Léonard IMBERT

"Background studies for the CUPID-Mo, CUPID and CROSS neutrinoless double beta decay"

Abstract:

The two neutrino double beta decay (2νββ) is a standard model process that has been observed for several isotopes. The neutrinoless double beta decay (0νββ) is a hypothetical decay whose observation would open the door to physics beyond standard model. Such observation would indicate that the neutrino is a Majorana particle and that the lepton number conservation is violated. Scintillating bolometers are an excellent technology to search for such a rare decay thanks to their excellent energy resolution and high detection efficiency. The energy released in the bolometer is transferred in heat, which is read out as an electrical signal. Part of the energy is released in scintillation light. The simultaneous detection of heat and light allows the discrimination between β/γ and α particles. The CUPID-Mo experiment studied the 0νββ decay of 100Mo with 20 Li2MoO4 scintillating bolometers and fixed the best limit for the 0νββ half-life for this nucleus. This Ph.D. work presents the background model of CUPID-Mo based on GEANT4 simulations. We obtained a background index of B = 3.7 +0.9 -0.8 (stat) +1.5 -0.7 (syst) x 10^{-3} coups/ΔE_{FWHM}/mol_{iso}/yr, the smallest background index for a 0νββ decay bolometric experiment. The next generation 0νββ bolometric experiment CUPID has chosen the technology of Li2MoO4 scintillating bolometers based on the excellent results demonstrated by CUPID-Mo. We present the projected background of CUPID, which is partially obtained from the CUPID-Mo background model. We also present two studies on the spectral shape measurement of the 2νββ decay of the 100Mo in CUPID-Mo and the spectral shape measurement of the 113Cd β decay in the framework of the CROSS project. The study of the spectral shapes can further constrain the theoretical nuclear models, whose knowledge is absolutely necessary to interpret the 0νββ decay. These studies can also give inputs for theoretical parameters like the effective weak axial-vector coupling strength. We could obtain the most precise measurement of the 100Mo half-life of $T_{1/2}$ = (7.07 +/- 0.02 (stat.) +/- 0.11 (syst.)) x 10^{18} yr. We could also access for the first time to new parameters describing the theoretical spectral shape. Concerning the study of the 113Cd β decay, our data is compatible with a mild quenching of the weak axial-vector coupling constant for three nuclear models.