

Anomaly-free model building: algebraic geometry and the Froggatt-Nielsen mechanism (11+3)

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We present methods to find anomaly-free gauged $U(1)$ Froggatt-Nielsen type models using results from real algebraic geometry. These methods should be of general interest for model building beyond the Standard Model when rational charges are required. We consider models with a gauged $U(1)$ flavour symmetry with one flavon and provide several model examples based on different physical assumptions. Necessary conditions for these models to be free from gauge anomalies are derived and we show that the field content of the Standard Model is not sufficient and thus additional fields are needed. Two such extensions are considered; two Higgs doublets and right-handed neutrinos providing Dirac masses. With these extensions, the fermion masses and mixings in the Standard Model, including neutrinos, can in great part be explained.

Moreover, we show that the UV-behaviour of these models are in general plagued by Landau poles. Two different UV-completions are considered; through vector-like fermions and through Higgs doublets. In the fermion completion, the gauge couplings are in general plagued with Landau poles while in a scalar completion this may be avoided, but instead the quartic couplings generally blow up. Thus, the generic case is that neither completion works, but the scalar completion might be saved by appropriate choice of parameters in the scalar potential. This conclusion does not change if we allow $U(1)$ to be anomalous or global.

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