Minimally modified A_4 model for neutrino masses and mixings

XII Biennial National Conference of Physics Academy of North East (PANE 2021)

15-17 Dec 2021, Tripura University

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06-12-2021

INTRODUCTION

- The A_4 flavor symmetry model proposed by Altarelli and Feruglio produces tri-bimaximal mixing.

- $$U_{TBM} = \begin{pmatrix} \sqrt{\frac{2}{6}} & \sqrt{\frac{1}{3}} & 0 \\ -\sqrt{\frac{1}{6}} & \sqrt{\frac{1}{3}} & -\sqrt{\frac{1}{2}} \\ -\sqrt{\frac{1}{6}} & \sqrt{\frac{1}{3}} & -\sqrt{\frac{1}{2}} \end{pmatrix}$$

- However, recent reactor neutrino experiments have indicted that the $U_{e3} \approx 0.15$.

- In this work, we present a minimally modified A_4 model that can accommodates the new global fit data.

MINIMALLY MODIFIED A_4 MODEL

Fields	l	e^c	μ^c	τ^c	ν^c	$H_{u,d}$	ϕ_S	ϕ_T	ξ_1	ξ_2	ξ_3
A_4	3	1	$1^{'}$	$1^{''}$	3	1	3	3	1	1"	1'
Z_3	ω^2	ω	ω	ω	1	1	ω	1	ω	ω	ω

Where

Fields	Vacuum Expectation Value(VEV)
$<\phi_S>$	(v_s, v_s, v_s)
$<\phi_T>$	$(v_T, 0, 0)$
$<H_u>$,$<H_d>$	$v_u,\ v_d$
$<\xi_1>$, $<\xi_2>$, $<\xi_3>$	$u_1,\ u_2,\ u_3$

$$-L_m = \frac{Y_e}{\Lambda} e^c(\phi_T l)_1 H_d + \frac{Y_\mu}{\Lambda}\mu^c(\phi_T l)_{1'} H_d + \frac{Y_\tau}{\Lambda}\tau^c(\phi_T l)_{1''} H_d + y_1\xi_1(l\nu^c)_1 + y_2(\xi_2)_{1''}(l\nu^c)_{1'} + y_3(\xi_3)_{1'}(l\nu^c)_{1''} + \frac{y_a}{\Lambda}\phi_S(lH_u\nu^c)_A + \frac{y_b}{\Lambda}\phi_S(lH_u\nu^c)_S + M(\nu^c H_u \nu^c) + \text{h.c}$$

where $y_i\xi(l\nu^c) = \frac{y_i}{\Lambda}\xi(lh_u\nu^c)$, i=1,2,3

- We consider the basis where charge lepton mass matrix is diagonal.

$$m_D = \begin{pmatrix} 2a+c & -a+b+d & -a-b+e \\ -a-b+ & 2a+e & -a+b+c \\ -a+b+e & -a-b+c & 2a+d \end{pmatrix}$$

$$M_R = \begin{pmatrix} m & 0 & 0 \\ 0 & 0 & m \\ 0 & m & 0 \end{pmatrix}$$

- $m_\nu = (m_D)^T M_R^{-1} m_D$
- Diagonalisation: $U^*_{PMNS} m_\nu U^\dagger_{PMNS}$

A global-fit result for neutrino oscillation are given in the table:

Neutrino oscillation parameters	Best fit$\pm 1\sigma$	3σ
$\theta_{12}/^\circ$	34.3 ± 1.0	31.4-37.4
$\theta_{13}/^\circ$(NO)	$8.53^{+0.13}_{-0.12}$	8.13-8.92
$\theta_{13}/^\circ$(IO)	$8.58^{+0.12}_{-0.14}$	8.17-8.96
$\theta_{23}/^\circ$(NO)	49.26 ± 0.79	41.20-51.33
$\theta_{23}/^\circ$(IO)	49.46 ± 0.79	41.16-51.25
$\Delta m^2_{21}[10^{-5} eV^2]$	$7.50^{+0.22}_{-0.20}$	6.94-8.14
$\lvert\Delta m^2_{31}\rvert[10^{-3} eV^2]$(NO)	$2.55^{+0.02}_{-0.03}$	2.47-2.63
$\lvert\Delta m^2_{31}\rvert[10^{-3} eV^2]$(IO)	$2.45^{+0.02}_{-0.03}$	2.37-2.53

$m_1 + m_2 + m_3 <$0.12 eV(NO) and 0.15 eV(IO) .

δ° is (194^{+24}_{-22} for NH and 28^{+26}_{-28} for IH).

RESULTS

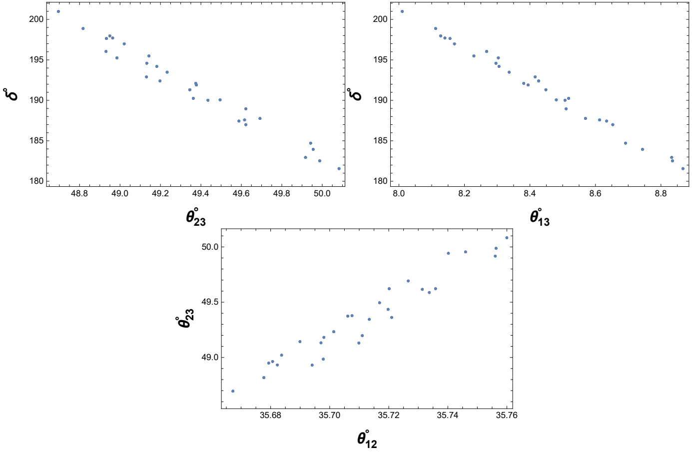

Figure: The allowed region of the oscillation parameters(NH) predicted by the model.

Conclusion

- The prediction of θ_{23}, θ_{13} and θ_{13} are around 49°, 8.43° and 35.7° respectively.
- The CP-violating phase δ is found around 191.4°.

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THANK YOU