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Title: The XENON1T Electronic-Recoil Excess

Abstract: The nature of dark matter remains one of the biggest problems is modern physics, where it has remained elusive to decades of terrestrial experimentation. Our XENON collaboration has been operating a series of ultra-radiopure experiments to probe sub-keV momentum transfers, which may arise from cosmogenic particles. Traditionally, we search for WIMP dark matter, where our latest XENON1T experiment is the most sensitive such detector to date. Our data consists of either recoiling nuclei (e.g. WIMPs) or electrons, where a model-agnostic approach means that any excess or discovery may have multiple interpretations if only using XENON data. Even though XENON is primarily designed for observing nuclear recoils, the unprecedentedly low-radioactivity gives sensitivity to any new physical phenomena that may present itself via electronic recoils. Using our XENON1T data, we announced in June 2020 evidence (>3σ) of an electronic-recoil excess. Different interpretations of this excess were explored, ranging from new physics such as solar axions (3.5σ), a neutrino magnetic moment (3.2σ), or bosonic dark matter (3σ local, 4σ global), to detector effects such as tritium (3.2σ) or argon. This result cannot be interpreted in isolation as for some interpretations, for example, there is strong tension with stellar evaporation. Additionally, detector-oriented backgrounds such as tritium and argon have experimental physics reasons why these could not be the source. Accordingly, these has been extensive interest in the literature (>>120 papers) to find an explanation. I will review the field of dark-matter direct detection, present details on how XENON1T operated, provide details on this analysis, discuss interpretation

attempts, and inform on how our new XENONnT experiment may provide the answers we crave.