

Exploring the Landscape of Spontaneous CP Violation in Supersymmetric Theories

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The strong CP problem remains one of the most significant unresolved issues in the Standard Model. A promising approach is to assume that CP is an exact symmetry of the Lagrangian, broken spontaneously by the vacuum. Supersymmetry (SUSY) provides a natural framework for such scenario, offering both protection of hierarchies and flat directions where spontaneous CP violation (SCPV) can occur. However, realizing physical CP-violating phases in concrete models is generally nontrivial and highly model-dependent. In this work, we study the stabilization of CP-violating phases in two distinct SUSY scenarios. First, we investigate SCPV by SUSY-conserving dynamics, extending the group-theoretic spurion formalism and introducing a method to determine whether the necessary condition for SCPV is satisfied only from the superpotential. Second, we construct a model in which CP is spontaneously broken along an approximate flat direction, stabilized by soft SUSY-breaking and non-perturbative effects. This setup predicts light pseudo-Goldstone bosons with masses determined by the SUSY-breaking scale. Our results provide a unified view of SCPV in SUSY theories and offer practical tools for realistic model building.

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