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Investigation of double beta decay of ^{116}Cd with the help of enriched $^{116}CdWO_4$ crystal scintillators

Abstract

Neutrinoless double beta decay is considered as a powerful tool to study properties of neutrinos and weak interactions. The process is forbidden in the framework of the Standard Model since it violates the lepton number and requires the neutrinos to be massive Majorana particles. ^{116}Cd is one of the most promising double beta isotopes taking into account the theoretical calculations, the large energy of decay, the relatively high isotopic abundance and possibility to increase it by centrifugation. The Aurora experiment at Gran Sasso investigates double beta decay of ^{116}Cd with the help of 1.16 kg cadmium tungstate crystal scintillators enriched in ^{116}Cd to 82% ($^{116}CdWO_4$). The low level of background allows investigating the two neutrino mode of the decay of ^{116}Cd with the highest up-to-date accuracy. The sensitivity of the experiment to the neutrinoless double beta decay of ^{116}Cd to the ground state of ^{116}Sn is estimated as $T_{1/2} \geq 1.9\times10^{23}$ yr at 90% CL, which corresponds to the effective Majorana neutrino mass limit $\leq (1.2 - 1.8)$ eV. New limits are obtained for the double beta decay transitions of ^{116}Cd to the excited levels of ^{116}Sn, and for the neutrinoless double beta decay with emission of majorons. The radioactive contamination by thorium and the total alpha activity in a sample cut from the $^{116}CdWO_4$ crystal boule were reduced by the recrystallization method by factors of 10 and 3, respectively, which confirms the possibility of ultra-radiopure $^{116}CdWO_4$ crystal scintillators production.

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