

Approximate alignment without decoupling in the 2HDM naturally

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The 2HDM scalar potential governed by a generalized CP symmetry (called GCP3) is known to yield natural Higgs alignment independently of $\tan(\beta)$. Nevertheless, such a model does not yield a realistic extended Higgs sector for two reasons. First, the model possesses an axion associated with the electroweak scale, which has long been ruled out by data. Second, the GCP3 symmetry cannot be extended to the Yukawa sector in a way consistent with the flavor sector. Both problems can be alleviated by introducing vector like quarks. Mass terms associated with the vector like quark sector provide soft-breaking of the GCP3 symmetry thereby avoiding the presence of the axion. Moreover, the GCP3 symmetry can be used to connect the SM quarks to the vector like quarks, while preserving the SM flavor structure (up to small mixing between the quarks and their vector-like partners). The naturalness of the Higgs alignment, which is now approximate due to soft-breaking effects, is preserved as long as the UV cutoff of the theory is not too large.

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