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Extending 2HDM by a singlet scalar field - the case for dark matter

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We extend the two-Higgs doublet models of Type I and Type II by adding a real gauge-singlet scalar S which is the Dark Matter (DM) candidate (2HDMS models). We impose theoretical constraints derived from perturbativity, stability, unitarity and correct electroweak symmetry breaking and require that the lightest CP-even Higgs, h, fit the LHC data for the $\sim$ 125.5 GeV state at the 68%˜C.L. after including existing constraints from LEP and B physics and LHC limits on the heavier Higgs bosons. We find that these models are easily consistent with the LUX and SuperCDMS limits on DM-Nucleon scattering and the observed DM abundance for S masses above about 55 GeV. At lower m_S, the situation is more delicate. For points with m_S in the $6-25$ GeV range corresponding to the CDMS II and CRESST II positive signal ranges, the DM-Nucleon cross sections predicted by the Type I and Type II models more or less automatically fall within the $95\%-99\%$ C.L. signal region boundaries. Were it not for the LUX and SuperCDMS limits, which exclude all (almost all) such points in the case of Type I (Type II), this would be a success for the 2HDMS models. In fact, in the case of Type II there are a few points with $5.5\ \mathrm{GeV} < m_S < 6.2\ \mathrm{GeV}$ that survive the LUX and SuperCDMS limits and fall within the CDMS II 99% C.L. signal region. Possibilities for dark matter to be isospin-violating in this 2HDMS context are also examined.

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