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MEASUREMENT OF INTERNAL CONVERSION K/L_3 RATIO AND α_K COEFFICIENT FOR 307.7 keV E 2 RETARDED TRANSITION IN ^{169}Tm

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Abstract: Internal conversion K/L_3 ratio and α_K coefficient for 307.7 keV E2 retarted transition in ^{169}Tm were determined. An iron-free double focusing spectrometer and Ge (Li) detector were used to measure the conversion electron and gamma-ray intensities respectively. Conversion coefficients and conversion ratios were determined from the electron and gamma-ray intensities. The results are in good agreement with theoretical values of Sliv and Band, and Hager and Seltzer.

1. Introduction

Retarted electromagnetic transitions in nuclei have been investigated extensively, and series of experiments in which both K-conversion coefficients and L-subshell ratios are determined have been carried out. Many anomalies ascribed to nuclear structure effects were observed, especially in E1 and M1 transitions. Such anomalies may occur also in higher order multipole transitions. Pauli[1] has derived formulae suitable for the investigation of nuclear structure effects in the electron conversion process.

In this paper, we present the results of measurements of the internal conversion ratios and conversion coefficients for the 307.7 keV E 2 retarted transition in ^{169}Tm.

2. Experimental procedure

An iron-free double focusing spectrometer[2], 50 cm in radius, and GM counter having a 0.40 mg/cm^2 thick window, were used to measure the conversion electron spectra. The targets were prepared by electrodeposition of inactive Yb, from the ytterbium chloride solution in pyridine, on to aluminium foils. The thickness of ytterbium was either 0.15 mg/cm^2 or 0.07 mg/cm^2. The layers were irradiated by a neutron flux of an order of magnitude of 10^{13} n/cm^2 s, over a period of about 20 days. After irradiation each source was left for about a month before the measurements were made, to avoid radiations from short lived isotopes, in particular to make sure that there is no contribution from 4.2 days ^{175}Yb activity.

The lithium-drifted coaxial germanium detector was prepared in our Laboratory*, from monocrystals supplied by Hoboken. It had a depletion depth equal to 7.7 mm, and an axial length of 32.6 mm, corresponding to an active volume of 14 cm^3. ORTEC electronic equipment together with a 1024-chanel analyser was used. The line-width at the energies of ^{60}Co gamma-rays was 3.2 keV. The sources were cut into samples of 2×2 mm, and were fixed to lucite holders.

The efficiency calibration curve was obtained by making use of a set of calibrated sources, suplied by IAEA (^{22}Na, ^{57}Co, ^{60}Co, ^{137}Cs ...).

Figs. 1—3 show the spectra of gamma-rays and of internal conversion in K and L-shells. The relevant lines were measured seven times, with different sources. Errors in line and ratio intensities, involving uncertainties of the calibration curve, were estimated in a manner similar to that described previously[3].

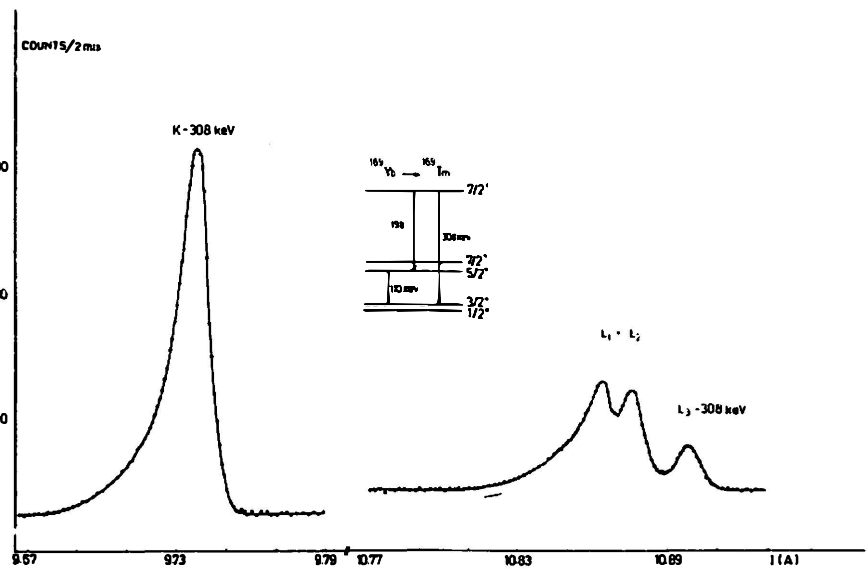

Fig. 1. K- and L-conversion lines of the 307.7 keV transition in ^{169}Tm. I is the spectrometer current.

