ANGULAR CORRELATION OF THE γ CASCADE DUE TO THE 440—337 keV TRANSITION IN Sm^{150}

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The angular correlation of the γ cascade emitted by the excited Sm^{150} nucleus in the 440—337 keV transition was measured at 90°, 135°, and 180°. An analysis of the experimental data shows that the spin of the second level in Sm^{150} is 4.

THE $_{62}Sm^{150}$ nucleus is at the boundary of the region of strongly deformed nuclei, and hence the low-lying excited states are either rotational or vibrational. The ratio of the energies of the second and first excited levels is $E_{II}/E_I = 2.3$ (E_{II} = 777 keV, E_I = 337 keV) and not 3.3 as in the case of rotational levels; it can therefore be assumed that the spectrum of the ground state is vibrational. If this is so, then the spin of the second level of this nucleus is either 0, 2, or 4. The data reported thus far in the literature are ambiguous. Thus Rosler and Fenstermacher gave the value 3 and Draper [2] gave the values 2, 3, or 4. In the present article we report the results obtained from the angular-correlation measurements of 440- and 337-keV γ rays emitted by Sm^{150} in the transitions $E_{II} - E_I - E_0$.

The experiment was carried out with a neutron beam from one of the horizontal channels of the VVR-S-2 reactor. The neutrons first passed through a quartz filter 10 cm long to increase the amount of thermal neutrons and then through a CB_4 and lead collimator. This gave a beam diameter of 15 mm at the channel exit.

The target consisted of samarium oxide disks 10 mm in diameter and 1 mm thick placed perpendicularly to the beam with the center on the beam axis. The angular correlation was measured with the aid of two scintillation counters; one was fixed and the other rotated in the vertical plane so that the axis of rotation coincided with the beam axis.

A block diagram of the electronic equipment is given in Fig. 1. A single-channel analyzer passed only pulses corresponding to 440-keV γ rays, so that a 400-channel SA-40 pulse-height analyzer recorded only the spectra in coincidence with these γ rays. The position of the discriminator window is shown in Fig. 2.

The measurements were made at angles θ = 90, 135, and 180°. From the spectra we determined the area of the photopeak at 337 keV.

The background was found from the measured shape of the 325-keV γ line of Cr^{51} with allowance for the contribution from random coincidences; the latter was calculated on the basis of the known resolution of the coincidence circuit. At 180° we also took into account the additional background produced by 511-keV γ lines arising in the annihilation of positrons.

The absence of any systematic side effects associated with the experimental arrangement was checked with measurements of the known correlation between the 1.17- and 1.33-MeV γ lines from the Ni^{60} spectrum.

The table lists the experimental and theoretical values of $W(\theta)/W(\pi/2) - 1$ for γ rays of the 440—330 keV cascade [$W(\theta)$ and $W(\pi/2)$ are the numbers of counts at the angles θ and $\pi/2$ respectively; the listed errors are statistical]. The theoretical values were calculated on the basis of the paper of Ferentz and Rosenzweig [3] with allowance for corrections for the finite solid angles

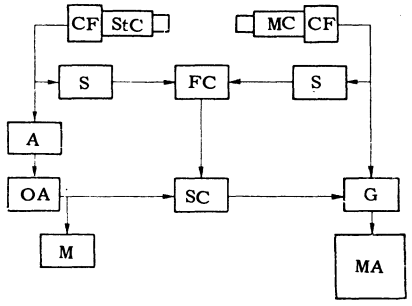

FIG. 1. Block diagram of the experiment: StC – stationary counter, MC – movable counter, CF – cathode follower, S – shaping circuit, FC – fast coincidences ($\tau = 4.8 \times 10^{-8}$ sec), A – linear amplifier, OA – single-channel analyzer, SC – slow coincidences (2×10^{-6} sec), G – gate, MA – 400 channel SA-40 analyzer, M – monitor.

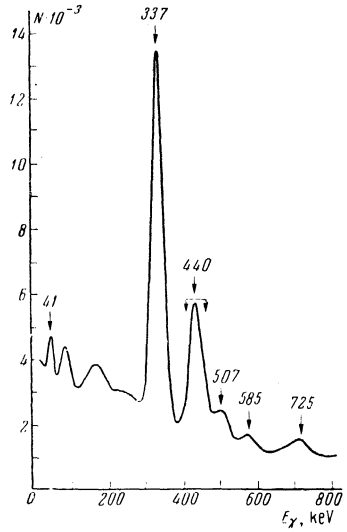

FIG. 2. Gamma spectrum for the capture of thermal neutrons by Sm^{149}. The position of the window of the single-channel analyzer is shown in the figure (N is the number of counts).

subtended by the counters [4] and for the extended source [5] with four values of spin: 0, 2, 3, and 4. Here we took the multiplicity of the γ rays to be two, as has been done by Groshev et al.[6] It follows from the table that the spin of the 777-keV level is 4.

