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Super-kam, SNO

LMA-MSW 解

$\Delta m^2_{\odot} \simeq 5\times10^{-5}\,eV^2$, $\tan^2\theta_{\odot} = 0.34$

$\theta_{\odot} \simeq 30^\circ$

$\Delta m^2_{atm} \simeq 2.5\times10^{-3}\,eV^2$, $\sin^2 2\theta_{atm} \simeq 1$

$$\frac{\Delta m^2_{\odot}}{\Delta m^2_{atm}} \simeq \frac{1}{50}$$

- Hierarchy $(m_3 \gg m_2 \gg m_1)$

  $\frac{m_2}{m_3} \simeq \frac{1}{\eta} \simeq 0.14$ $\left(\frac{m_\mu}{m_\tau} \simeq 0.06 \;,\; \sqrt{\frac{m_\mu}{m_\tau}} \simeq 0.24\right)$

- Degenerate $(m_3 \simeq m_2 \simeq m_1)$

  $m_3 \simeq m_0 + \delta \quad m_2 = m_0 + \varepsilon \quad m_1 = m_0$

  $2m_0\delta \simeq 2.5\times10^{-3}\,eV^2 \quad 2m_0\varepsilon = 5\times10^{-5}\,eV^2$

  taking $m_0 = 0.5\,eV \quad \delta = 2.5\times10^{-3}\,eV \quad \varepsilon = 5\times10^{-5}\,eV$

  $\varepsilon/\delta = 1/50$

- Inverse Hierarchy $(m_2 \simeq m_1 \gg m_3)$

  $m_1 \simeq \sqrt{2.5\times10^{-3}}\,eV \simeq 0.05\,eV$

  $m_2 \simeq m_1 + \varepsilon \quad \varepsilon = 5\times10^{-4}\,eV$

Mixings and phases

$\theta_{12}, \theta_{23}, \theta_{13}, \phi, \rho, \sigma$

- 2×2 Mass Matrix

  2つの固有値と 1つの Angle simple!

- 3×3 Mass Matrix

  Frampton, Glashow, Marfatia

$M_{ab} = 0 \quad M_{\alpha\beta} = 0 \qquad M = U^* \begin{pmatrix} \lambda_1 & & \\ & \lambda_2 & \\ & & \lambda_3 \end{pmatrix} U^\dagger$

$\lambda_1 = m_1 e^{2i\rho} \quad \lambda_2 = m_2 e^{2i\sigma} \quad \lambda_3 = m_3$

$$\sum_{i=1}^{3} (U_{a1} U_{b1} \lambda_1) = 0 \qquad \sum_{i=1}^{3} (U_{\alpha 1} U_{\beta 1} \lambda_i) = 0$$

$$\frac{\lambda_1}{\lambda_3} = \frac{U_{a3} U_{b3} U_{\alpha 2} U_{\beta 2} - U_{a2} U_{b2} U_{\alpha 3} U_{\beta 3}}{U_{a2} U_{b2} U_{\alpha 1} U_{\beta 1} - U_{a1} U_{b1} U_{\alpha 2} U_{\beta 2}} \qquad \frac{\lambda_2}{\lambda_3} = \frac{(3 \to 1,\ 2 \to 3)}{\text{〃} \quad \text{〃}}$$

$M_{ee} = 0 \quad M_{e\mu} = 0$ から

$$\frac{\lambda_1}{\lambda_3} = \frac{s_{13}}{c_{13}^2} \left(\frac{s_{12} s_{23}}{c_{12} c_{23}} e^{i\phi} - s_{13} \right)$$

$$\frac{\lambda_2}{\lambda_3} = -\frac{s_{13}}{c_{13}^2} \left(\frac{c_{12} s_{23}}{s_{12} c_{23}} e^{i\phi} + s_{13} \right)$$

θ_{13} が $|\lambda_1|, |\lambda_2|$ と決める。

$\theta_{23} = 45° \quad \theta_{12} = 30° \quad \theta_{13} = 5° \quad \phi = 90°$

$$\frac{\Delta m_\odot^2}{\Delta m_{atm}^2} \simeq \frac{1}{70}$$

$$\begin{pmatrix} 0 & 0 & \lambda \\ 0 & 1 & 1 \\ \lambda & 1 & 1 \end{pmatrix}$$