



Contribution ID: 56

Type: Oral presentation (young scientists)

Fuelling the search for light dark matter-electron scattering

Tuesday, 19 July 2022 16:00 (10 minutes)

Dark matter (DM) detectors employing a Spherical Proportional Counter (SPC) have demonstrated a single-electron detection threshold and are projected to have small background rates. We explore the sensitivity to DM-electron scattering with SPC detectors in the context of DarkSphere, a proposal for a 300 cm diameter fully-electroformed SPC. SPCs can run with different gases, so we investigate the sensitivity for five targets: helium, neon, xenon, methane, and isobutane. We use tools from quantum chemistry to model the atomic and molecular systems, and calculate the expected DM induced event rates. We find that DarkSphere has the potential to improve current exclusion limits on DM masses above 4 MeV by up to five orders of magnitude. Neon is the best all-round gas target but using gas mixtures, where methane and isobutane constitute 10% of the gas, can improve the sensitivity, especially when combined with helium. Our study highlights the currently untapped potential of SPCs to search for DM-electron scattering in the MeV-to-GeV DM mass range.

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Session Classification: Parallel 2C - Direct detection II