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Discrete Flavor Symmetries and Origin of CP Violation

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We discuss the origin of CP violation in settings with a discrete (flavor) symmetry G. We show that physical CP transformations always have to be class-inverting automorphisms of G. This allows us to categorize finite groups into three types: (i) Groups that do not exhibit such an automorphism and, therefore, in generic settings, explicitly violate CP. In settings based on such groups, CP violation can have pure group-theoretic origin and can be related to the complexity of some Clebsch-Gordan coefficients. (ii) Groups for which one can find a CP basis in which all the Clebsch-Gordan coefficients are real. For such groups, imposing CP invariance restricts the phases of coupling coefficients. (iii) Groups that do not admit real Clebsch-Gordan coefficients but possess a class-inverting automorphism that can be used to define a proper (generalized) CP transformation. For such groups, imposing CP invariance can lead to an additional symmetry that forbids certain couplings. We make use of the so-called twisted Frobenius-Schur indicator to distinguish between the three types of discrete groups. We present one explicit example for each type of group, thereby illustrating the CP properties of models based on them. We also show that certain operations that have been dubbed generalized CP transformations in the recent literature do not lead to physical CP conservation.

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