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The spontaneous $\mathbb{Z}_2$ breaking Twin Higgs

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The Twin Higgs model seeks to address the little hierarchy problem by making the Higgs a pseudo-Goldstone of a global $SU(4)$ symmetry that is spontaneously broken to $SU(3)$. Gauge and Yukawa couplings, which explicitly break $SU(4)$, enjoy a discrete $\mathbb{Z}_2$ symmetry that accidentally maintains $SU(4)$ at the quadratic level and therefore keeps the Higgs light. Contrary to most beyond the Standard Model theories, the quadratically divergent corrections to the Higgs mass are cancelled by a mirror sector, which is uncharged under the Standard Model groups. However, the Twin Higgs with an exact $\mathbb{Z}_2$ symmetry leads to equal vevs in the Standard Model and mirror sectors, which is phenomenologically unviable. An explicit $\mathbb{Z}_2$ breaking potential must then be introduced and tuned against the $SU(4)$ breaking terms to produce a hierarchy of vevs between the two sectors. This leads to a moderate but non-negligible tuning. We propose a model to alleviate this tuning, without the need for an explicit $\mathbb{Z}_2$ breaking sector. The model consists of two $SU(4)$ fundamental Higgses, one whose vacuum preserves $\mathbb{Z}_2$ and one whose vacuum breaks it. As the interactions between the two Higgses are turned on, the $\mathbb{Z}_2$ breaking is transmitted from the broken to the unbroken sector and a small hierarchy of vevs is naturally produced. The presence of an effective tadpole and feedback between the two Higgses lead to a sizable improvement of the tuning. The resulting Higgs boson is naturally very Standard Model like.

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