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Can a Pseudoscalar with a Mass of 365 GeV in Two-Higgs-doublet Models Explain the CMS $t\bar{t}$ Excess?

by

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ALL INTERESTED ARE WELCOME
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Abstract

We investigate the recently reported $t\bar{t}$ excess by the CMS Collaboration within the framework of conventional Two-Higgs-Doublet Models (2HDMs). Considering all four types (I, II, X, and Y), we perform a comprehensive parameter space scan using the best-fit values for a pseudoscalar boson A: M_A = 365 GeV, Γ_A/M_A = 2%, and $\tan\beta$=1.28. Theoretical requirements and experimental constraints are systematically applied, including conditions from a bounded-below scalar potential, vacuum stability, unitarity, perturbativity, Flavor-Changing Neutral Currents (FCNCs), and direct searches at high-energy colliders. Our analysis shows that perturbativity imposes upper bounds of around 723 GeV on $M_{H^\pm}$ and M_H. FCNC constraints exclude all viable parameter space in Types II and Y, while a small region persists in Types I and X, but this region is ultimately ruled out by recent $t\bar{t}Z$ measurements by the ATLAS and CMS Collaborations at the LHC. We conclude that conventional 2HDMs alone cannot accommodate a pseudoscalar boson that explains the observed $t\bar{t}$ excess within the viable parameter space. However, incorporating toponium effects in the background fit could potentially alter this conclusion.

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