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Probing Sub-Gev Dark Matter with Superfluid Helium-4

We propose a new technology for dark matter direct detection, using superfluid helium as the target material. Superfluid helium has many merits as a detector target: these include good kinematic matching to low mass dark matter, feasibility for achieving good intrinsic radiopurity, and its unique ability to be cooled down to milli-Kelvin temperatures while remaining as a liquid. To measure the 16 eV prompt scintillation photons, we will submerge novel calorimeteric photodetectors in the liquid, while rotons and phonons will be detected by quantum evaporating helium atoms off the liquid surface, into vacuum, and then onto a calorimeter. The binding energy from helium adsorption to the calorimeter surface allows for the amplification of these quantum evaporation signals, allowing us to potentially reach recoil energy thresholds down to 1 meV. Taking into account the relevant backgrounds and the detector discrimination power, sensitivity projections show that a small detector (~100g scale) can already explore new parameter space. I will discuss the technology and instrumentation underlying this proposal, as well as the work we are doing at UC Berkeley and UMass Amherst to advance this campaign, which includes measuring the nuclear recoil light yield of liquid helium and studying film burner technology.

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