We also made an additional analysis of the experimental results under the assumption that the $E_{II} - E_I$ transition includes an admixture of M1 transitions. For mixed transitions of the type $2[xE2 + (1-x)M1]2(2)0$, where x is the fraction of E2 transitions, no single value of x is compatible with both experimental points. Figure 3 shows the calculated correlation curves when the quantity $2[xE2 + (1-x)M1]2(2)0$ is chosen so that the curves pass through one of the experimental points. Curve b (x = 0.99) passes through the experimental point at 180°, but is significantly at variance with experiment at 135°, while curve a (x = 0.78) passes through the experimental point at 135°, but strongly disagrees with the experimental point at 180°.

Under the assumption of spin 3, all mixtures with M1 transitions lead to values of $W(\theta)/W(\pi/2)$ less than unity. By way of example, the calculated curve c in Fig. 3 represents a transition of the type $3(0.98E2 + 0.02M1)2(2)0$.

Hence the values of 2 and 3 for the spin of the E_{II} level are also excluded if it assumed that the transitions are mixed.

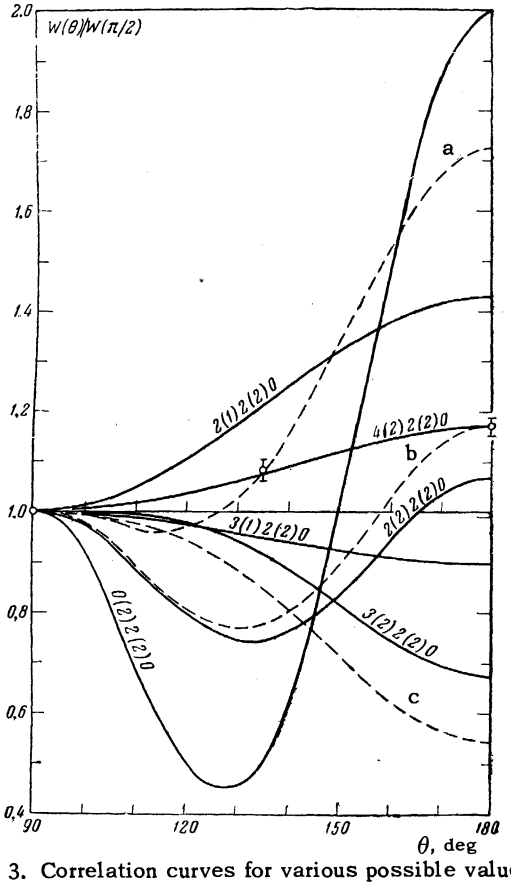

FIG. 3. Correlation curves for various possible values of the spin of the second level and for different multipolarities of the E_{II}–E_I transition; the solid lines represent pure transitions and the dashed lines represent mixed transitions. Curves a, b, and c correspond to transitions of the type $2(0.72E2 + 0.28M1)2(2)0$, $2(0.99E2 + 0.01M1)2(2)0$, and $3(0.98E2 + 0.02M1)2(2)0$, respectively.

The analysis also indicates that the $E_{II} - E_I$ transition is pure. Preliminary estimates show that the effect of γ rays of energy greater than 440 keV on the correlation is not important. A spin of 4 and not 3 is indicated by the fact that the 777-keV level belongs to the vibrational band of the ground state. A spin of 2 is ruled out by the experimental results, since no 777-keV line is visible in the spectrum obtained with one crystal.

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θ, deg	$W(\theta)/W(\pi/2) - 1$				
	Experimental value	Theoretical value (corrected)			
		cascade 0(2)2(2)0	cascade 2(2)2(2)0	cascade 3(2)2(2)0	cascade 4(2)2(2)0
135	0.082±0.020	—0.464	—0.261	—0.081	0.068
180	0.170±0.015	0.968	0.076	—0.317	0.158

Singureanu and A. Gelberg for discussions of the results.

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186