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Fundamental and Applied Science with Rare Isotope Doped Superconducting Sensors (25+5)

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By leveraging many years of development by the materials science, quantum computing, astronomy, and AMO communities, we have entered an era where practical precision experiments are possible (and already taking data) in subatomic physics with superconducting sensors. These devices are characterized by their exceptionally high energy resolution and low thresholds for the detection of various types of radiation from the eV to MeV scale – particularly nuclear beta and electron capture (EC) decay which serve as sensitive probes of the structure and symmetries at the microscopic scale of our Universe. For the past few years, we have taken the approach of embedding rare isotopes in thin-film superconducting tunnel junctions (STJs) to precisely measure the recoiling atom that gets an eV-scale "kick"from the neutrino, electron, or photon. These recoils are encoded with the fundamental quantum information of the decay process, and carry unique signatures of weakly coupled beyond standard model (BSM) physics; including neutrino mass, exotic weak currents, and potential "dark"particles created within the energy-window of the decay. These measurements provide a complimentary and (crucially) model-independent portal to the dark sector with sensitivities that push towards synergy between laboratory and cosmological probes. In this talk, I will discuss the broad program we have developed to provide leading limits in these areas, the technological advances across several sub-disciplines of science required to enable this work, and future applications including biomedical sciences, nuclear safeguards, and computing.

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