Bubbles and Neutrinos

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Detecting Neutrinos

• Lots of different kinds of detectors...

<table>
<thead>
<tr>
<th>Detector</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerenkov</td>
<td>$\mathcal{O}$(MeV)</td>
</tr>
<tr>
<td>Radiochemical</td>
<td>$\mathcal{O}$(hundreds keV)</td>
</tr>
<tr>
<td>Scintillation</td>
<td>$\mathcal{O}$(MeV)</td>
</tr>
<tr>
<td>Tracking</td>
<td>$\mathcal{O}$(Gev)</td>
</tr>
</tbody>
</table>
Different Neutrino Interaction

- Neutrinos can scatter elastically with an entire nucleus
- Coherent Elastic Neutrino-Nucleus Scattering (CEνNS)
- Search for the nuclear recoil
- UPPER energy threshold of tens of MeV neutrinos for most nuclei
Look to our peers

- This is an issue dark matter detectors have been dealing with for years
- Many MANY ways to see that small energy deposit
- Trickiest part may be the background rejection…
Coherent Neutrino Scattering

• I said we were looking for this

Recoil Energy <10s of keV
Coherent Neutrino Scattering

- We’re actually looking for this
Example Dark Matter Detector - PICO

- Small deposit of energy overcomes threshold in Gibbs potential
- This then results in vaporization - production of bubble
- Note that threshold is controllable
  - At most thresholds, gammas not an issue
Example Dark Matter Detector - PICO

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\[ 10^{-10} \sim 3 \text{ keV} \]
\[ 10^{-10} \sim 11 \text{ keV} \]
Revisit a bit of history

- In 1956, Glaser made a xenon bubble chamber
- No bubbles in pure xenon even at 1keV threshold with gamma source
- Normal production in 98% xenon + 2% ethylene (scintillation completely quenched)
- Scintillation suppresses bubble nucleation (?)

Phys. Rev. 102, 586 (1956)
The SBC Detector

- Roughly 10kg of Argon
- SiPMs used for scintillation detection
- Much of the internal detail modelled on PICO 500
- Only added challenge is to keep it cold
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M. Laurin, UdeM
Ongoing work

- Vacuum jacket
- Pressure vessel
- Pressure bellows
- SiPM testing
A neutrino source

• Now need to find somewhere to produce these neutrinos

• Candidates:
  • Supernovae - high flux pulse, little control on timing
  • Stopped pion sources - controllable, but low flux
  • Reactors - huge flux but no on/off control
• SBC has investigated several reactor options

• With the projected threshold shown, could be a significant number of events

• Preliminary talks with Laguna Verde reactor in Mexico

L.J. Flores, E. Peinado, UNAM
What can we do?

• Improvement on statistics could be very important for future Ar dark matter experiments
• This process is also very dependent on $\sin^2\theta_W$, providing another way to constrain it
• This also means any non-standard interactions of neutrinos could be seen here…
… also we can look for dark matter
Multiple goals

- Having several goals means building several detectors
- First undergoing construction and commissioning at Fermilab, then to be used for CEvNS
- Second to be built at SNOLAB starting in 2021
The collaboration

- Canadian groups at Queen’s, University of Alberta, TRIUMF, Université de Montréal
- US groups at Northwestern, Fermilab, IUSB, UCSB, Drexel, NEIU, PNNL
- Mexican group at UNAM
Conclusions

• The SBC collaboration will be investigating both CE\nuNS and dark matter

• Vibrant group, always looking for collaborators

• Look for us in the future!