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Overview of neutrino electromagnetic properties

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We start with an introduction to the theory of neutrino electromagnetic properties [1-5]. Then we consider experimental constraints on neutrino magnetic μν and electric dν moments, millicharge qν, charge radii <rν2> and anapole aν moments from the terrestrial experiments (the bounds from MUNU, TEXONO and GEMMA experiments, as well as from Super-Kamiokande and Borexino). A special credit is done to severe constraints on μν , qν and <rν2> [6-10]. The best reactor [6] and solar [7] neutrino and astrophysical [11,12] bounds on μν, as well as bounds on qν from the reactor neutrinos [8] are included in the recent issues of the Review of Particle Physics (PRD). The best astrophysical bound on qν [13], the most severe astrophysical bound on μν [14] and new results on μν and qν of the CONUS experiment [15] are reviewed.

In the recent studies [16] it is shown that the results of the XENON1T collaboration [17] at few keV electronic recoils could be due to the scattering of solar neutrinos endowed with finite Majorana transition μν of the strengths lie within the limits set by the Borexino experiment with solar neutrinos [7]. The comprehensive analysis of the existing and new extended mechanisms for enhancing neutrino transition μν to the level appropriate for the interpretation of the XENON1T data and leaving neutrino masses within acceptable values is provided in [18].

Considering neutrinos from all known sources, including data from XENON1T and Borexino, the strongest up-to-date exclusion limits on the active-to-sterile neutrino transition μν are derived in [19] .

A comprehensive analisys of constraints on neutrino qν from experiments of elastic neutrino-electron interaction and future prospects involving coherent elastic neutrino-nucleus scattering is presented in [20].

We present results of the recent detailed study [21] of the electromagnetic interactions of massive neutrinos in the theoretical formulation of low-energy elastic neutrino-electron scattering. Using results of [21], on the basis of the COHERENT data [9] new bounds on the neutrino charge radii are obtained [10]. The obtained constraints on the nondiagonal neutrino charge radii [10] have been included by the Editors of Phys. Rev. D to "Highlights of 2018", and has been included by the PDG to the Review of Particle Physics.

The main manifestation of neutrino electromagnetic interactions, such as: 1) the radiative decay in vacuum, in matter and in a magnetic field, 2) the neutrino Cherenkov radiation, 3) the plasmon decay to neutrino-antineutrino pair, 4) the neutrino spin light in matter, and 5) the neutrino spin and spin-flavour precession are discussed. Phenomenological consequences of neutrino electromagnetic interactions (including the spin light of neutrino [22]) in astrophysical environments are also reviewed.

We also discuss: 1) new effects in neutrino spin, spin-flavour and flavor oscillations under in the transversal matter currents [23, 24] and magnetic field [25,26], 2) our newly developed approach to the problem of the neutrino quantum decoherence [27] and 3) also our recent proposal [28] for an experimental setup to observe coherent elastic neutrino-atom scattering (CEνAS) using antineutrinos from tritium decay and a liquid helium target (the predicted sensitivity to μν is 7×10−13μB).

In [29] we investigate effects of non-zero Dirac and Majorana CP violating phases on neutrino-antineutrino oscillations ν e ↔ ν¯e, νe ↔ ν¯μ and νe ↔ ν¯τ in a magnetic field of astrophysical environments (the results are of interest for future experiments JUNO, DUNE and Hyper-Kamiokande).

In the talk we also trace, following the latest studies [30], how the search for neutrino magnetic and electric moments in low-energy neutrino scattering experiments are sensitive to the Hamiltonian fundamental parameters.

The best world experimental bounds on neutrino electromagnetic properties are confronted with the predictions of theories beyond the Standard Model.

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In-person participation

No

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