

Multi-Higgs models with softly broken large discrete symmetry groups

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We develop methods to study the scalar sector of multi-Higgs models with large discrete symmetry groups that are softly broken. While in the exact symmetry limit, the model has very few parameters and can be studied analytically, proliferation of quadratic couplings in the most general softly broken case makes the analysis cumbersome. We identify two sets of soft breaking terms which play different roles: those which preserve the symmetric vacuum expectation value alignment, and the remaining terms which shift it. Focusing on alignment preserving terms, we check which structural features of the symmetric parent model are conserved and which are modified. We find remarkable examples of structural features which are inherited from the parent symmetric model and which persist even when no exact symmetry is left. The general procedure is illustrated with the example of the three-Higgs-doublet model with the softly broken symmetry group $\Sigma(36)$, A_4 , and S_4 . In some special cases we find stable Dark Matter candidates.

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