The Majorana neutrino mass matrix indicated by the current data

北京大学物理学院
School of Physics, Peking University

Xinyi Zhang and Bo-Qiang Ma

School of Physics and State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing 100871, China

Introduction

Abstract

The Majorana neutrino mass matrix combines information from the neutrino masses and the leptonic mixing in the flavor basis. Its invariance under some transformation matrices indicates the existence of certain residual symmetry. We offer an intuitive display of the structure of the Majorana neutrino mass matrix, using the whole set of the oscillation data. The structure is revealed in dependence on the lightest neutrino mass. We find that there are three regions with distinct characteristics of structure. A group effect and the μ-τ exchange symmetry are observed. Implications for flavor models are discussed.

Why are we presenting this work?

- The experimental measurements of the oscillation parameters are getting more and more precise.
- The Majorana neutrino mass matrix is directly connected to yukawas in models and its entries show up in cross sections of lepton flavor violating process.

What is our objective?

To see to what degree, the structure of the Majorana neutrino mass matrix is constrained by the current data.

How do we get the work done?

Simply using the relation that correlates the mass and the mixing matrix, i.e., $\mathrm{M} = \mathrm{U}^{\star}\mathrm{diag}(\mathrm{m}_1, \mathrm{m}_2, \mathrm{m}_3)\mathrm{U}^{\dagger}$

we reconstruct the Majorana mass matrix up to an unknown mass by using the whole set of the oscillation data given by the global fit.

Why another work on this topic? Especially when it is also using a non-sophisticated method?

Nothing but a curiosity to see the magnitudes of the Majorana neutrino mass matrix entries in an obvious way.

Results

Hierarchical case

Normal hierarchy

$$m_2 \simeq \sqrt{\Delta m^2_{21}} = 0.0086 \text{ eV};$$

$$m_3 \simeq \sqrt{\Delta m^2_{31}} = 0.0492 \text{ eV};$$

$$\mathrm{M} \simeq \begin{pmatrix} 0.0015 & 0.0058 & 0.0065 \\ . & 0.0248 & 0.0209 \\ . & . & 0.0292 \end{pmatrix}$$

Inverted hierarchy

$$m_1 \simeq m_2 \simeq \sqrt{\Delta m^2_{32}} = 0.0491 \text{ eV};$$

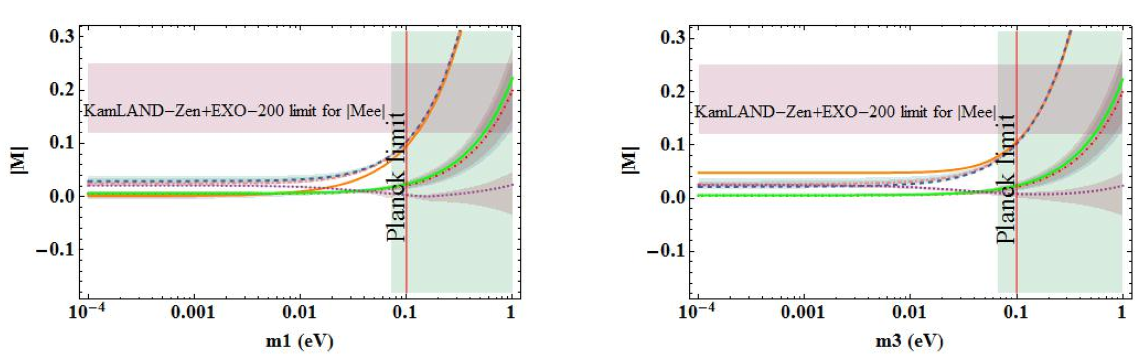
$$\mathrm{M} \simeq \begin{pmatrix} 0.0480 & 0.0049 & 0.0055 \\ . & 0.0267 & 0.0250 \\ . & . & 0.0213 \end{pmatrix}.$$

