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Variant Nelson-Barr Mechanism with Minimal Flavor Violation

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Within the general framework of using spontaneous CP violation to solve the strong CP problem, we construct a variant Nelson-Barr model in which the Standard Model (SM) quark contribution to the strong CP phase is cancelled by new heavy QCD-charged fermions. This cancellation is ensured by choosing conjugate representations for the new colored states under the same global flavor symmetry of SM quarks. Choosing the global flavor symmetry to be that of minimal flavor violation, we suppress higher-order corrections to the strong CP phase to well below current experimental constraints. More than two dozen massless Goldstone bosons emerge from spontaneous flavor symmetry breaking, which yield strong astrophysical constraints on the symmetry breaking scale. In the early universe, the Goldstone bosons can be thermally produced from their interactions with the heavy colored fermions and contribute to ΔNeff at a measurable level. As a function of reheating temperature, the predicted ΔNeff shows an interesting plateau behavior we dub the "flavor stairway", which encodes information about the SM quark flavor structure.

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