

# Vector Dark Matter From Hidden Gauge Symmetry : $U(1)_D$ and $SU(2)_D$

*Tuesday, 19 August 2025 19:55 (5 minutes)*

We present a unified study of vector dark matter (VDM) from hidden gauge symmetries  $U(1)_D$  or  $SU(2)_D$ . Starting from the renormalizable Higgs-portal UV theory for VDM with a dark Higgs field, we integrate out the radial mode of the dark Higgs to derive the leading low-energy interactions for Higgs-portal VDM, which are constrained into the validity domain in the UV theory. We also make the VDM stability realized: for  $U(1)_D$ , a dark charge-conjugation (residual  $Z_2$ ) forbids VDM from decaying; for  $SU(2)_D$ , a residual/custodial symmetry similarly stabilizes the lightest state of VDM. While the Higgs-portal EFT for VDM looks similar in both cases, non-abelian self-interactions of  $SU(2)_D$  qualitatively modify the thermal history relative to  $U(1)_D$ . Finally, we show how the isospin representation of the dark Higgs that breaks  $SU(2)$  controls the VDM mass spectrum and the VDM–dark-Higgs interactions, and how this feeds into the relic density and phenomenology, highlighting the representation-dependent signatures.

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**Session Classification:** Poster session