Neutrino Mass Matrix at GUT Scale and its Related Topics

T. Miura, T. Sindou and E. Takasugi

Department of Physics, Osaka University
Toyonaka, Osaka 560-0043, Japan

From the atomosphric and the solar neutrino data, we explore the neutrino mass matrix at GUT scale (M_R), just after the neutrino mass matrix is derived by the see-saw mechanism. We examine a class of models such that $V_{13} = 0$ at GUT scale where there are two mixing angles (θ_{12} and θ_{23}, three masses and two Majorana CP phases at GUT scale. (No Dirac CP violation phase because $\theta_{13} = 9$.) Therefore, $|V_{13}|$ and a Dirac phase δ are induced by the radiative correction following the renormalization group.

As a general feature, we found that $\tan^2\theta_{12}(M_R) \leq \tan^2\theta_{12}(m_Z) \equiv \tan^2\theta_{\rm sol}$. The SNO data implies that $\tan^2\theta_{\rm sol} \sim 0.34$ which is much less than the maximal value 1. Therefore, the mixing angle $\tan^2\theta_{12}(M_R)$ must be much less than 1. Even the small mixing angle $\theta_{12}(M_R)$ can reproduce the solar neutrino data. As a conclusion, the model which predicts the Bi-maximal mixing at M_R scale is not accepted.

If we use the neutrino oscillation data, $\sin^2 2\theta_{\rm sol}$, $\sin^2 2\theta_{\rm atm}$, $\Delta m^2_{\rm sol}$ and $\Delta m^2_{\rm atm}$, $|V_{13}|$ and the effective mass of the double beta decay $< m_\nu >$ are determined by $M_1(M_R)$ and $\sin\theta_{12}(M_R)$. In order to determine the value of δ, we need the information of a Majorana phase, which will be determined by considering the leptogenesis. In particular, if neutrino mass $M_1 \sim 0.05$ eV, $|V_{13}| \sim 0.05$ and $< m_\nu > \sim 0.02$ eV are expected.