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Singlet fermionic dark matter and Veltman conditions

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We reexamine a renormalizable model of a fermionic dark matter with a gauge singlet Dirac fermion and a real singlet scalar which can ameliorate the scalar mass hierarchy problem of the Standard Model (SM). Our model setup is the minimal extension of the SM for which a realistic dark matter (DM) candidate is provided and the cancellation of one-loop quadratic divergence to the scalar masses can be achieved by the Veltman condition (VC) simultaneously.
This model extension, although renormalizable, can be considered as an effective low-energy theory valid up to cut-off energies about 10 TeV. We calculate the one-loop quadratic divergence contributions of the new scalar and fermionic DM singlets,and constrain the model parameters using the VC and the perturbative unitarity conditions.
Taking into account the invisible Higgs decay measurement, we show the allowed region of new physics parameters satisfying the recent measurement of relic abundance. With the obtained parameter set, we predict the elastic scattering cross section of the new singlet fermion into target nuclei for a direct detection of the dark matter. We also perform the full analysis with arbitrary set of parameters without the VC as a comparison, and discuss the implication of the constraints by the VC in detail.

Primary author: Dr NAM, Soo-hyeon (Korea University)

Co-authors: Dr KIM, Yeong Gyun (Gwangju National University of Education); Dr LEE, Kang Young (Gyeongsang National University)

Presenter: Dr NAM, Soo-hyeon (Korea University)

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