Introducing the SnowBall Chamber
Supercooled Water for Dark Matter and Neutron Detection
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SnowBall Chamber
• Detect incoming particle with phase transition from liquid to solid
• Similar to cloud, bubble chamber

Super Cooling:
• Liquid cooled below normal freezing point, metastable
• Impurities, scratches, or vibrations cause nucleation. [1]
• Spontaneous nucleation limit -48°C

Goals
• Demonstrate sensitivity to NR
• Explore low-mass dark matter and coherent neutrino scattering
• Explore use for detecting fissile materials for homeland security application: cargo monitoring

Methods
• The water filtered and distilled through 20 nm membrane
• Smooth quartz vessel to minimize nucleation sites
• AmBe as a neutron calibration source, Cs-137 source to demonstrate gamma discrimination
• The thermal bath is cooled at a rate of -2°C/min until the water freezes, then melted and brought back to the starting temperature before restarting.

Temperature Analysis
• Decrease in supercool time when the AmBe source is present w/ lead shielding compared to the control, 7.8σ significance.
• AmBe result is only significant when Pb shielding is used
• Cs-137 has had no discernable effect

Results

Temperature Analysis
Data from an actual event showing the spike in temperature from freezing.

Exothermic reaction implies low energy threshold

(left) Average supercool times showing a decrease with AmBe present
(right) Control and AmBe w/ Pb shielding separated into runs

Image Analysis:
• Lacking 3-D reconstruction, we focus on number of nucleation sites
• More multiple scatters in AmBe compared to control, 4.6% vs 20%, expected for neutrons in water
• AmBe w/ Pb and control only done so far

Conclusion
• Demonstrated neutron sensitivity
• Hints of high gamma discrimination
• Combination could make for ideal low-mass WIMP detector

Future Work
• Automate the image analysis
• Add additional camera for 3-D reconstruction
• Begin working towards a modular detector, multiple small volumes may increase live-time
• Create an emulsion for a supercooled droplet detector

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References