

The Cross-Disciplinary Hunt for Dark Matter: Machine Learning and Material Science Meet Astroparticle Physics

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The age of WIMP-like dark matter direct detection is drawing to a close due to their non-detection at exquisitely sensitive liquid-noble detectors. However, models where the dark matter is lighter than the mass of a proton remain largely inaccessible to existing probes. Recently, molecular targets have emerged as particularly well-suited detector materials to look for this sub-GeV dark matter. In this talk, I will show how theoretical techniques in chemistry and material science can be used to design searches that are sensitive to the best-motivated models of sub-GeV dark matter. I will review the latest development in molecule-based direct detection techniques and introduce how machine learning can be used to explore the vast and intractable space of potential materials, optimizing for theoretically-motivated electronic properties relevant to dark matter interactions. I will then present new constraints on sub-GeV dark matter from searches of molecular UV and IR signatures in gas and ice giants in the solar system. These astrophysical searches provide powerful new probes of unexplored parameter space and complement existing strategies for detecting dark matter.

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