Gamma-Ray Angular Correlations and Spin Assignments in Sm^{149}†

O. K. HARLING
Hanford Laboratories, General Electric Company, Richland, Washington

AND

C. A. VENTRICE
The Pennsylvania State University, University Park, Pennsylvania

AND

J. J. PINAJIAN
Oak Ridge National Laboratory, Oak Ridge, Tennessee

(Received 28 May 1963)

Levels in Sm^{149}, following electron-capture decay from Eu^{149}, occur at 22.5, 277, 350, 529, and 558 keV. Experimentally determined coefficients of the correlation function are $A_2=-0.398\pm0.040$, $A_4=0.122\pm0.024$; $A_2=-0.139\pm0.018$, $A_4=0.218\pm0.065$; and $A_2=0.147\pm0.022$, $A_4=-0.267\pm0.080$, respectively, for the following gamma cascades: 180–328, 281–277, and 73–277 keV. Assuming a mixture of dipole and quadrupole radiation for all of the cascading gamma rays, the theoretical coefficients were calculated and compared with the experimental results. Spin assignments for the excited states in Sm^{149}, which are consistent with the experimental results, are $\frac{7}{2}$ (22.5 keV), $\frac{9}{2}$ (277 keV), $\frac{9}{2}$ (350 keV), $\frac{7}{2}$ or 11/2 (529 keV), and $\frac{7}{2}$ (558 keV). The quadrupole-dipole mixing has been determined for the cascading gamma rays. The half-life of the isotope associated with the 281–277-keV coincidence was measured in order to reduce the uncertainty of assigning the 281-keV gamma ray.

I. INTRODUCTION

THE *K*-capture decay of Eu^{149} to Sm^{149} has been studied previously[1–4] by use of magnetic spectrographs, scintillation counters, and gas proportional counters. The decay schemes proposed in these references are in fair agreement. However, spin assignments are lacking for the excited states in Sm^{149}. The ground-state spin of Sm^{149} has been found[5–7] to be $\frac{7}{2}$. Information of gamma-ray multipolarity can be obtained from the conversion-electron data of Refs. 1 and 2. A gamma ray of about 281 keV has been reported in Ref. 4, but has not been seen by other experimenters.

In the present work we report the results of gamma-gamma directional correlations performed using scintillation spectrometers and a high-pressure gas proportional counter. Correlations were measured for four of the cascades which arise from the Eu^{149} decay: 178.4/327.7 keV, 281/277.2 keV, 72.9/277.2 keV, and 327.7/22.5 keV. In addition, coincidence and half-life investigations were performed in order to establish the existence of a 281-keV gamma-ray transition between the 558.3-keV level and the 277.2-keV level of Sm^{149}.

Assuming a mixture of dipole and quadrupole radiation for all of the cascading gamma rays, we have calculated theoretical coefficients and compared them with our experimental results. Spin assignments for the excited states in Sm^{149} are made based on this comparison. The quadrupole-dipole mixing has been determined for the cascading gamma rays.

II. EXPERIMENTAL PROCEDURE

Apparatus

The bulk of the electronic equipment used has been described in a previous paper.[4] 3-×3-in. and 2-×2-in. NaI crystals were utilized for most of the correlation measurements. These were mounted about 10 in. above a wooden correlation table. The crystal mounts were made of aluminum and with minimum bulk to reduce scattering. One detector was movable and could be positioned at any angle with respect to the fixed detector. The sources were placed in thin Lucite cylinders about 0.1 in. in diameter by 0.28-in. long. The wall thickness of these plastic holders was only 7 mils, so that self scattering and source holder scattering could be neglected at most energies. The source was suspended from above by a tapered aluminum rod which was attached to a rifle sight. Adjustment of the lead screws on the gun sight provided an accurate adjustment for the source position in the horizontal plane. The two detectors were aligned so that their axes of symmetry were in the same horizontal plane and passed through the center of the source.

A proportional counter filled to 3 or 4 atm with a 90–10% mixture of argon and methane was used to measure coincidences at 22.5 keV. A thin aluminum window, about 0.010-in. thick, provided a well-defined opening for these low-energy photons.

† Work supported in part by the U. S. Atomic Energy Commission.

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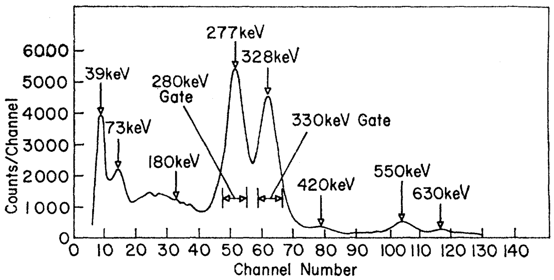

FIG. 1. Eu^{149} singles spectrum taken with 2-in.×2-in. NaI crystal.

