MAYORANA School
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FACULTY OF MATHEMATICS,
PHYSICS AND INFORMATICS
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Majorana neutrino masses and neutrino-antineutrino oscillations

SUPERVISOR

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Mixing matrix

$$U = \begin{pmatrix} e^{i\phi_1}\, c12\, c13 & e^{i\phi_2}\, s12\, c13 & s13 \\ e^{i\phi_1}(-c23\, s12 - c12\, s13\, s23\, e^{i\delta}) & e^{i\phi_2}\,(c12\, c23 - s12\, s13\, s23\, e^{i\delta}) & c13\, s23\, e^{i\delta} \\ e^{i\phi_1}(s12\, s23 - c12\, c23\, s13\, e^{i\delta}) & e^{i\phi_2}\,(-c12\, s23 - c23\, s12\, s13\, e^{i\delta}) & c13\, c23\, e^{i\delta} \end{pmatrix}$$

Neutrino Oscillation Parameters (Normal Ordering, Best Fit)	
Parameter	**Best Fit ±1σ**
θ_{12} [°]	$33.68^{+0.7}_{-0.7}$
θ_{23} [°]	$0.47^{+1.0}_{-0.8}$
θ_{13} [°]	$8.56^{+0.1}_{-0.1}$
δ [°]	$212^{+26}_{-0.4}$
Δm^2_{21} [10^{-5} eV^2]	$7.49^{+0.1}_{-0.1}$
$\Delta m^2_{3\ell}$ [10^{-3} eV^2]	$2.51^{+0.02}_{-0.02}$

