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Constraints on Spin dependent and Spin Independent Dark Matter-Electron Scattering

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Direct searches of dark matter (DM) through its scattering with electrons have been a rapidly growing field in the past decade. With the low-threshold capabilities of modern detectors in electron recoil (ER) and new ideas inspired by theoretical studies, the coverage of DM mass, $m\chi$, has gradually been extended from sub-GeV towards an increasingly lower reach. So far, most attention is given to the DM-electron interaction which is spin-independent (SI) of both DM and electrons. Various experiments have already set stringent exclusion limits on its cross-section, σ (SI) - e, in the mass range of MeV to GeV. The current best limit above 30 MeV is set by XENON1T for their huge exposure mass and time; in the range of 1–30 MeV, several experiments capitalizing the condensed phases of materials such as semiconductor silicon and germanium show potential improvements upon future scale-up. But, what about spin-dependent (SD) interactions? While there can be numerous models to motivate studies of SD DM-electron interactions from the top down, a more straightforward, bottom-up approach is through nonrelativistic (NR) effective field theory. For this purpose, one has to rely on theoretical analysis. In this work, we try to address the above questions using the atom, Germanium, and Xenon—where most calculations can be carried out using nonrelativistic effective field theory. Basically, we study DM-atom scattering through the SD and SI DM-electron interaction at leading order, using well-benchmarked, state-of-the-art atomic many-body approaches. Exclusion limits are derived from various data of xenon and germanium detectors. The sub-GeV dark matter is a less explored region and is highly motivated for next-generation experiments. Its studies complement the very active research on the SI and SD interactions, and together they can provide a more comprehensive understanding of the nature of DM and its interactions with matter.
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