DD WG Friday: summary

(only a small selection)

Ranny Budnik

Rouven Essig
• several possible targets identified that have good prospects for observable DM signals
• backgrounds unknown in all (to different degrees), but need experimental work to identify issues (and deal with them)
• detector backgrounds much more important than “classical” (e.g. radioactive) backgrounds
• xenon/LZ
• xenon bubble chamber
• superfluid helium
• semiconductors
• scintillators
• color centers
• graphene sheets
• carbon nanotubes
• superfluid helium
10:00  Jeremy Mock – Xenon Bubble Chambers for Direct Dark Matter Detection
       ![BubXe_Vfinal.pdf]
10:15  Tien-Tien Yu – LDM detection using electron scattering in scintillators
       ![Scintillator_SLACw.png]
10:30  Aaron Manalaysay – Towards the ultimate ionization threshold in semiconductor detectors
       ![SLAC_darkSectors.png]
10:45  Lauren Hsu – Low Energy Nuclear Recoil Ionization Yield and SuperCDMS Sensitivity (k vs threshold effects)
       ![darksectors_calibr.png]
11:00  Ranny Budnik – Color Centers as radiation detectors
       ![CC_SLAC.pdf]
13:30  Maria Elena Monzani – Perspectives for low-mass dark matter searches with the LZ experiment
       ![DarkSectors_Monz.png]
13:45  Tien-Tien Yu – LDM detection with electron recoils in with semiconductor targets
14:00  Yoni Kahn – Searching for sub-GeV DM with Graphene Target
       ![GrapheneDM-2.pdf]
14:15  discussion
15:15  Antonio Polosa: Carbon nanotubes for DM directional detection
15:30  Dan McKinsey – DM detection in liquid Helium
15:45  Scott Hertel – Helium part II
16:00  discussion
Single Electron Sensitivity in LZ

- Single electron signal depends on field configuration:
  - expected >50 p.e./electron (x2 higher than Xenon10)
  - expected 97.6% extraction efficiency for electrons

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-Anode separation (and tolerance)</td>
<td>13.0 mm (±0.2 mm)</td>
</tr>
<tr>
<td>Gas gap (and tolerance)</td>
<td>8.0 mm (±0.2 mm)</td>
</tr>
<tr>
<td>Field in LXe (GXe)</td>
<td>5.2 kV/cm (10.2 kV/cm)</td>
</tr>
<tr>
<td>Electron emission probability</td>
<td>97.6%</td>
</tr>
<tr>
<td>S2 photon yield</td>
<td>820 ph/e</td>
</tr>
<tr>
<td>S2 width FWHM</td>
<td>1.2 µs</td>
</tr>
<tr>
<td>Detailed modeling</td>
<td></td>
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<tr>
<td>S2 photon yield</td>
<td>910 ph/e</td>
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<tr>
<td>S2 photon rms</td>
<td>2.0%</td>
</tr>
<tr>
<td>S2 width FWHM</td>
<td>1.0 µs to 2.0 µs&lt;sup&gt;a&lt;/sup&gt;</td>
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</tbody>
</table>

<sup>a</sup> The larger value is for diffusion-broadened S2 pulses from interactions near the cathode (see Figure 3.6.4).

- Reaching HV specs has proven elusive in all LXe detectors
  - very extensive fields/grid R&D/testing in progress at SLAC
BubXe: xenon bubble chamber

Jeremy Mock

LXe detector + bubble chamber = LXe bubble chamber

→ has energy information
→ has great misidentification probability
→ active on all 3 channels at a time!
3.6 events in a DAMIC-like or SuperCDMS-like experiment

work in progress to reach \(\sim\) eV sensitivity (currently at \(\sim\) 40-50 eV)
A scintillator is a material that, when struck by an incoming particle, absorb its energy re-emits the absorbed energy in the form of light.

Conduction Bands

Exciton Band

Scintillation Photons

Valence Bands

Exciton Band

Activator Excited States

Activator Ground State

Material: e.g. TIBr, NaI, CsI

Need array of TES w/ single photon sensitivity ~few eV

(R&D in progress)
Color centers as NR radiation detectors

O(10eV) threshold, long lived signals
(experimental work in progress)
Graphene: adapt PTLOEMY

Yoni Kahn

0.5 kg of graphene sheets; threshold ~ 5eV has directionality

Calorimeter

$\vec{E}$ $\times$ $\vec{B}$
Carbon nanotubes

~ keV NR threshold has directionality
Superfluid Helium

<table>
<thead>
<tr>
<th></th>
<th>Liquid density (g/cc)</th>
<th>Boiling point at 1 bar (K)</th>
<th>Electron mobility (cm²/Vs)</th>
<th>Scintillation wavelength (nm)</th>
<th>Scintillation yield (photons/MeV)</th>
<th>Long-lived radioactive isotopes</th>
<th>Triplet molecule lifetime (μs)</th>
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</thead>
<tbody>
<tr>
<td>LHe</td>
<td>0.145</td>
<td>4.2</td>
<td>low</td>
<td>80</td>
<td>19,000</td>
<td>none</td>
<td>13,000,000</td>
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<tr>
<td>LNe</td>
<td>1.2</td>
<td>27.1</td>
<td>low</td>
<td>78</td>
<td>30,000</td>
<td>none</td>
<td>15</td>
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<tr>
<td>LAr</td>
<td>1.4</td>
<td>87.3</td>
<td>400</td>
<td>125</td>
<td>40,000</td>
<td>39Ar, 42Ar</td>
<td>1.6</td>
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<tr>
<td>LKr</td>
<td>2.4</td>
<td>120</td>
<td>1200</td>
<td>150</td>
<td>25,000</td>
<td>81Kr, 85Kr</td>
<td>0.09</td>
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<tr>
<td>LXE</td>
<td>3.0</td>
<td>165</td>
<td>2200</td>
<td>175</td>
<td>42,000</td>
<td>136Xe</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Experimental work in progress studying helium’s properties
good NR/ER discrimination