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Neutrino evolution accounting for the longitudinal and transversal magnetic fields and matter currents

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We consider neutrino spin oscillations in arbitrary moving matter accounting for the longitudinal $\mathbf{j}_{\parallel}$ and transversal $\mathbf{j}_{\perp}$ matter currents in respect to the direction of the neutrino propagation. From the quasiclassical treatment to the problem, based on the generalized Bargmann-Michel-Telegdi equation that describes the evolution of the three-dimensional neutrino spin vector $\mathbf{S}$ developed earlier [1], it is known that the neutrino spin precession and the corresponding oscillations $\nu_e^L \Leftrightarrow \nu_e^R$ can be engendered by the neutrino weak interaction with the transversal matter current $\mathbf{j}_{\perp}$. We have developed [2] the consistent quantum treatment of this effect based on the direct calculations of the effective Hamiltonian of the neutrino evolution in the presence of the longitudinal $\mathbf{j}_{\parallel}$ and transversal $\mathbf{j}_{\perp}$ matter currents. In addition, we now also account for the neutrino magnetic moment interaction with a constant magnetic field $\mathbf{B} = \mathbf{B}_{\perp} + \mathbf{B}_{\parallel}$. The developed quantum treatment to the neutrino spin oscillations due to weak interaction with the transversal matter current $\mathbf{j}_{\perp}$ has provided proper account for the neutrino mixing effects. The obtained closed expressions for the neutrino spin oscillation probabilities are of interest for the astrophysical applications.

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