Double Beta Decay Experiments in Novi Sad

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Abstract: Despite the great interest in $\beta^{-}\beta^{-}$ decay, $\beta^{+}\beta^{+}$ decays are rarely investigated due to the low probability of detecting these processes with available low-level equipment. If $\beta^{+}\beta^{+}$, $\beta^{+}EC$, or ECEC decay occurs in a thin sample of a material, the positrons will be stopped and annihilated inside the material, leading to the emission of two or four coincidence gamma photons energy of 511 keV. The paper presents the results of measurements of double beta decay of 64 Zn, 50 Cr, and 54 Fe isotopes. In the first experiment, 511-keV gamma rays originating from the annihilation of positrons in natural zinc were measured by a coincidence technique to obtain a non-zero value for the $(0\nu+2\nu)$ half-life. In the second experiment, the result of measuring double beta decay of 50 Cr is presented, which suggests a result other than zero at 95% CL and gives the lowest limit for the half-life of this process. In the third experiment, neutrino-less ECEC decay of 54 Fe was examined. Under the decay theory, gamma rays are emitted whose energy does not coincide with the energies of gamma rays emitted by nuclei from known discrete excited states. Iron shield of an internal volume of 1 m³ and thickness of 25 cm served as a source for measuring the $(0\nu+2\nu)$ process in 54 Fe, whose yield in natural iron is 5.4%. We obtain the lower limit for the half-life for 54 Fe: $T(0\nu, K, K) > 4.4x10^{20}$ yr, $T(0\nu, K, L) > 4.1x10^{20}$ yr, and $T(0\nu, L, L) > 5.0x10^{20}$ yr. For 50 Cr limit for the half-life is $T(0\nu+2\nu) > 1.3(6)x10^{18}$ yr, and for 64 Zn $T(0\nu+2\nu, EC\beta+)=1.1(0.9)x10^9$ years.

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