JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN VOL. 34, SUPPLEMENT, 1973
PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NUCLEAR MOMENTS AND NUCLEAR STRUCTURE, 1972

V–9 Electromagnetic Properties of the 249.7 keV Level in ^{177}Hf

K. P. GOPINATHAN, A. P. AGNIHOTRY, S. B. PATEL* and M. S. BIDARKUNDI†

Tata Institute of Fundamental Research, Bombay, India
†Indian Institute of Technology, Powai, Bombay, India

The half-life of the 249.7 keV level in ^{177}Hf (see Fig. 1) as deduced from Coulomb excitation measurements[1–3] by different workers varies from 48–110 ps. The magnetic moment of this level has been determined by Brooker *et al.*[4] by perturbed angular correlation measurement of the 71.7–249.7 keV cascade using hyperfine field on Hf in iron. The value of the g factor deduced from their experiment is $g = +0.26 \pm 0.09$ using a value of 100 ps for the half-life of the level. We report here a direct measurement of the half-life of this level by the 249 keV β –249.7 keV γ delayed coincidence using a time-to-pulse-height converter (TAC).

The relative intensities of the 136.7 and 249.7 keV γ-rays from this level and the L sub-shell conversion ratios of the 136.7 keV transition have also been determined to calculate the mixing ratio and the reduced transition probabilities.

A source of 6.8d ^{177}Lu was made by neutron irradiation of 76% enriched ^{176}Lu which was vacuum evaporated onto ~1 mg/cm^2 pure aluminium foil. The β rays were detected by a 2.5 cm diam. ×0.5 cm thick NE-111 plastic scintillator mounted on RCA 8575 photomultiplier. The anode pulses were shaped by an ORTEC constant fraction discriminator and these provided the STOP input to the TAC. The β gate was chosen near the end point of the 249 keV β group feeding the 249.7 keV level to minimise the contribution of the 175 keV β group feeding the 321.3 keV level. The START pulse for the TAC was provided by the Compton of the 249.7 keV γ ray detected in a 2.5 cm diam. × 2.5 cm thick KL-236 plastic scintillator mounted on RCA 8575 photomultiplier. The anode pulse was shaped by an ORTEC fast discriminator. The γ gate was chosen at the Compton edge of the 249.7 keV γ ray. The gated output pulses from the TAC were analysed in a multichannel analyser. A typical time spectrum obtained with the ^{177}Lu source is shown in Fig. 2 as the filled circles. The prompt spectrum was taken using a ^{60}Co source under the same conditions. This is shown by the crosses and the solid line in Fig. 2. The calibration of the TAC was done by standard cables and by observing the β-γ delay spectrum of the 279 keV level in ^{203}Tl having a half-life of 0.28 ns.[5]

The time spectrum with ^{177}Lu source showed a slow-decaying component of intensity ~5%

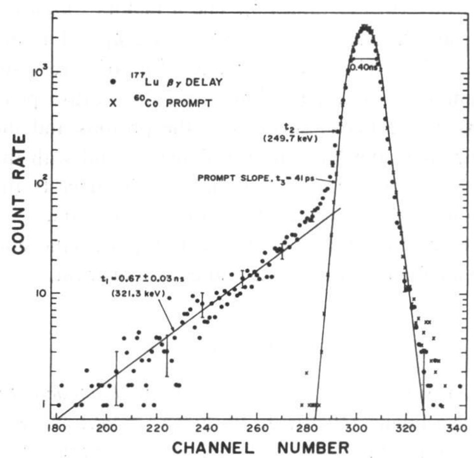

Fig. 2. The time spectrum with ^{177}Lu source (filled circles) along with the prompt spectrum using ^{60}Co (crosses and the solid line).

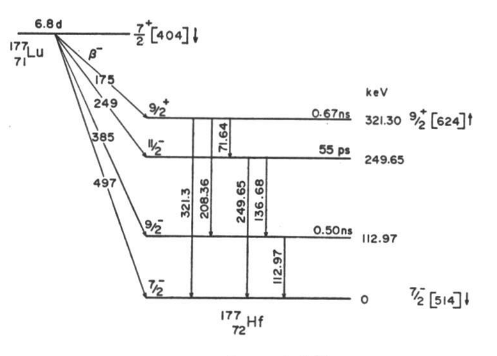

Fig. 1. Decay scheme of 6.8 d ^{177}Lu.

