Preface

The discovery of a standard model-like Higgs boson and the hitherto absence of evidence for other new states may indicate that if WIMPs comprise cosmological dark matter, they are heavy compared to electroweak scale particles, $M \gg m_{W^\pm}, m_{Z^0}$. In this limit, the absolute cross section for a WIMP of given electroweak quantum numbers to scatter from a nucleon becomes computable in terms of standard model parameters. Extending aspects of heavy particle formalism familiar from heavy quark effective theory, we develop heavy WIMP effective theory to isolate universal behavior within the WIMP paradigm.

We present ingredients necessary for this effective theory framework, including the formalism for bottom-up construction of heavy particle Lagrangians based on induced representations of the Lorentz group, the complete calculation of one- and two-loop weak-scale matching amplitudes, a consistent renormalization scheme in the presence of nontrivial residual masses, and the QCD framework for passing from the theory renormalized at the electroweak scale to the theory of quarks and gluons below the charm scale.

We analyze the heavy WIMP limit of WIMP-nucleon scattering and present the first complete calculation of the leading spin-independent cross section in standard model extensions consisting of one or two electroweak $SU(2)_W \times U(1)_Y$ multiplets, including a careful treatment of perturbative and hadronic-input uncertainties. The standard model exhibits a surprising transparency of nucleons to WIMP scattering, due to a cancellation between scalar and tensor amplitude contributions. The resulting cross-section predictions and their fractional uncertainties depend sensitively on parameter inputs, and we investigate the impact of model-independent inputs, such as perturbative QCD corrections and nucleon scalar matrix elements, and of model-dependent inputs, such as WIMP quantum numbers, additional electroweak multiplets, and extended Higgs sectors.

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