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Multi-Higgs model with Abelian and non-Abelian discrete symmetries

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Abstract.

Usually in the context of the standard model and its multi-Higgs extensions the fermions mass matrices has the form $M_{\alpha\beta} = \sum_i (\Gamma_i)_{\alpha\beta}\langle\Phi^0_i\rangle$, where Γ_i denotes an arbitrary complex dimensionless 3×3 matrices (for Majorana it is symmetric), and $\langle\Phi^0_i\rangle$ denotes the set of vacuum expectation values (VEVs) of one or more neutral scalar field. The mixing matrix and the mass pattern of each charged sector depend on the structure of the respective Γ_i's. It is well known that explicit, and predictive, forms of these matrices can be obtained by imposing flavor symmetries.

Here we will turn the problem upside down. Mass matrices will be of the form $M_{\alpha\beta} = f(\overline{\langle\Phi^0\rangle})_{\alpha\beta}$,where f denotes some dimensionless ($\mathcal{O}(1)$) parameters. In general we need at most two f's and $\overline{\langle\Phi^0\rangle}_{\alpha\beta}$ is a matrix built with the VEVs of several scalar fields. At first sight, there is no gain in predictive power, we are just changing a dimensionless general matrix $\Gamma_{\alpha\beta}$ by another one with mass dimension $(\overline{\langle\Phi^0\rangle})_{\alpha\beta}$. However it seems easier, at least in principle, to explain patterns of dynamical variables like VEVs, than dimensionless numbers. The value of the former can be explained by the dynamics (for instance by studying the scalar potential) and extra flavor symmetries that we can impose to the model.

Therefore, we propose a multi-Higgs extension of the standard model with $A_4\otimes Z_3\otimes Z'_3\otimes Z''_3$ symmetries in which the mass matrices of the charged fermions, obtained from renormalizable interactions, are diagonal. Corrections induced by non-renormalizable interactions deviate these matrices from the diagonal form. Active neutrinos acquire mass only from non-renormalizable interactions. The main entries of the neutrino mass matrix arise only through dimension five operators, while the diagonal entries arise only from dimension six operators.

The basic idea is to consider $SU(2)_L$ fermions doublets in the triplet representation of the A_4 symmetry and Higgs doublets or right-handed fermions, singlet under the gauge symmetry, transforming as triplet or singlet of A_4. The predictive power is a consequence of the discrete symmetries imposed to the model: $A_4\otimes Z_3\otimes Z'_3\otimes Z''_3$.

In conclusions, the mass matrices obtained, which arise because of the symmetry of the model, give appropriate insight concerning the solution of the flavor problem. Of course, it is necessary to explain how these symmetries are realized from a more fundamental theory.