* On leave from Ramnarain Ruia College, Bombay.

(Fig. 2). The half-life of this component was determined by least-squares fit of the linear part to be $t_1 = 0.67 \pm 0.03$ ns, corresponding to that of the 321.3 keV level.[6,7] This can be explained as due to a part of the 175 keV β–321.3 keV γ cascade accepted in the energy gates. After correcting for this component the TAC spectrum showed a slope, $t_2 = 68$ ps, while the prompt slope was, $t_3 = 41$ ps. An approximate value of the half-life of the 249.7 keV level was obtained as $t = (t_2^2 - t_3^2)^{1/2} = 55$ ps. A least squares adjustment of the TAC spectrum was made using the above values of t and t_1 as the zeroth order approximation and the observed prompt spectrum. From this fit the half-life of the 249.7 keV level was obtained as $t(249.7) = 55 \pm 5$ ps. The error includes possible uncertainty in the time calibration.

The intensities of the 136.7 and 249.7 keV γ rays relative to that of the 113 keV γ ray are determined by using a Ge(Li) detector to be 0.0087 ± 0.0020 and 0.031 ± 0.003 respectively.

The L sub-shell conversion ratios of the 136.7 keV transition were measured by a double focusing electron spectrometer to be $L_{\rm I}/L_{\rm II}/L_{\rm III} = 28 \pm 8/112 \pm 23/100$. By comparing with the theoretical values[8] the multipole mixing ratio of the 136.7 keV transition is determined to be $(5 \pm 5)\%$M1 + $(95 \pm 5)\%$E2. Using this along with the total conversion coefficients $\alpha(249.7) = 0.14$ theoretical[8] and $\alpha(136.7) = 1.2$ (present experiments), the reduced M1 transition probability from the 249.7 keV ($11/2^-$) state is calculated to be

$$B(\mathrm{M1}, 11/2 \rightarrow 9/2) = 1.4 \times 10^{-3}\left[\frac{e\hbar}{2\mathrm{M}c}\right]^2.$$

From this value of B(M1) we get the collective model parameter $|g_K - g_R| = 0.04$ for the rotational band. The experimental g factor of the 249.7 keV level may be recalculated from the measurements of Brooker *et al.*[4] using the present value of the half-life, giving $g(249.7)_{\rm expt.} = 0.47 \pm 0.16$. The values of $g_R = 0.253 \pm 0.013$ and $g_K = 0.211 \pm 0.013$ have been derived[9] from the experimental values of the magnetic moments of the ground state and the 113 keV level of ^{177}Hf and the B(M1) value of the 113 keV level. Using these values the calculated g factor of the 249.7 keV level is $g(249.7)_{\rm calc.} = 0.24 \pm 0.015$. This value is not in agreement with the experimental value[4] re-calculated using the present value of the half-life of the level.

References

1) J. De Boer, M. Martin and P. Marmier: Helv. phys. Acta **32** (1959) 377; **32** (1959) 658.
2) O. Hansen, M. C. Olesen, O. Skilbreid and B. Elbek: Nuclear Phys. **25** (1961) 634.
3) Nuclear Data Sheets, NAS-NRC, June 1965.
4) W. H. Brooker, T. A. McMath, J. Murray and J. A. Cameron: Canad. J. Phys. **46** (1968) 1523.
5) C. M. Lederer, J. M. Hollander and I. Perlman: *Table of Isotopes* (Sixth Edition, Wiley, New York, 1967).
6) R. Rougny, J. J. Samueli and A. Sarazin: J. Phys. (France) **26** (1965) 63.
7) E. E. Berlovich, Y. K. Gusev, V. V. Il'in and M. K. Nikitin: Zh. eksper. teor. Fiz. **43** (1962) 1625; Soviet Physics-JETP **16** (1963) 1144.
8) R. S. Hager and E. C. Seltzer: Nuclear Data **A4** (1968) 1.
9) Z. Bochnacki and S. Ogaza: Nuclear Phys. **69** (1965) 186.