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Closing the window for WIMPy inelastic dark matter with heavy nuclei

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The kinematics of WIMP dark matter-nuclear scattering is drastically altered in the presence of inelastic dark matter, where the dominant dark matter component is up-scattered to a heavier state with certain mass splitting. With hundreds of keV mass splitting inelastic dark matter will evade the search in most direct detection experiments, where the momentum transfer is limited either by the mass of target nuclei, or by the detector response. We propose a novel way to search for inelastic dark matter in nuclear decay searches. In such experiments, inelastic dark matter scattering may excite the isotopes to an excited state and the deexcitation gamma ray leaves detectable signals in the gamma ray detector. We illustrate the kinematics of inelastic dark matter in light of heavy nuclear targets, and derive the bound on inelastic dark matter from the induced excitation of hafnium and osmium isotopes. We also set the limit on inelastic dark matter nuclear scattering from the alpha decay search with CaWO_4 and PbWO_4 crystals, which extends to a mass splitting of 640 keV, much beyond the current limits from XENON1T and CRESST.

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