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Various perspectives of Two Higgs Doublet models and Naturalness criteria.

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We study the implication of a criterion of naturalness for a broad class of two Higgs doublet models (2HDMs). In particular, we assume the cancellation of quadratic divergences in what are called the type I, type II, lepton-specific and flipped 2HDMs. This results in a set of relations among masses of the physical scalars and coupling constants, a generalization of the Veltman conditions of the Standard Model. With a softly broken $U(1)$ symmetry, we have studied the various limiting values of the scalar mixing angles α and β. These correspond to the Standard Model Higgs particle being the lighter CP-even scalar (alignment) or the heavier CP-even scalar (reverse alignment), and also the limit in which some of the Yukawa couplings of this particle are of the opposite sign from the vector boson couplings (wrong sign). Imposing further the constraints from the electroweak T-parameter (or ρ parameter), stability and perturbative unitarity conditions produce a range for the masses of each of the remaining physical scalars. We also calculate the $h \rightarrow \gamma\gamma$ decay rate in the wrong sign limit.

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