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# Probing Sub-GeV Dark Matter with Superfluid Helium

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We propose a new dark matter detector that will be sensitive to nuclear recoils of sub-GeV dark matter, using superfluid helium as a target. Superfluid helium has many merits as a detector target: these include good kinematic matching to low mass dark matter, excellent intrinsic radiopurity, and its unique ability to be cooled down as a liquid to milli-Kelvin temperatures. We propose to read out the recoil signals by calorimetry based on transition edge sensor readout. Calorimeters submerged in the liquid will measure prompt scintillation photons with near-100% efficiency, while the long-lived rotons and phonon excitations will be detected by quantum evaporation of helium atoms from the liquid surface, into vacuum, and then onto a calorimeter array. The binding energy from helium absorption to the calorimeter surface allows for the amplification of these quantum evaporation signals, allowing sub-eV recoil energy thresholds. Taking into account the relevant backgrounds and detector discrimination power based on the light:heat ratio, sensitivity projections show that a small detector (∼kg scale) can already explore new parameter space.

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