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Compact Perturbative Expressions for Oscillations with Sterile Neutrinos in Matter

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We extend a simple and compact method for calculating the three flavor neutrino oscillation probabilities in uniform matter density to schemes with sterile neutrinos, with favorable features inherited. The only constraint of the extended method is that the scale of the matter potential is not significantly larger than the atmospheric Δm^2 , which is satisfied by all the running and proposed accelerator oscillation experiments. Degeneracy of the zeroth order eigensystem around solar and atmospheric resonances are resolved. Corrections to the zeroth order results are restricted to no larger than the ratio of the solar to the atmospheric Δm^2 . The zeroth order expressions are exact in vacuum because all the higher order corrections vanish when the matter potential is set zero. Also because all the corrections are continuous functions of matter potential, the zeroth order precision is much better than $\Delta m^2_{\text{solar}}/\Delta m^2_{\text{atm}}$ for weak matter effect. Numerical tests are presented to verify the theoretical predictions of the exceptional features. Moreover, possible applications of the method in experiments to check the existence of sterile neutrinos are discussed.

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