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Stringy origin of modular flavor symmetry and spontaneous CP violation

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We examine a common origin of four-dimensional flavor, CP, and $U(1)_R$ symmetries in the context of heterotic string theory with standard embedding. We find that flavor and $U(1)_R$ symmetries are unified into the $Sp(2h + 2, \mathbb{C})$ modular symmetries of Calabi-Yau threefolds with h being the number of moduli fields. Together with the \mathbb{Z}_2^{CP} CP symmetry, they are enhanced to $GSp(2h + 2, \mathbb{C})$ generalized symplectic modular symmetry.

We exemplify the S_3, S_4, T', S_9 non-Abelian flavor symmetries on explicit toroidal orbifolds with and without resolutions and \mathbb{Z}_2, S_4 flavor symmetries on three-parameter examples of Calabi-Yau threefolds. Thus, non-trivial flavor symmetries appear in not only the exact orbifold limit but also a certain class of Calabi-Yau threefolds. These flavor symmetries are further enlarged to non-Abelian discrete groups by the CP symmetry. We also discuss the spontaneous CP violation in the context of Calabi-Yau flux compactifications.

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