Evidence of a Low-Intensity β^- Transition in the Disintegration of ^{99}Tc

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Evidence of very low-intensity β^- transition in the disintegration of ^{99}Tc has been demonstrated. It leads to an 89-keV excited level of ^{99}Rh. Its intensity is 1.6×10^{-5}.

The radioactivity of ^{99}Tc by β^- disintegration was suggested by Seaborg and Segrê[1] in 1939 and subsequently revealed.[2] The half-life, the maximum energy of the β^- emission, and the shape of the β^- spectrum have been studied by many authors[3-8] and it seems to be established that this radionuclide decays by a second-forbidden β^- transition ($\frac{9}{2}^+ \rightarrow \frac{5}{2}^+$), with a maximum energy of 292 keV. In addition, more recent work on ^{99}Rh[9,10] has shown the existence of an 89.4-keV excited level of ^{99}Ru, with a spin of $\frac{3}{2}^+$. Thus ^{99}Tc could have a β^- transition leading to this excited level, its intensity would be very weak (~10^{-6}) since it would be a second-forbidden unique transition ($\frac{9}{2}^+ \rightarrow \frac{3}{2}^+$), and the corresponding $\log ft$ value would lie between 12 and 13.[11] This β^- transition would have to be observed through 89.4-keV γ photons.

We therefore used a ^{99}Tc solution of high specific activity (about 100 μCi/g), analyzed by β and γ spectrometry. No β^- emission of energy higher than 300 keV was observed using a spectrometer equipped with a Si(Li) detector ($\Delta E \sim 1.5$ keV). Moreover the γ radiation analysis obtained by means of a spectrometer equipped with a Ge(Li) detector ($\Delta E \sim 2$ keV) shows no peak for energies above 100 keV. The only peak is observed at 89.7 keV, superimposed on the external bremsstrahlung (Fig. 1).

The activity of the solution was measured with a 4π proportional counter; allowing for self-absorption, which is the main correction, the accuracy was estimated at 5% (random errors are negligible). The energy and intensity of the 89.7-keV peak were determined by means of a γ spectrometer with a Ge(Li) detector. The peak energy was measured using the γ transition of ^{57}Co and ^{109}Cd as reference.[12] The value obtained is 89.7 ± 0.4 keV, the associated error being due chiefly to the

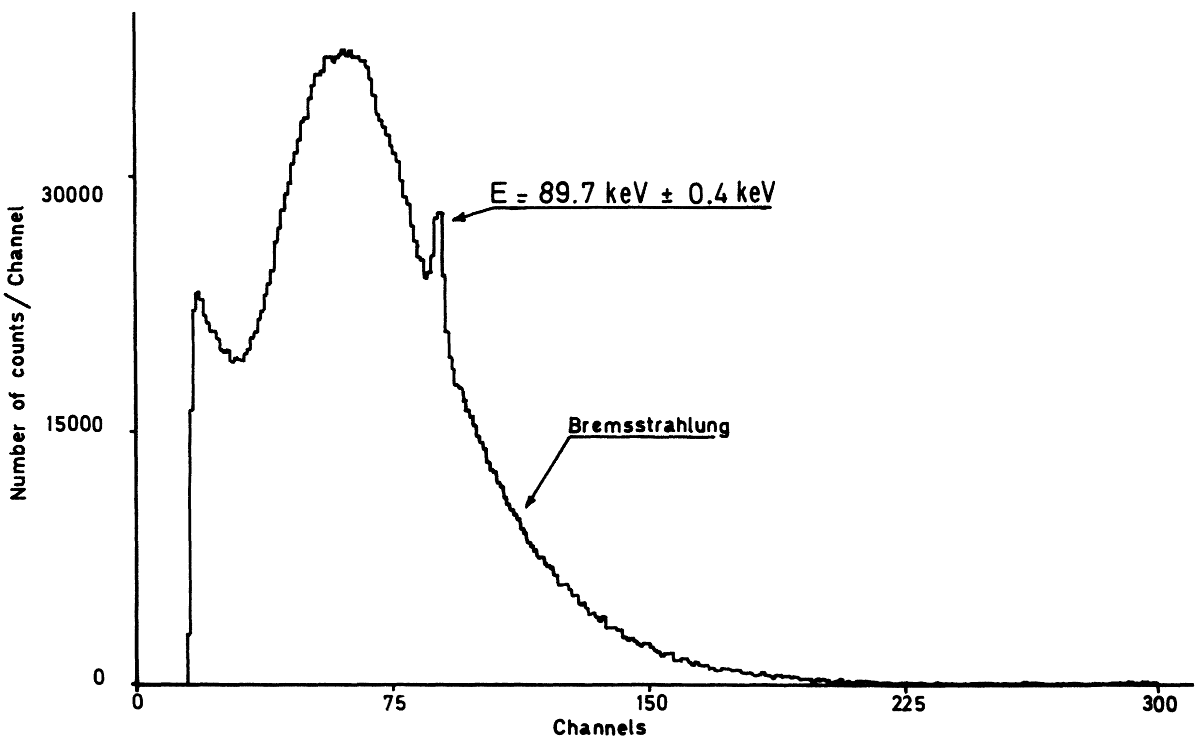

FIG. 1. ^{99}Tc spectrum, 8-cm^2 × 8-mm Ge(Li) detector.

uncertainty on the abscissa of the peak. This energy is in good agreement with that measured by Moss and McDaniels[9] and Antonova, Grigorev, and Protasova,[10] who found 89.36 ± 0.40 and 89.6 ± 0.4 keV, respectively, by studying the disintegration of ^{99}Rh. This seems to show that the peak observed in the decay of ^{99}Tc does in fact belong to ^{99}Ru.

The intensity of the peak was determined using the curve plotting detector efficiency against photon energy. In this region the efficiency is known to within 3%. The area was evaluated by comparing the peak to a Gaussian curve, but being so small with respect to the bremsstrahlung spectrum it is subject to considerable error (15% for a confidence level of 99.7%). Finally the peak intensity obtained is $(6.5 \pm 1.5) \times 10^{-6}$ with respect to the ^{99}Tc disintegration rate.

The 89.7-keV transition is a mixture $M1$ and $E2$. The δ^2 factor can be evaluated at 2.3 ± 0.5 from the values given by Connors[13] and Kistner, Monaro, and Schwarzchild.[14] The total internal conversion coefficient is then estimated at 1.5 using the calculated values of Hager and Seltzer.[15] Thus the rate of ^{99}Tc β^- transition to this excited level would be about 1.6×10^{-5}, which leads to a $\log f_0 t$ value 15.6 taking the ^{99}Tc half-life as 2.12×10^5 yr. The $\log f_2 t$ value would be 12.6, which corresponds to that of a second-forbidden unique transition.[11]

Thus the existence of this β^- transition seems to be justified both by the energy of the ^{99}Ru γ transition and by its intensity and the corresponding $\log f_2 t$ value.

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