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On the possibility of the Majorana nature of neutrinos

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One of the most popular explanations for the smallness of the neutrino mass is the seesaw mechanism [1], in which the neutrino should be a Majorana fermion. The concepts of *C* and *CPT* conjugations play an important role in the theory of Majorana fermions. We have shown that in the literature there are five nonequivalent concepts of charge conjugation (*C1* - *C5*) and, accordingly, five possible types of Majorana fermions:
1. A fermion coinciding with its conjugate according to Pauli [2].
2. A fermion coinciding with its charge conjugate according to Majorana [3] and Kramers.
3. A truly neutral fermion coinciding with its antiparticle [3].
4. A fermion coinciding with its conjugate according to Schwinger [4].
5. A fermion coinciding with its charge conjugate with charge conjugation by means of creation and annihilation operators.

Previously, we have proven that Majorana fermions of the second type cannot be physical particles [5]. In this work, we analyze the possibility of a neutrino being a Majorana fermion of the other types.
We have proven that the non-QFT Pauli conjugation operator *C1*, defined in the framework of the theory of "holes"in the Dirac Sea, is equivalent to the QFT conjugation operator *C4*. Charge conjugation *C3* is equivalent to the *CPT* inversion with reversal of the sign of the spin projection and chirality. The most commonly used in QFT conjugation *C4* is antiunitary, reverses the particle chirality, and is not a charge conjugation. Its result coincides with the *C5* charge conjugation only for chiral symmetric fermions.
We have proven that a comparison of operators in the coordinate representation and the representation of occupation numbers allows us to uniquely determine the phases of the operators *P* and *C*, up to sign, and limit the number of variants of charge conjugation and Majorana spinors.

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Section

Neutrino physics and nuclear astrophysics

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