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Broadening Direct Searches for Light Dark Matter

Abstract

Direct searches for low-mass DM were originally designed using the same conceptual picture as WIMP searches. However, over the last five years, the crucial role of in-medium effects has come into sharp focus. A new theoretical framework in the language of condensed matter physics has emerged for understanding the relationship between the properties of detector systems and their sensitivity to DM interactions. I will report on three recent advances that leverage this formalism to substantially broaden the design considerations for the next generation of experiments, and even extract new constraints from existing data. First, for DM-electron interactions, large new datasets generated by the materials science community have enabled the first data-driven search for optimal detector materials, which promises to significantly enhance the sensitivity of near-future experiments. Second, just as detectors designed to detect nuclear scattering have been used to study electronic scattering, I will explain how in-medium effects make the reverse possible as well, allowing us to set new limits on DM-nucleon scattering using the low-threshold detectors designed to detect electronic scattering. Third, with the advent of low-threshold detectors sensitive to energy deposits as low as 50 meV, we have finally entered the regime where the interaction rate can be significantly enhanced due to the geometry of the detector system. These three considerations promise to substantially accelerate the search for light DM in both mass and cross section over the coming years.