Neutrino Oscillation on Epicycles

Benda XU

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Algebraic Complexity

- Three flavor survival probability

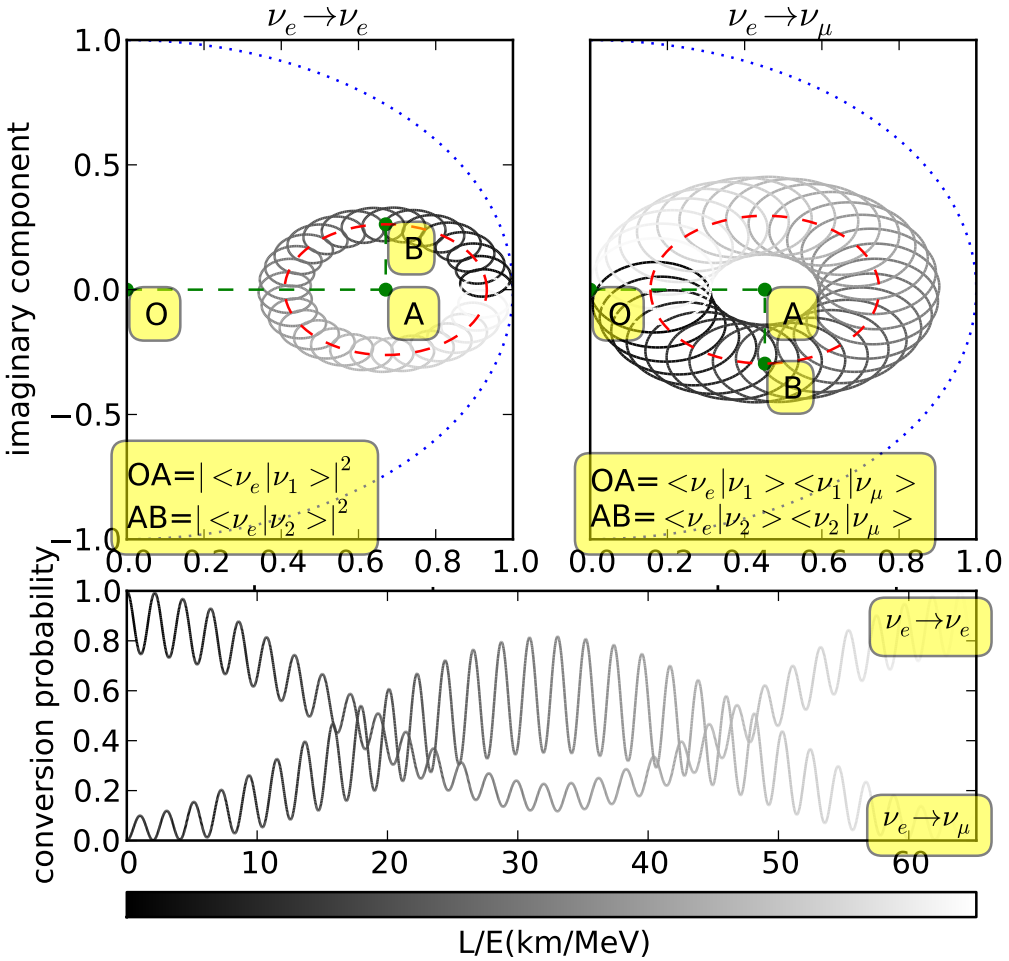
$$\begin{aligned} P_{\bar{\nu}_e \to \bar{\nu}_e} = & \quad 1 - \sin^2 2\theta_{13}(\cos^2\theta_{12}\sin^2\Delta_{31} + \sin^2\theta_{12}\sin^2\Delta_{32}) - \cos^4\theta_{13}\sin^2 2\theta_{12}\sin^2\Delta_{21} \\ = & \quad 1 - 2s_{13}^2 c_{13}^2 - 4c_{13}^2 s_{12}^2 c_{12}^2 \sin^2\Delta_{21} + 2s_{13}^2 c_{13}^2 \sqrt{1 - 4s_{12}^2 c_{12}^2 \sin^2\Delta_{21}}\cos(2\Delta_{32} \pm \phi), \end{aligned}$$

where $\Delta_{21} \equiv \Delta m_{21}^2 L/4E$, $\Delta_{32} \equiv \Delta m_{32}^2 L/4E$, in which L is the baseline and E is the antineutrino energy, and

$$\sin\phi = \frac{c_{12}^2 \sin 2\Delta_{21}}{\sqrt{1 - 4s_{12}^2 c_{12}^2 \sin^2\Delta_{21}}}, \cos\phi = \frac{c_{12}^2 \cos 2\Delta_{21} + s_{12}^2}{\sqrt{1 - 4s_{12}^2 c_{12}^2 \sin^2\Delta_{21}}}.$$

- Conversion probability ($P_{\bar{\nu}_e \to \bar{\nu}_\nu}$) has more terms.

Epicycle Show (Others)



Visualization is Important

- My favorite quote:

In QED, as in other quanrum field theories, we can use the little pictures invented by my colleague Richard Feynman, which are supposed to give the illusion of understanding what is going on in quantum field theory.
–M. Gell-Mann