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Cross-sections and experimental signatures for collider, indirect, and direct detection of a well-defined dark matter WIMP

Using MadGraph, MadAnalysis, and Delphes, we have calculated the cross-sections and experimental signatures for detection of a well-defined dark matter WIMP [1-3] at proton, electron-positron, and muon colliders. At the 14 TeV high-luminosity LHC the cross-section for creation of a pair of these WIMPs is about 20 fb, and the background in missing transverse energy, invariant mass, and pseudorapidities is often orders of magnitude higher than the signal, with a total cross-section of about 400 pb. But after appropriate cuts the background is almost entirely removed, with a reduction in signal of about a factor of 3, implying that observation of this particle at the high-luminosity LHC should be barely possible after its operation begins in 2029. At the planned 100 TeV proton collider, the cross-section for creation is about 800 fb, but much more severe cuts will be required. At the planned 10 TeV muon collider, the cross-section is about 175 fb with well-defined peaks in pseudorapidity at about ± 2.5. Using micrOMEGAs, in a fit to the observed relic abundance, we have determined the mass of this WIMP to be about 70 GeV/c^2 and the indirect detection annihilation cross-section to be given by $\langle \sigma_{ann} v \rangle \approx 1.2 \times 10^{-26}$ cm^3/s. Finally, we have calculated the cross-section per nucleon for direct detection as a function of the form factor and the effective quark masses in loop diagrams. If these are taken to be the current masses, the cross-section σ_{dir} is well below the onset of the neutrino fog, but if they are taken to be about the same as in Higgs-mediated scattering, σ_{dir} rises to $\sim 10^{-12}$ pb.

[1] Reagan Thornberry et al., EPL [Europhysics Letters] 134, 49001 (2021), arXiv:2104.11715.
[2] Bailey Tallman et al., proceedings of ICHEP 2022, arXiv:2210.05380.
[3] Bailey Tallman et al., LHEP-342 (2023), arXiv:2210.15019.

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