$\nu_\mu \to \nu_e$ with matter effect

Approximate formula (Lindener, Huber et al.)

$$
\begin{aligned}
P(\nu_\mu \to \nu_e) \quad \approx \quad & \sin^2\theta_{23}\frac{\sin^2 2\theta_{13}}{(\hat{A}-1)^2}\sin^2((\hat{A}-1)\Delta) \\
& +\alpha\frac{8J_{CP}}{\hat{A}(1-\hat{A})}\sin(\Delta)\sin(\hat{A}\Delta)\sin((1-\hat{A})\Delta) \\
& +\alpha\frac{8I_{CP}}{\hat{A}(1-\hat{A})}\sin(\Delta)\cos(\hat{A}\Delta)\sin((1-\hat{A})\Delta) \\
& +\alpha^2\frac{\cos^2\theta_{23}\sin^2 2\theta_{12}}{\hat{A}^2}\sin^2(\hat{A}\Delta)
\end{aligned}
$$

$J_{CP} = 1/8 \sin\delta_{CP}\cos\theta_{13}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}$

$I_{CP} = 1/8 \cos\delta_{CP}\cos\theta_{13}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}$

$\alpha = \Delta m^2_{21}/\Delta m^2_{31}$, $\Delta = \Delta m^2_{31} L/4E$

$\hat{A} = 2VE/\Delta m^2_{31}$