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First Demonstration of a Scintillating Xenon Bubble Chamber for Dark Matter and CEνNS Detection

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A new type of particle detector which combines the advantages of liquid noble TPCs and superheated bubble chambers has been for the first time demonstrated with a 30-gram prototype scintillating liquid xenon bubble chamber operated at Northwestern University. The new technology has the potential, which is the aim of current ongoing work, to be virtually only sensitive to nuclear recoils at thermal noise limited thresholds. We have observed simultaneous bubble nucleation and scintillation by nuclear recoils in liquid xenon with the prototype chamber. The observed single- and multiple-bubble rates when exposed to a ^{252}Cf neutron source indicate that, for a thermodynamic "'Seit" threshold of 8.3 keV, the minimum nuclear recoil energy required to nucleate a bubble is between 11 and 25 keV. This is consistent with the observed scintillation spectrum for bubble-nucleating events. We see no evidence for bubble nucleation by gamma rays at the thresholds studied, setting a 90% CL upper limit of 6.3×10^{-7} bubbles per gamma interaction at a 4.2-keV thermodynamic threshold. This indicates stronger gamma discrimination than in $\mathrm{CF_3I}$ bubble chambers, supporting the hypothesis that scintillation production suppresses bubble nucleation by electron recoils, while nuclear recoils nucleate bubbles as usual. This chamber is instrumented with a CCD camera for near-IR bubble imaging, a solar-blind PMT to detect 175-nm xenon scintillation light, and a piezoelectric acoustic transducer to detect the ultrasonic emission from a growing bubble. The neutron and gamma measurements establish the noble-liquid bubble chamber as a promising new technology for WIMP and CEνNS detection.

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