13th Annual Meeting of the Helmholtz Alliance ”Physics at the Terascale”

Contribution ID: **1** Type: **not specified**

Light stops, heavy gluinos, and a novel solution to the little hierarchy problem

Tuesday 26 November 2019 11:30 (15 minutes)

Radiative corrections with new heavy particles coupling to Higgs doublets destabilize the electroweak scale and require an ad-hoc counterterm cancelling the large loop contribution. If the mass scale m1 of these new particles in in the TeV range, this feature constitutes the "little fine-tuning problem". We consider the case that the new-physics spectrum has a little hierarchy with two particle mass scales m1, m2 and m2 = O(10 m1) and no tree-level couplings of the heavier particles to Higgs doublets. As a concrete example we study the (next-to-)minimal supersymmetric standard model ((N)MSSM) for the case that the gluino mass M3 is significantly larger than the stop mass parameters m_{L,R} and show that the usual one-loop fine-tuning analysis breaks down. If m_{L,R} is defined in the dimensional-reduction (DR-bar) or any other fundamental scheme, corrections enhanced by powers of M3^2/m_{L,R}^2 occur in all higher loop orders. After resumming these terms we find the fine-tuning measure substantially improved compared to the usual analyses with M3 <~ m_{L,R}. In our hierarchical scenario the stop self-energies grow like M3^2, so that the stop masses m_{L,R}^{OS} in the on-shell (OS) scheme are naturally much larger than their DR-bar counterparts m_{L,R}^{DR-bar}. This feature permits a novel solution to the little fine-tuning problem: DR-bar stop masses are close to the electroweak scale, but radiative corrections involving the heavy gluino push the OS masses, which are probed in collider searches, above their experimental lower limits. As a byproduct, we clarify which renormalization scheme must be used for squark masses in loop corrections to low-energy quantities such as the B-B-bar mixing amplitude.

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Session Classification: Physics beyond the SM