

Paths to Solving the Strong CP Problem and the Footprints Left Behind

We explore two major approaches to the strong CP problem, the axion solution and spontaneous CP violation (SCPV). We first focus on composite axion models, which provide a compelling realization of the axion solution but face serious cosmological challenges, in particular the domain wall problem. We present a new framework based on a special embedding of gauge symmetries, where the domain wall number is reduced to unity in the ultraviolet theory, and small instanton effects induce a controlled bias term that lifts the vacuum degeneracy and allows domain walls to decay without spoiling the axion solution. We then turn to the axionless approach based on SCPV, where CP is an exact symmetry of the Lagrangian and is broken only spontaneously. In supersymmetric theories, SCPV can be realized along flat directions and stabilized by supersymmetry-breaking and non-perturbative dynamics, and the framework is compatible with viable cosmology including Affleck–Dine baryogenesis. These mechanisms provide distinct paths to resolving the strong CP problem with testable implications.

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