

High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries

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We explore a class of axion models where an accidental $U(1)$ Peccei-Quinn (PQ) symmetry automatically arises from the interplay of vertical (grand-unified) and horizontal (flavor) gauge symmetries. Focusing on a specific $SO(10)$ or Pati-Salam realization, we analyze the quality of the PQ symmetry and demonstrate that the model non-trivially reproduces the Standard Model flavor structure. A high-quality axion, immune to the PQ quality problem, is obtained for $m_a \approx 0.01$ eV, corresponding to a post-inflationary PQ-breaking scenario. A distinctive feature of this setup is the presence of parametrically light fermions, known as anomalous, introduced to cancel the gauge anomalies of the flavor symmetry. We investigate their cosmological production in the early universe, highlighting how measurements of ΔN_{eff} could serve as a low-energy probe of the UV dynamics addressing the PQ-quality problem.

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