* The detector was prepared by Dr V. Ajdačić, Dr B. Lalović, Mr. I. Slavić and B. Petrović

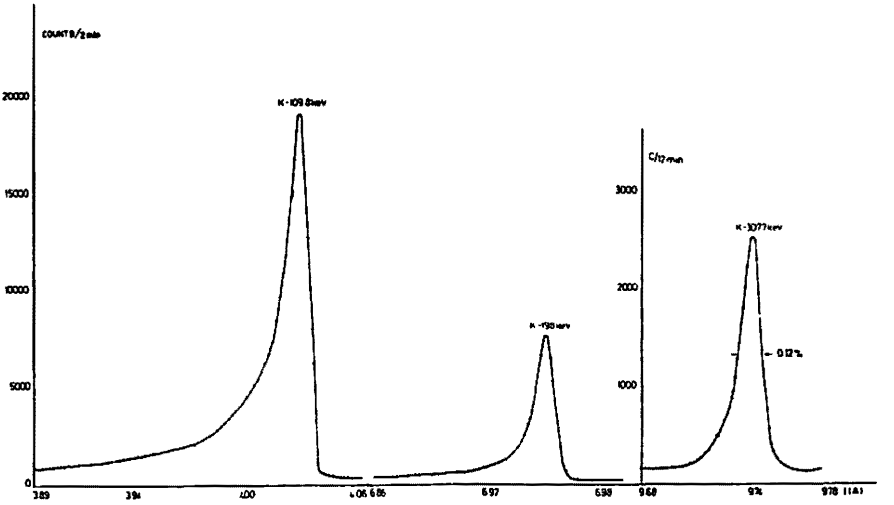

Fig. 2. K — conversion lines of the 109.7, 197.97 and 307.7 transitions in ^{169}Tm. I is the spectrometer current.

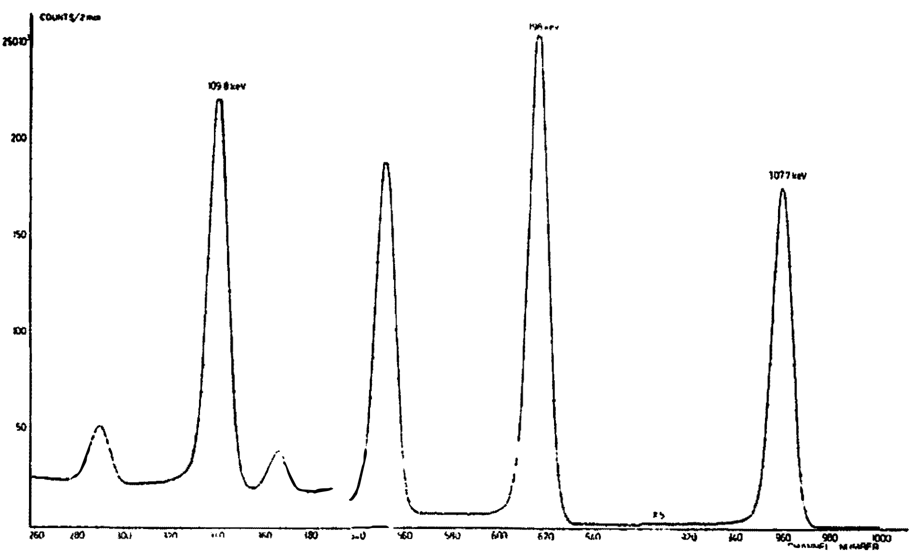

Fig. 3. Parts of the Ge(Li) gamma-ray spectrum of ^{169}Tm with relevant lines.

3. *Results*

Conversion coefficients α_K for the 307.7 keV transition were determined from the electron and gamma-ray intensities by the NPG method[4]. The gamma-ray intensity I_γ and the K electron intensity I_K of the unknown transition were measured relative to the gamma-ray $I_{\gamma R}$ and electron I_{KR} intensities of a reference transition. If the K-conversion coefficient α_{KR} of our reference transition is known, the unknown conversion coefficient is obtained from

$$\alpha_K = \left(\frac{I_K}{I_\gamma}\right)\left(\frac{I_{\gamma R}}{I_{KR}}\right)\alpha_{KR} \,. \tag{1}$$

The 109.8 keV and 197.97 keV transitions in the same nucleus were used as reference transitions.

