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A probabilistic approach to the hierarchy problem

In this work, we provide a simple model that studies the probability to obtain a given hierarchy between two scales. In particular, we work in a theory with a light $SU(2)_L$ sector and a heavy $SU(2)_H$ sector, and two scalar doublets with each one corresponding to one sector. Furthermore, both sectors can interact by means of a $U(1)_X$. By the Coleman-Weinberg mechanism, the gauge bosons and scalars obtain different masses. We analyze the mass ratio of these sectors in order to discuss the hierarchy between them, and we define a probability associated to this hierarchy. We study different cases in which one of the sectors is fixed or both of them have free parameters, and also consider the effect of including an interaction between them. We conclude that the probability of obtaining very large hierarchies is (logarithmically) small but not negligible. In this toy model some interesting situations are provided, for example, our result could be applied to a theory with a known low-energy sector and an additional weakly-interacting heavy dark sector.

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