Beta-Vibrational Band in ^{152}Sm

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The intensities of the γ rays (444.1-, 563.9-, 656.1-, 688.0-, and 810.5-keV) between the various levels of the β-vibrational band and the ground-state rotational band of ^{152}Sm are measured from an analysis of high-resolution (2.6-keV) γ-ray spectra of the 98%-enriched 12.4-yr ^{152}Eu decay. Upper limits of the intensities of the $4_\beta^+ \rightarrow 6^+$ and $4_\beta^+ \rightarrow 2^+$ transitions are also given. From the α_k of the 444.1-keV transition, the $2_\beta^+ \rightarrow 4^+$ branching is shown to be less than 5% of the total 444.1-keV γ intensity. A small but definite broadening of the 810.5-keV photopeak is observed. From these observations it is concluded that the reported $B(E2)$ ratios for these transitions may have to be changed considerably.

1. INTRODUCTION

THERE is a close similarity between the level spectra of the two isotonic nuclei ^{154}Gd and ^{152}Sm. Recently, Reidinger *et al.*[1] have compared the $B(E2)$ ratios between members of the β-vibrational band and the ground-state (g.s.) rotational band and have found pronounced differences between the $B(E2)$ ratios in the two nuclei. In the present work, we have attempted to determine, as accurately as possible, the intensities of the relevant weak γ rays in the decay of 12.4-yr ^{152}Eu. γ-ray spectra are taken with a 10-yr-old 98%-enriched ^{152}Eu source and a high-resolution (2.6-keV) Ge(Li) detector. Using the excellent internal conversion data of Malmsten *et al.*[2] we have also obtained the K-conversion coefficients α_K, for these transitions. An accurate determination of α_K for these weak transitions is felt to be the best way to identify the levels under our consideration. Our results reveal that a reliable determination of the $B(E2)$ ratios for the β-vibrational band in ^{152}Sm is beset with very considerably difficulties. We discuss the relevant aspects.

2. 444-keV TRANSITION FROM 2^+ β-VIBRATIONAL LEVEL AT 811-keV TO THE 4^+, 366.5-keV LEVEL OF THE g.s. ROTATIONAL BAND

There is an alternate placement of the 444-keV transition in ^{152}Sm between levels at 2^-, 1530 keV and 2^+, 1086 keV. From Table I, we see that the experimental value of α_K agrees with the theoretical value for a pure $E1$ transition. If, however, the experimental α_K value is increased by twice its quoted error then the theoretical α_K values (Table I) could permit the presence of a maximum of 5% $E2$ component in the 444-keV transition. One can thus conclude that the 444-keV transition from the 2^+, 811-keV level to the 4^+, 366.5-keV level, if present, must be less than 5% of the total intensity of 444-keV γ ray. From coincidence experiments,[1] 10% of the total 444-keV γ intensity is ascribed to this transition. The reason for this discrepancy is not understood by us.

3. 811-keV TRANSITION FROM 2^+ β-VIBRATIONAL LEVEL TO 0^+ GROUND STATE

A close doublet of 809 and 810 keV is reported in Ref. 3. Undoubtedly, this has important bearing on the $2'^+ \rightarrow 0^+$ γ-ray branching. A small but systematic broadening of the line shape for this transition is observed by us in all the runs (see Fig. 1). The peak is centered at 810.5 keV and a doublet of 810 and 811 keV of about the same intensity can fit the line shape very well. However, in the absence of more precise values for the energies of the members of the doublet the intensities can not be determined unambiguously. It is, therefore, not possible to determine exactly how much overestimation has been made in the reported $B(E2)$ value[1] for the $2'^+ \rightarrow 0^+$ transition. We suggest that a study of the line shape be made with improved energy resolution.

4. 1022-keV LEVEL AS 4^+-MEMBER OF β-VIBRATIONAL BAND

The 1022-keV level is excited in (p, p') (Ref. 4) and (d, d') (Ref. 5) reactions. From the (d, d') cross sections at 90° and 125°, this level is assigned a spin parity of 4^+. But no detailed fit of the angular distribution data is available. In decay scheme studies, the same level is presumably seen and it accounts for the 656-keV transition feeding the 4^+, 366.5-keV level. From the α_K value of the 656-keV γ-ray (Table I) we notice a large $E0$ admixture, and this is the *only* evidence that the 656-keV transition is $4'^+ \rightarrow 4^+$. (Such $E0+E2$ admixture is found for the 688-keV, $2'^+ \rightarrow 2^+$ transition also.) We have failed to ascribe any other γ transition to or from this level although some 51 γ transitions are observed by us. Particular efforts are made to detect the possible 310- and 900-keV transitions from this level to the 6^+ and 2^+ levels of the gs rotational band. The intensities of these γ rays, if present, are less than 0.03 and 0.04, respectively, in the scale given in Table I.

