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Z' limits and naturalness in $U(1)$ extended models

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Non-minimal supersymmetric models are able to solve some of the naturalness problems of the minimal supersymmetric standard model (MSSM), such as the need for large radiative corrections to accommodate a 125 GeV Higgs. Models with an additional $U(1)'$ symmetry at low energies may raise the tree level Higgs mass through F- and D-term contributions, reducing the need for such corrections, and also allow for the solution of the MSSM μ problem. On the other hand, in one example of such a $U(1)$ extension, the exceptional supersymmetric standard model (E_6SSM), it has been found that a new tree level fine tuning arises due to large experimental limits on the Z' mass in this model. We investigate the fine tuning associated with these limits in a wider class of $U(1)$ extended models that are based on an underlying E_6 symmetry at the grand unification (GUT) scale. We adopt a conservative approach in which the soft parameters are set at low energies, thus removing any tuning that comes from assumptions about how SUSY is broken. In this case, we find that increasing the limits on the Z' mass increases the fine tuning, highlighting the importance of Z' searches at run II of the LHC for constraining naturalness in these models. In general, the severity of this tuning depends rather strongly on the choice of $U(1)'$ charges. As a result, models such as the $U(1)_I$ inert model are able to satisfy current Z' mass limits without having a large fine tuning, while in others the limits are already strong enough that a moderate degree of tuning is required.

Primary author: HARRIES, Dylan (University of Adelaide)

Co-authors: Prof. WILLIAMS, Anthony (University of Adelaide); ATHRON, Peter

Presenter: HARRIES, Dylan (University of Adelaide)

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