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Theoretical constraints on beyond Standard Model extensions of the Higgs potential

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Abstract

A standard requirement in quantum field theories is that their potential is lower-bounded, such that no direction in the Phi field space leads to $V(Phi)to - infty$. This work presents a comprehensive study and comparison of the relative restrictiveness of conditions constraining scalar potentials in extensions of the Higgs sector. We illustrate our study on the potential parameters with two particular Higgs sector extensions: the Real Singlet Extension (RSE) and the Two-Higgs-Doublet Model (2HDM), separating $mathbb{Z}_{2}$-conserving and $mathbb{Z}_{2}$-violating cases. In order to do this, we derive and compare these conditions to other studies found in the literature. Additionally, we develop a publicly available code that allows the user to perform a numerical analysis of the positivity conditions for rather involved scenarios (e.g., the $mathbb{Z}_2$ violating case). Finally, we apply those restrictions to the physical parameters and deduce an upper and a lower bound on the masses of new heavy scalars.

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