

# A new way of Analytic approximation for four flavor neutrino oscillation with matter effect

We provide a series of expansion formulas for 3+1 scheme neutrino oscillation probabilities in matter with a constant density.

We use a new approach named the Jacobi-like method, which can diagonalize a complex Hermitian Hamiltonian matrix to handle matter effects

for four-flavor neutrino oscillation with high precision. This work can be applied to current or proposed accelerator

neutrino experiments such as DUNE, NO $\nu$ A, T2HK, T2HKK when neutrino mass  $m_4 \gg m_k (k = 1, 2, 3)$ .

We present the performance of the new method on different oscillation channels with similar

mixing matrix form to the vacuum case. Furthermore, neutrino oscillation probability

functions we studied are greatly simplified with three levels of accuracy.

We argue that the effective mixing caused by matter effects between active neutrinos and sterile neutrinos

changes more slightly than that among  $\nu_e, \nu_\mu$  and  $\nu_\tau$

when  $m_4 \gg m_k (k = 1, 2, 3)$ .

## Presentation Type

T4. Neutrino, Astrophysics and Cosmology

## Summary

Our analytical approximation formulas have high accuracy with a good simplicity. This result can be applied in lots of experiments such as T2HK, T2HKK, NU $\nu$ A and DUNE. We find that the effective  $\theta_{12}$  and  $\delta_{12}$  can be affected firstly by matter effects and the effective  $\theta_{13}$  and  $\delta_{13}$  are the second ones. It is remarkable that the effective mixing between active neutrinos and sterile neutrinos changes more slightly than active mixing when  $m_4 \gg m_k (k = 1, 2, 3)$ .

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