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Renormalization Group Evolution of Neutrino Mass Parameters

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In order to compare predictions for neutrino masses, mixings and CP phases from high-energy theories with experimental results, it is necessary to take the Renormalization Group (RG) running of these quantities into account. We present techniques for calculating the relevant Renormalization Group Equations (RGE's) in various models and show numerical examples.

We study the evolution of the effective neutrino mass matrix of the light neutrinos from the GUT scale to the electroweak scale in see-saw models. We present the calculation of the RGE's for the dimension 5 neutrino mass operator [1–3], which govern the running of the neutrino mass matrix below the lowest see-saw scale. In the energy ranges between the GUT scale and the lowest see-saw scale, various effective theories arise from integrating out the heavy singlets at their mass thresholds [4].

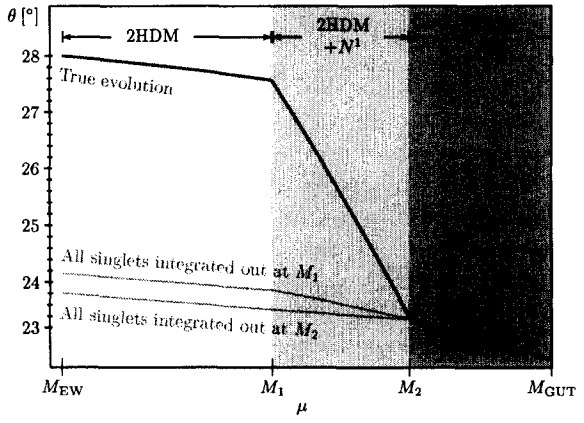

Figure 1. Evolution of the mixing angle θ in a 2 Higgs Doublet Model with 2 generations. For examples for the SM and the MSSM see [4].

In a numerical analysis for two lepton doublets and two singlets, we have found that the RG evolution of the mixing angle in the case where the heavy degrees of freedom are integrated out appropriately differs substantially from the case where all of them are integrated out at a common scale [4] (figure 1). The gray-shaded regions mark the various effective theories. The kinks in the evolution of the mixing angle correspond to the mass thresholds at the see-saw scales.

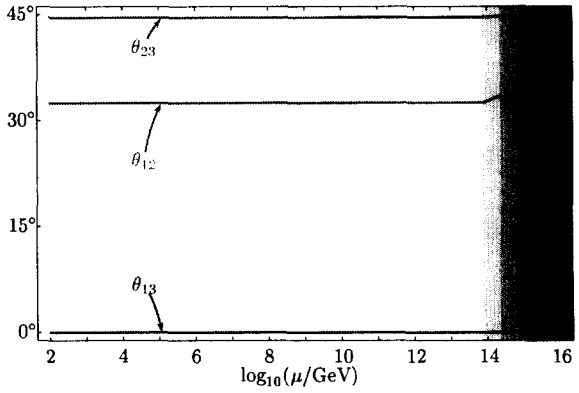

Figure 2. Typical example for the evolution of the mixing angles in the SM. Further examples – also for the MSSM – can be found in [5].

In a study with 3 neutrino flavours, we show that the experimentally favored neutrino mass parameters, with maximal θ_{23}, small θ_{13} and $\theta_{12} \approx 33°$ given by the LMA solution of the solar neutrino problem, can be obtained in a natural way from bimaximal mixing at the GUT scale by RG running (figure 2). A generic feature of the RG evolution with zero CP phases is that the solar mixing angle θ_{12} evolves sizably, whereas the change of θ_{13} and θ_{23} is comparatively small [5].

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