I. 7 Electron Neutrino Mass from the Electron Capture of $^{163}$Ho


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For the study of electron neutrino mass $m_{\nu_e}$ the MX-ray from the electron capture decay of $^{163}$Ho was measured.\(^1\) $^{163}$Ho was produced by the $^{164}$Dy(p,2n) reaction by a large-current internal irradiation of an enriched $^{164}$Dy target inside the CYRIC cyclotron.\(^2\)\(^-\)\(^4\) $^{163}$Ho was chemically separated and electroplated to give several sources of $^{163}$Ho for MX-ray measurement. The number of $^{163}$Ho atoms in the source was determined by the PIXE method using a proton beam from the CYRIC cyclotron. MX-rays accompanying electron capture of $^{163}$Ho were measured with a Si(Li) low-energy photon spectrometers. Fig. 1 shows the gamma-ray spectrum of one of the $^{163}$Ho sources measured with a Ge(Li) detector, indicating a high radiochemical purity except a very small contamination of $^{88}$Y.

From the MX-ray measurement the total number of emitted MX-rays per $^{163}$Ho atom was obtained to be $(4.7\pm1.5)\times10^{-15}$ sec\(^{-1}\) and the number of $^{163}$Ho atoms was determined by the PIXE measurement to be $(0.88\pm0.26)\times10^{16}$ for source No. 3 which is the strongest. Using the average M fluorescence yield of 98% we obtained the partial M-capture half life of $^{163}$Ho to be $T_{1/2}^{M} = (4.5\pm1.5)\times10^{4}$ y. Using these values together with the log ft value of $^{163}$Ho and a theoretical pairing reduction factor of the nuclear matrix element of $^{163}$Ho to $^{163}$Dy electron capture, we obtain a relation between $m_{\nu_e}$ and the electron-capture Q value as shown in Fig. 2. If we use the experimental value of $Q = 2.3 \pm 1.0$ keV measured by the CERN group\(^5\), we obtain an upper limit of $m_{\nu_e}$ of 1.25 keV/c\(^2\). On the other hand if we assume $m_{\nu_e} = 0$ we can deduce $Q = 2.45 \pm 0.08$ keV and a total half life of $^{163}$Ho of $T_{1/2} = (6\pm2)\times10^{3}$ y.

Improvement of the experimental values obtained here is in progress.

References
3) Proc. 4th Workshop on the Mass of the Electron Neutrino, held at KEK, March 27, 1982; KEK Rept. KEK 82-8, Sept. 1982 E.

Fig. 1. Gamma-ray spectrum of one of the $^{163}$Ho sources

Fig. 2. Relation of $m_{\nu_e}$ and $Q$. The shaded region corresponds to the experimental value with error obtained by the present study.