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Electromagnetic neutrinos: New constraints and new effects in oscillations

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Abstract:

We have continued discussions of neutrino electromagnetic properties [1,2] and have performed a detailed and accurate study [3] of the electromagnetic interactions of massive neutrinos in the theoretical formulation of low-energy elastic neutrino-electron scattering.
Using the derived new expression for a neutrino electromagnetic scattering cross section [3],
we obtained [4] a new bound on the neutrino charge radii from COHERENT elastic neutrino-nucleus scattering data. Worthy of note, our paper [4] has been included by the Editors Suggestion to the Phys.Rev.D "Highlights of 2018".
A reasonable part of the proposed talk is dedicated to results of our recently performed detailed studies of new effects in neutrino spin, spin-flavour and flavor oscillations under the influence of the transversal matter currents [5] and a constant magnetic field [6]. These two effects can be summarized as follows:

1) it is shown [5] that neutrino spin and spin-flavor oscillations can be engendered by weak interactions of neutrinos with the medium in the case when there are the transversal matter currents (for the appearance of neutrino spin oscillations in this case there is no need either for a neutrino nonzero magnetic moment or for an external magnetic field); different possibilities for the resonance amplification of oscillations are discussed, the neutrino Standard Model and non-standard interactions are accounted for;

2) within a new treatment [6] of the neutrino flavor, spin and spin-flavour oscillations in the presence of a constant magnetic field, that is based on the use of the exact neutrino stationary states in the magnetic field, it is shown that there is an interplay of neutrino oscillations on different frequencies; in particular: a) the amplitude of the flavour oscillations $\nu Le \leftrightarrow \nu L\mu$ at the vacuum frequency is modulated by the magnetic field frequency, and b) the neutrino spin oscillation probability (without change of the neutrino flavour) exhibits the dependence on the neutrino mass square difference $\Delta m2$.

The discovered new phenomena in neutrino oscillations should be accounted for reinterpretation of results of already performed experiments on detection of astrophysical neutrino fluxes produced in astrophysical environments with strong magnetic fields and dense matter. These new neutrino oscillation phenomena are also of interest [7,8] in view of future experiments on observations of supernova neutrino fluxes with large liquid-scintillator detectors like JUNO, for instance.

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Abstract Title

Electromagnetic neutrinos: New constraints and new effects in oscillations

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