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CP violation and cold electroweak baryogenesis in the Standard Model

Generating sufficient amount of CP violation that would account for the observed matter-antimatter asymmetry in the universe is a long-standing problem in particle physics. It is a common lore that new physics beyond the Standard Model is needed for this purpose. This claim is based on earlier perturbative estimates of effective CP violation in the bosonic sector of the Standard Model induced by the quark CKM mixing as well as on the fact that the current lower limit on the Higgs boson mass rules out the possibility of a strongly first-order electroweak phase transition. We argue that within the cold electroweak baryogenesis scenario, there is still space for the baryon asymmetry to be generated solely from known electroweak physics. Sakharov's condition of being sufficiently far off equilibrium is satisfied by coupling the Higgs boson to a new field such as the inflaton. It is this coupling rather than a thermal electroweak transition what triggers the change of the sign of the Higgs boson mass squared in the fast expanding early universe. On the Standard Model side, we further develop the program initiated by Shaposhnikov, Smit, and others. We carry out a nonperturbative calculation of the lowest effective CP violating operator in the boson sector at nonzero temperature. By inspecting the temperature dependence of the effective coupling, we conclude that sizeable CP violation can be achieved, and sufficient baryon asymmetry thus generated, at temperatures of the order of the charm quark mass.

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