Table 1

Comparison of experimental and theoretical K conversion coefficients of the 307.7 keV transition in ^{169}Tm

Author	α_K (307.7 keV)
L. A. Sliv and I. M. Band[15]	0.0484
R. S. Hager and E. C. Seltzer[16]	0.0483
E. N. Hatch et. al.[17]	0.040
J. W. Michelich et. al.[18]	0.059 ± 0.012
M. S. El-Nesr and E. Bashandy[19]	0.044 ± 0.005
Z. Grabowski et. al.[11]	0.048 ± 0.005
present work*	
(109.8 keV)[a]	0.0488 ± 0.0035
(197.97 keV)[b]	0.0496 ± 0.0040

a) 109.8 keV; b) 197.97 keV in the same nucleus.

Table 2

Comparison of experimental and theoretical ICC ratios for the 307.7 keV transition in ^{169}Tm

Author	K/L	K/L$_3$
L. A. Sliv and I. M. Band[15]	3.36	14.8
R. S. Hager and E. C. Seltzer[16]	3.47	15.1
Z. Grabowski et. al.[11]	3.4 ± 0.3	
Y. Gizon and A. Baudry[20]	3.51 ± 0.15	16.4 ± 0.75
present work	3.49 ± 0.11	15.5 ± 0.8

In recent years the 109.8 keV transition has been studied by several authors[5-10], and a small E2 admixure of 2.2% was found.

The 197.97 keV transition is forbidden by the K-selection rule. This transition has been investigated[11] using the directional correlation method. Evidence of the penetration effect, as predicted by the theory[12], has not been

* α_K (307.7 keV) is derived by the formula (1) with α_{KR} theoretical coefficients for reference transitions.

found. Consequently, our results for L-subshell conversion ratios, are in good agreement with those reported in Ref. [6, 13, 14] and show an E2 admixure of 8.5%.

The experimental results of other authors for the 307.7 keV transition are compared in Table 1 and 2 with our results, and with the theoretical conversion coefficients interpolated from the tables published by Sliv and Band[15] and Hager and Seltzer[16]. The uncertainties of the theoretical values are not included.

For α_K (307.7 keV) two values of the conversion coefficients are shown. These are derived by the formula (1) from the theoretical values α_{KR} for the 109.8 and 197.97 keV transitions, respectively (Table 1).

Our α_K values are in good agreement with the theoretical values for a pure E2 transition.

Differences between experimental K/L and K/L_3 ratios and theoretical values are less than 5%.

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MERENJE K/L_3 ODNOSA I α_K KOEFICIJENTA UNUTRAŠNJE KONVERZIJE ZA 307,7 keV E 2 ZAKAŠNJELI PRELAZ U ^{169}Tm

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Sadržaj

Eksperimentalno su određeni konverzioni odnos K/L_3 i apsolutni konverzioni koeficijent α_K za E 2 usporeni prelaz sa energijom od 307,7 keV u ^{169}Tm. Spektar konverzionih elektrona meren je pomoću dvostruko fokusirajućeg bezželjeznog spektrometra. Intenziteti gama linija određeni su pomoću Ge (Li) detektora. Konverzioni odnosi određeni su iz odnosa intenziteta konverzionih linija. Apsolutni konverzioni koeficijenti određeni su upoređivanjem intenziteta konverzionih i gama linija za dati prelaz od 307,7 keV i prelaza sa poznatim multipolnim smešama, u istom jezgru, sa energijama od 109,8 keV i 197,97 keV. Procenat komponente E 2 smeše za prelaz od 109,8 keV uzet je iz literature, dok je za prelaz od 198 keV eksperimentalno određen iz $L_1/L_2/L_3$ konverzionih odnosa.

Dobijeni rezultati upoređeni su sa tabličnim vrednostima koje su izračunali Sliv i Band, i Hager i Seltzer. Eksperimentalne vrednosti i za konverzioni koeficijent α_K i za konverzioni odnos K/L_3 pokazuje slaganje sa odgovarajućim teorijskim vrednostima u granicama greške eksperimenta.