GeV/}c^2\]

\[\sigma = 1 \times 10^{-45} \text{ cm}^2\]

\[a\text{Mirabolfathi - arXiv:1308.0044}\]
Dark photon absorption with CDMSlite data

- Mediator between standard model and dark matter with finite mass \(m_{A'}\)
- Absorption rate, \(R \approx \frac{\rho_{DM}}{m_{A'}c^2}\epsilon^2\sigma_{p.e.}(E_{\gamma} = m_{A'})c\)
- Signal is mono-energetic electron with \(E = m_{A'}\)
- Search strategy is a bump-hunt in our spectrum!
• Sensitivity extends down to band gap (Ge .7 eV, Si 1.1 eV)
• We can expect to cover a large amount of parameter space at SNOLAB
Recalling nucleus can emit a photon as it slows down in material.

- Energy of this photon can extend to higher energies than NR.
- Photon acts as a probe to low mass WIMP scattering below detector threshold.

1 GeV WIMP

- Single e/h-pair sensitivity has been recently demonstrated in 0.93g Si crystal
- Single e/h-pair resolution goal of SuperCDMS SNOLAB
- Such devices will have sensitivity to a variety of sub-GeV DM models with $\sim g*d$ exposures
• Sensitivity driven by thresholds
• Search requires good knowledge of electronic structure of target

---

Battaglieri et al. arXiv:1707.04591
Galactic axions

- Axions interact through axio-electric effect
- Peak at axion mass
- 5 year exposure and simple counting experiment

- Uncertainty in photo-electric cross section at low energies limits search
Summary

- SuperCDMS Soudan WIMP searches are nearly complete see B. Loer’s talk
- Theorists have provided us with many new channels to explore
- Current CDMSlite data can be used to search for these signals
- Future is looking equally bright with new technological achievements and the planned SuperCDMS SNOLAB experiment! see B. Loer’s talk
Backup Slides
interleaved Z-sensitive Ionization and Phonon (iZIP) Detectors

- Detector array: 15 Ge iZIP detectors (0.6 kg each) operating around 50 mK
- 4 phonon and 2 charge channels on each detector face
- Phonon channels are grounded, charge channels are biased at ±2 V
- Field configuration causes events near surface to have charge collection localized to one side
Yellin Optimal Interval

Conceptually similar to the optimal gap method except that it allows for $N$ events to fall into region.