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TABLE I. γ-ray intensities and α_K for transitions between members of β-vibrational band and g.s. rotational band in ^{152}Sm.

Transition From	Transition To	E_γ[a] (keV) (±0.5 keV)	I_γ $I_\gamma(344)=26$	I_{ek}[b] $I_{ek}(344)=72$	$10^3\,\alpha_K$ Expt $\alpha_K(344)=0.0302$	$10^3\,\alpha_K$ Theoret[c] $E1$	$E2$	$M1$
4^+	6^+	310.0[d]	<0.03	...	...	...	...	...
2^+	4^+	444.1	3.0±0.3	1.2±0.1	4.3±0.5	4.9	14.5	24.9
2^-	2^+							
0^+	2^+	563.9	0.34±0.08[e]	0.15±0.07	4.7±2.4	2.8	7.7	13.5
4^+	4^+	656.1	0.15±0.05	0.59±0.11	43.0±7.7	2.0	5.4	9.3
2^+	2^+	688.0	0.80±0.09	2.6±0.2	35.1±4.4	1.9	4.9	8.3
2^+	0^+	810.5[f]	0.34±0.05	0.09±0.04	2.8±1.5	1.3	3.3	5.6
4^+	2^+	900.3	<0.04	...	...	...	...	...

[a] In the text, the γ energies are rounded off to the nearest integers.
[b] Reference 2.
[c] L. Sliv and I. Band *Alpha-, Beta-, and Gamma-Ray Spectroscopy*, edited by K. Siegbahn (North-Holland Publishing Co., Amsterdam, 1965). The values have been kindly provided by Dr. E. B. Ewbank of Oak Ridge National Laboratory.
[d] Energy of 6^+ level is taken as 712 keV (Ref. 4). In Ref. 5, this level is reported at 705 keV.
[e] From graphical analysis of the 563.9- and 566.4-keV composite line using the energies from Ref. 2.
[f] The 810.5-keV line is composite (see text).

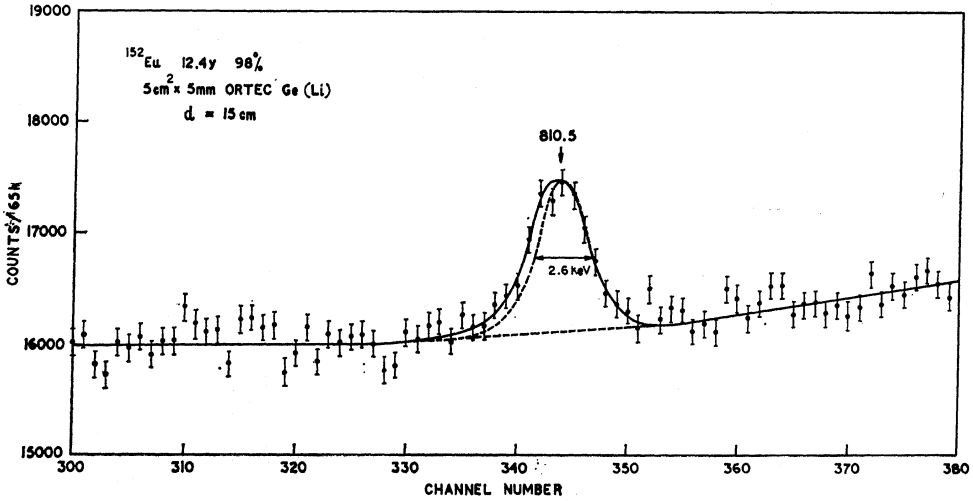

FIG. 1. A typical spectrum of the weak 810.5-keV line, showing the small line broadening. The dotted curve under the peak shows the observed shape for the 779- and 868-keV photopeaks in the same run with peak heights normalized.

The results of the present investigation indicate that the

$$B(E2;\,2'\rightarrow 4)/B(E2;\,2'\rightarrow 2)$$

and

$$B(E2;\,2'\rightarrow 0)/B(E2;\,2'\rightarrow 2)$$

ratios, listed in Table I of Ref. 1, may have to be reduced considerably. Therefore, the possibility[6] that the $2'^+\rightarrow 2^+$ transition is more than 80% $M1$ can not be ruled out from the available data. It will be worthwhile to measure the $E2/M1$ ratio from an angular correlation experiment between the 688- and 122-keV γ rays. Such large $M1$ admixture in similar $2'^+\rightarrow 2^+$ transitions has been reported recently.[7]

ACKNOWLEDGMENT

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[6] F. K. McGowan, R. Sayer, and P. H. Stelson, as requoted in Ref. 1.

[7] H. L. Nielsen, K. B. Nielsen, and N. Rud, Phys. Letters **27B**, 150 (1968).