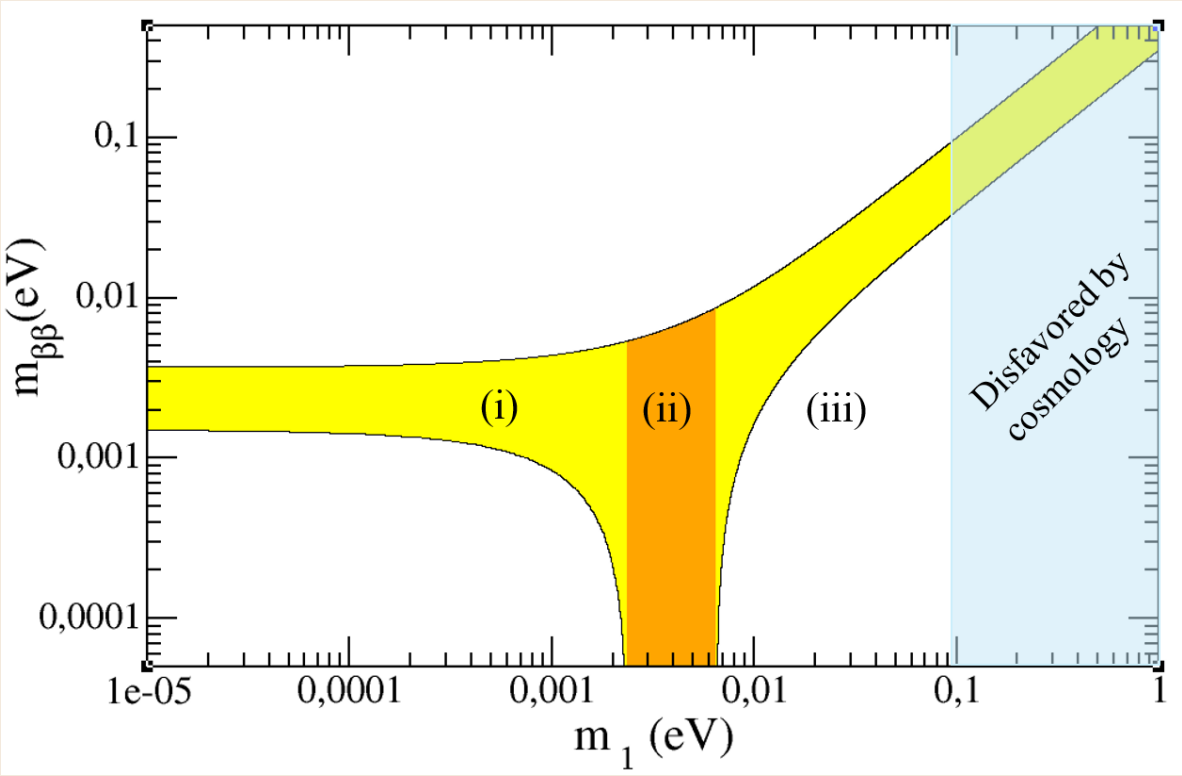
Effective Majorana mass for 0νββ

$$U = \begin{pmatrix} e^{i\phi_1}\, c12\, c13 & e^{i\phi_2}\, s12\, c13 & s13 \\ e^{i\phi_1}(-c23\, s12 - c12\, s13\, s23\, e^{i\delta}) & e^{i\phi_2}\,(c12\, c23 - s12\, s13\, s23\, e^{i\delta}) & c13\, s23\, e^{i\delta} \\ e^{i\phi_1}(s12\, s23 - c12\, c23\, s13\, e^{i\delta}) & e^{i\phi_2}\,(-c12\, s23 - c23\, s12\, s13\, e^{i\delta}) & c13\, c23\, e^{i\delta} \end{pmatrix}$$

$$m_{\beta\beta} = |M_{ee}| = \left| \sum_j^3 U_{ej}^2\, m_j \right| = \left| \rho_1 e^{2i\phi_1} + \rho_2 e^{2i\phi_2} + \rho_3 \right|$$

$$\rho_1 = c_{12}^2 c_{13}^2 m_1,\ \rho_2 = s_{12}^2 c_{13}^2 m_2 \text{ and } \rho_3 = s_{13}^2 m_3$$

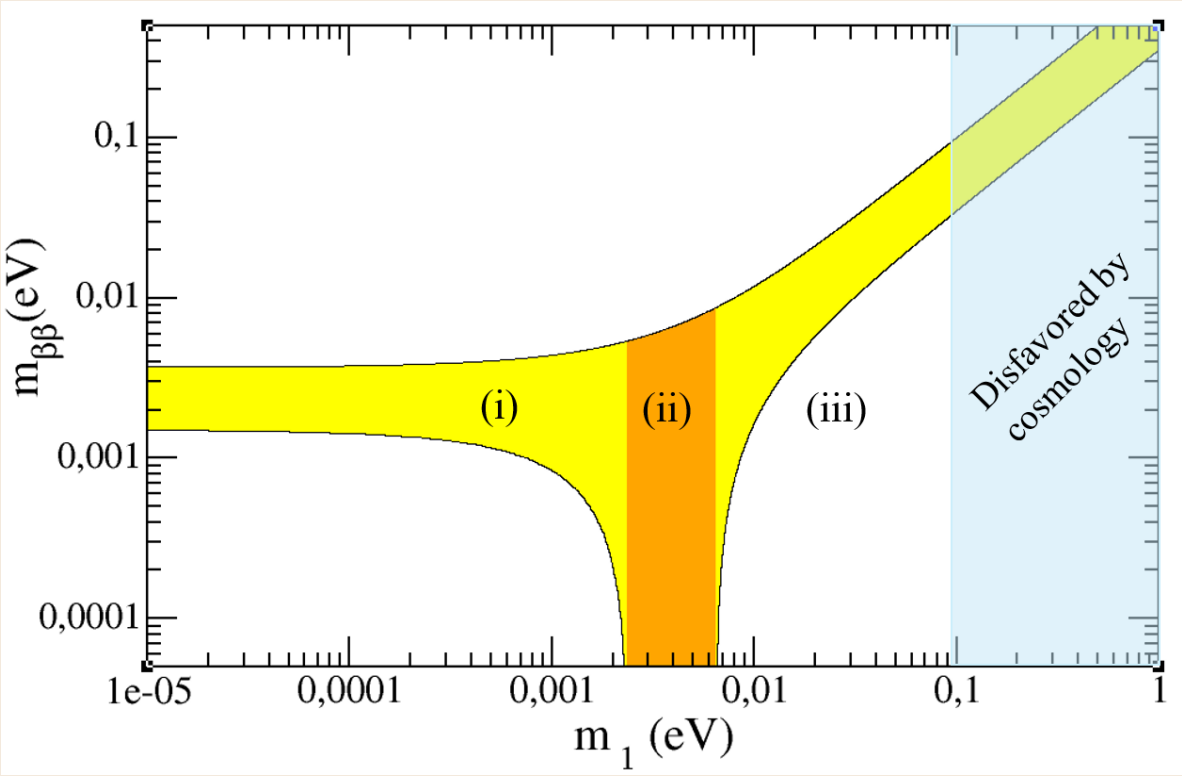
Effective Majorana mass for $0\nu\beta\beta$



$m_1 \in (2.34, 6.44\ )meV$

“ Terra incognita ”

Effective Majorana mass for 0νββ



$$\left(T_{1/2}^{0\nu}\right)^{-1} \propto \left(\frac{m_{\beta\beta}}{m_e}\right)^2$$

