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Manifestation of the neutrino magnetic moments in the high- energy neutrinos flavour ratios

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Neutrino propagation in Galactic and extragalactic magnetic fields is considered. We extend an approach developed in [1] to describe neutrino flavour and spin oscillations on astrophysical baselines using wave packets. The evolution equations for the neutrino wave packets in uniform and non-uniform magnetic fields are derived. The analytical expressions for neutrino flavour and spin oscillations probabilities accounting for damping due to the wave packet separation are obtained for the case of a uniform magnetic field. It is shown that terms in the flavour oscillations probabilities that depend on the magnetic field strength are characterized by two coherence lengths. One of the coherence lengths coincides with the coherence length for neutrino oscillations in vacuum, while the second one is proportional to the cube of the average neutrino momentum p_0^3. The probabilities of flavour and spin oscillations are calculated numerically for neutrino interacting with the non-uniform Galactic magnetic field. It is shown that oscillations on certain frequencies are suppressed on the Galactic scale due to the neutrino wave packets separation. The flavour compositions of high-energy neutrino flux coming from the Galactic centre and ultra-high energy neutrinos from an extragalactic source are calculated accounting for neutrino interaction with the magnetic field and decoherence due to the wave packet separation. It is shown that for neutrino magnetic moments $\sim 10^{-13}\mu_B$ and larger these flavour compositions significantly differ from ones predicted by the vacuum neutrino oscillations scenario.

Based on:

1) A.Popov, A.Studenikin, "High-energy neutrinos flavour composition as a probe of neutrino magnetic moments", arXiv: https://arxiv.org/abs/2404.02027.

2) A.Popov, A.Studenikin, Manifestations of nonzero Majorana CP-violating phases in oscillations of supernova neutrinos, Phys.Rev.D 103 (2021) 11, 115027.

3) A.Popov, A.Studenikin, Neutrino eigenstates and flavour, spin and spin-flavour oscillations in a constant magnetic field, Eur.Phys.J.C 79 (2019) 2, 144.

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