**Scintillating Bubble Chambers for WIMP detection**

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Scintillating bubble chambers are a compelling new technology for WIMP detection beyond the G2 program. These detectors combine the extreme electron rejection and simple instrumentation of a bubble chamber with the event-by-event energy resolution of a liquid scintillator. Two groups, led by Dahl at Northwestern University and Szydagis at the University at Albany, are actively pursuing R&D in scintillating bubble chambers. The Northwestern group recently made the first demonstration of simultaneous scintillation and bubble nucleation by low-energy nuclear recoils in superheated xenon [1], while the UAlbany group is pursuing superheated water bubble chambers to take advantage of advances in water-based scintillators, and also works on simulating electron rejection in scintillating bubble chambers [2].

The goal of the scintillating bubble chamber effort is the development of a detector with the scalability, target flexibility, and background discrimination needed to push WIMP sensitivity towards the neutrino floor (or follow-up a new signal) after the G2 program. This is made possible by a background discrimination capability orders of magnitude beyond the current leading technologies. The scintillating bubble chamber can be understood either as a PICO-style bubble chamber with incidental production and detection of scintillation light, providing an event-by-event energy signal that trivially identifies the alpha-decay and surface-chemistry backgrounds that have in the past hindered bubble chamber searches, or as a liquid-xenon chamber with S2/S1 discrimination replaced by “does-it-make-a-bubble” discrimination, a 107 improvement in electron recoil rejection that eliminates backgrounds from 85Kr, 214Pb, and solar neutrino electron scattering. Similarly, a liquid-argon bubble chamber can combine S1 pulse-shape and bubble-based discrimination to suppress the 39Ar background beyond what is possible in existing argon-based detectors, particularly at low (few-keVnr) thresholds.

The scintillating bubble chamber technique is now established in liquid xenon at the 30-gram scale [1], and the key next step is the construction of an *O*(10)-kg scale xenon bubble chamber to demonstrate the scalability of these detectors. Such a detector could be deployed at the Oak Ridge Spallation Neutron Source (SNS) to measure coherent scattering of neutrinos on xenon nuclei with the COHERENT collaboration. Several new institutions, including Drexel, RPI, Carleton, and Indiana University South Bend, have indicated specific interest in joining this program. This detector could be built on the 1-year time scale with a materials cost of ~$200k. This would also allow continued R&D investigating other liquid scintillators, including liquid argon, water, and (fluorinated-) hydrocarbons. This R&D can proceed on existing equipment (including the Northwestern chamber and the UAlbany 200-gram water prototype) and aims to deliver a comprehensive set of scintillating bubble chamber targets to probe spin-independent and spin-dependent coupling for WIMP masses down to the 1 GeV.



Figure 1: Sample nuclear recoil event from the Northwestern 30-gram xenon bubble chamber [1]. Clockwise from lower-left: (1) Pressure history for the event. (2) Image of the xenon target after bubble formation. Two views of the jar are used to reconstruct the 3-D position of the bubble. (3) Acoustic record of the event (blue) along with the camera exposure gate (magenta). Xenon PMT triggers appear as red circles, with the y-scale indicating the pulse-area in log-scale for each PMT hit. (4) Same as above, zooming in to the time of bubble formation. (5) Digitized PMT waveforms. The red waveform indicates the signal coincident with bubble formation, and the thin gray traces show the waveforms for the other triggers in the top-right plot. The ∼3-photoelectron pulse in this event is consistent with a low-energy nuclear recoil.

[1] D. Baxter *et al.* “First Demonstration of a Scintillating Xenon Bubble Chamber for WIMP and CENS Detection.” arXiv:1702.08861

[2] C. Levy *et al.* “Xenon Bubble Chambers for Direct Dark Matter Detection.” arXiv:1601.05131