$m_1 \in (2.34, 6.44\ )meV$

“ Terra incognita ”

Oscillations $\nu_e \rightleftharpoons \bar{\nu}_e$

$$m^L_{e\bar{e}} = \left| \rho_1 \, e^{-i(2\phi_1 - \frac{\Delta_{31}}{2E}L)} + \rho_2 \, e^{-i(2\phi_2 + \frac{\Delta_{21}-\Delta_{31}}{2E}L)} + \rho_3 \right|$$

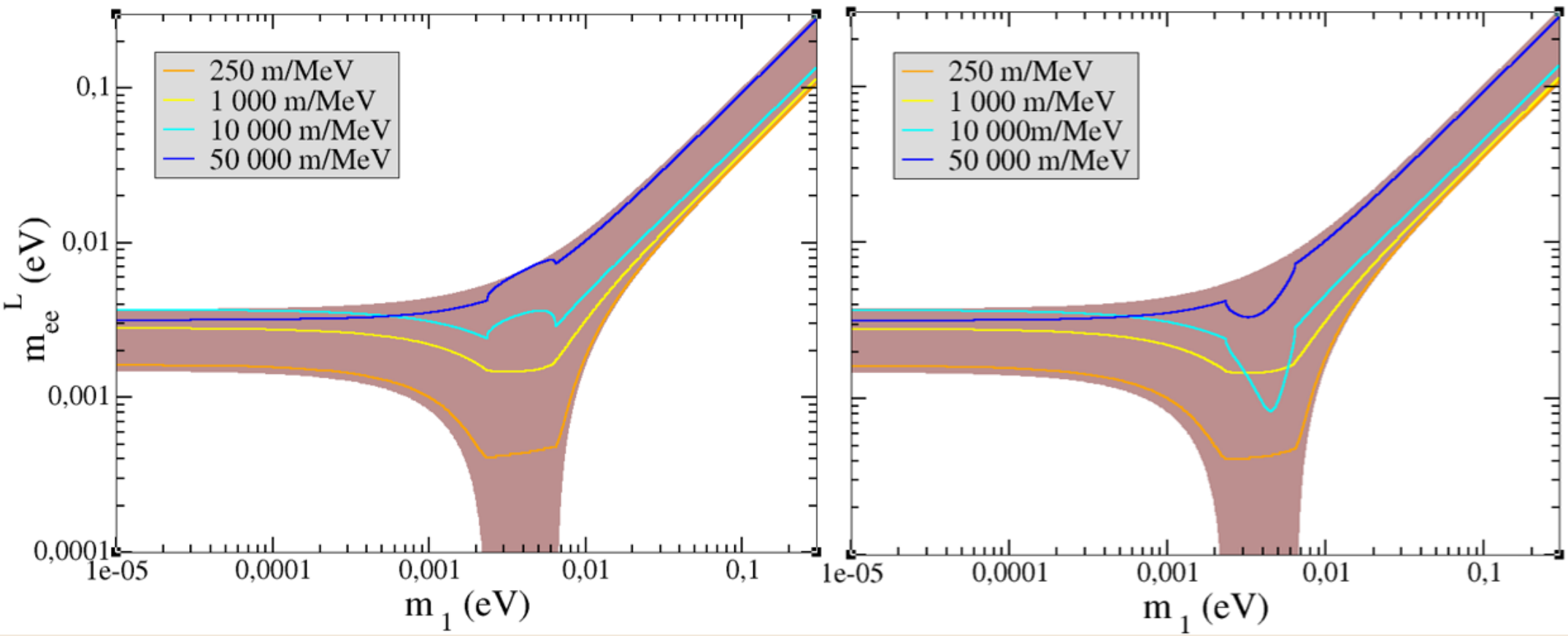
$$m^{L=0}_{ee} = m_{\beta\beta}$$

$$P(\nu_e \rightarrow \bar{\nu}_e) = \frac{\left(m^L_{e\bar{e}}\right)^2}{E^2}$$

Oscillations $\nu_e \rightleftharpoons \bar{\nu}_e$

$$m^L_{e\bar{e}} = \left| \rho_1 \, e^{-i(2\phi_1 - \frac{\Delta_{31}}{2E}L)} + \rho_2 \, e^{-i(2\phi_2 + \frac{\Delta_{21}-\Delta_{31}}{2E}L)} + \rho_3 \right|$$

$$m^{L=0}_{ee} = m_{\beta\beta}$$



Thank you for your attention