Quasi-degenerate

$$m_1 \simeq m_2 \simeq m_3 \simeq 0.1 \text{ eV};$$

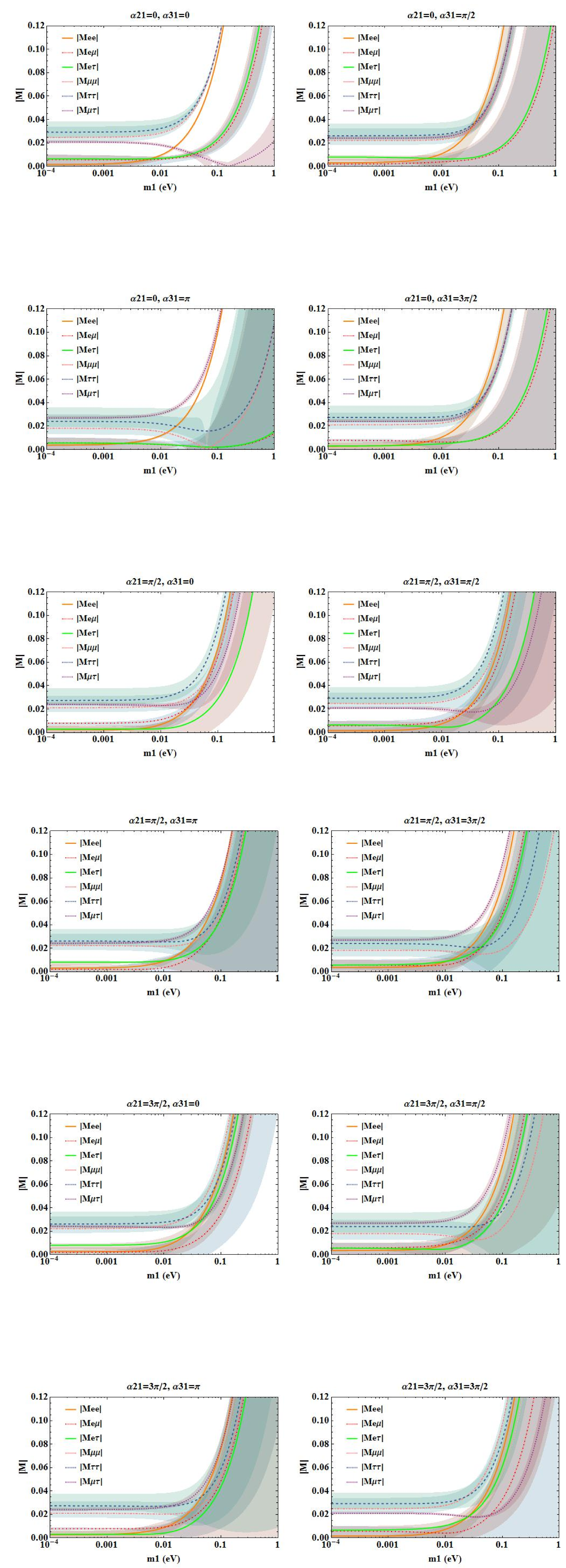
$$\mathrm{M} \simeq \begin{pmatrix} 0.0955 & 0.0200 & 0.0221 \\ . & 0.0980 & 0.0023 \\ . & . & 0.0975 \end{pmatrix}$$

General case



Examples of dominant structures of M

m_1(eV)	numerical results	parametrization	value of parameters
0.001	$\begin{pmatrix} 0.0022 & 0.0057 & 0.0064 \\ . & 0.0249 & 0.0206 \\ . & . & 0.0294 \end{pmatrix}$	$\begin{pmatrix} a/3 & a & a \\ . & 4a & 3a \\ . & . & 5a \end{pmatrix}$	$a \sim 0.006$
0.006 $\lvert M_{ee}\rvert = \lvert M_{e\mu}\rvert \simeq \lvert M_{e\tau}\rvert$	$\begin{pmatrix} 0.0058 & 0.0058 & 0.0066 \\ . & 0.0265 & 0.0191 \\ . & . & 0.0307 \end{pmatrix}$	$\begin{pmatrix} a & a & a \\ . & 4a & 3a \\ . & . & 5a \end{pmatrix}$	$a \sim 0.006$
0.01	$\begin{pmatrix} 0.0096 & 0.0062 & 0.0069 \\ . & 0.0285 & 0.0174 \\ . & . & 0.0325 \end{pmatrix}$	$\begin{pmatrix} b & a & a \\ . & 3a+b & 3a \\ . & . & 2a+b \end{pmatrix}$	$a \sim 0.006$ $b \sim 0.01$
0.016 $\lvert M_{ee}\rvert = \lvert M_{\mu\tau}\rvert$	$\begin{pmatrix} 0.0150 & 0.0068 & 0.0077 \\ . & 0.0320 & 0.0150 \\ . & . & 0.0355 \end{pmatrix}$	$\begin{pmatrix} a & a/2 & a/2 \\ . & 2a & a \\ . & . & 2a \end{pmatrix}$	$a \sim 0.016$
0.02	$\begin{pmatrix} 0.0189 & 0.0074 & 0.0083 \\ . & 0.0347 & 0.0134 \\ . & . & 0.0379 \end{pmatrix}$	$\begin{pmatrix} 3a-b & a & a \\ . & 5a-b & a+b \\ . & . & 4a+b \end{pmatrix}$	$a \sim 0.008$ $b \sim 0.005$
0.03 $\lvert M_{\mu\tau}\rvert \simeq \lvert M_{e\tau}\rvert \simeq \lvert M_{e\mu}\rvert$	$\begin{pmatrix} 0.0284 & 0.0088 & 0.0098 \\ . & 0.0419 & 0.0100 \\ . & . & 0.0445 \end{pmatrix}$	$\begin{pmatrix} 3a & a & a \\ . & 4a & a \\ . & . & 4a \end{pmatrix}$	$a \sim 0.01$
0.06	$\begin{pmatrix} 0.0570 & 0.0138 & 0.0154 \\ . & 0.0667 & 0.0025 \\ . & . & 0.0682 \end{pmatrix}$	$\begin{pmatrix} a-4b & 5b & 5b \\ . & a-b & b \\ . & . & a-b \end{pmatrix}$	$a \sim 0.07$ $b \sim 0.003$



Conclusions

- By recognizing the differences in stability of the relative magnitudes of entries of M, a simple division to the range of m_{min} is made.
- In Region 1 and Region 3, there are groups with distinguishable magnitudes.
- An approximating μ-τ exchange symmetry is recognized in all the three regions of both the normal and the inverted orderings.
- The non-zero Majorana phases change the above conclusions in a non-ignorable way.
- For non-oscillation data, the cosmology result puts a more stringent constraint than the 0υββ result.
- The allowed ranges of $|M_{\alpha\beta}|$ by the current data can be read from the plots.
- Possible texture zeros can be observed directly.
- Some examples of dominant structures are showed with parameterizations.

It requires precision improvements on these parameters to finally unveil the dominant structure of the Majorana neutrino mass matrix.

Bibliography

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Your comments are welcomed at
xzhang_phy@pku.edu.cn