Sources

The Eu^{149} which was used in these experiments was produced by (p,n) and $(p,2n)$ bombardment of Sm^{149} and Sm^{150}, respectively, at the ORNL 86-in. cyclotron. Most measurements were actually made from material produced in bombarding a 97.5% enriched sample of $Sm_2{}^{149}O_3$ with 12-MeV protons. Dilute hydrochloric acid was used to dissolve the rare-earth oxide for liquid sources.

Measurements

Detectors and source were carefully aligned and both detectors calibrated for energy. Source-to-detector distances were carefully measured. The coincidence circuits were used with resolving times of 10^{-6} to 10^{-7} sec. Spectra of accidental coincidences were obtained by using two independent sources with crystals shielded from one another, or by insertion of a suitable delay on one side of the coincidence circuit. At least a day was allowed for the electronic equipment to stabilize. During the coincidence experiments system gain was checked and adjusted every hour. Drifts during this period were generally very small.

A complete correlation experiment was carried out with Co^{60} to test the operation of the complete system. The experimental correlation coefficients agreed very well, after geometrical correlations were made, with the theoretical coefficients calculated for the 1170/1330-keV cascade.

With the Eu^{149} sample, coincidence spectra as a function of angle between detectors were taken with angles from 90 to 180 deg. A one-channel-analyzer energy gate was set on the gamma-ray peaks at 277 and at 328 keV for the angular correlation measurements. Coincidence distributions were usually taken at 15-deg intervals. Counting periods of from 2 to 15 h at each angle produced several thousand coincidence counts under the peaks of interest. In order to average out changes due to equipment drifts and source decay, the detector angle was varied between measurements and the average coincidence count for a given angle taken from a number of separate measurements.

Errors in the results due to scattering from one detector to the other were investigated with a graded anticompton shield placed between detectors. In addition, the pulse-height distribution and scatter probability for a monoenergetic Cs^{137} source was measured for the geometry of our experiments. The information which was obtained indicated that scattering between crystals had a negligible effect in the measurements reported here.

III. RESULTS AND ANALYSIS

Spectra

Figure 1 shows a typical pulse-height spectrum of gamma rays emitted from the Eu^{149} source. The positions of the one-channel-analyzer gate used during the coincidence measurements are also shown. The gamma rays at 420 and 630 keV are due to contaminating activities.

Figures 2 and 3 show the coincidence spectra obtained by gating at 330 and 280 keV, respectively. The area under the 178- and 277-keV peaks was evaluated after subtraction of the background coincidence spectra as indicated in the figures. A Gaussian fit was also made to the 277-keV peak to subtract the contribution from the 255-keV gamma ray which also appears in this coincidence spectrum.

Half-Life of the 281-keV Transition

The coincidence rate as a function of time was measured for the 281/277-keV coincidence. Data were taken, both with 180° and 90° geometry, for a period of 100 days. After comparison of the 90° and 180° data, these were averaged and plotted in Fig. 4. The half-life, of 115±10 days, which was obtained from the semilog plot, supports the assignment of the 281-keV transition to the Eu^{149} decay.

Angular Correlations

A power series in $\cos\theta$ was least-squares fitted to the experimental data. The experimental coefficients for the correlation function were then placed in the form

$$R(\theta)=1+A_2P_2(\cos\theta)+A_4P_4(\cos\theta)\,. \qquad (1)$$

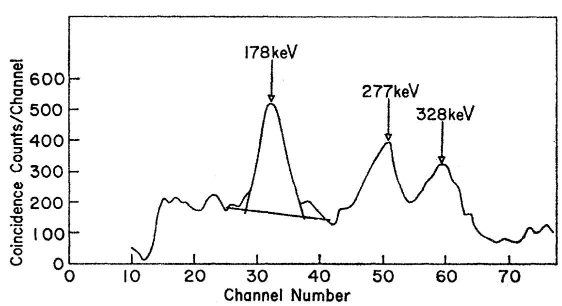

FIG. 2. Scintillation spectrum of gamma rays in coincidence with 327.7-keV gamma ray (Gate).

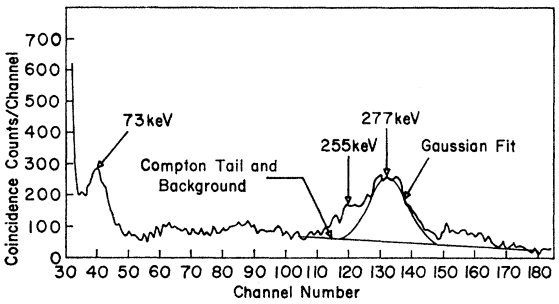

FIG. 3. Scintillation spectrum of gamma rays in coincidence with 277.2-keV gamma ray (Gate).

Theoretical coefficients used for comparison with the experimental data were calculated using[8,9]

$$\begin{aligned}A_k=\{&(1-Q_1)F_k(L_1L_1j_1j)\\&\pm2[Q_1(1-Q_1)]^{1/2}F_k(L_1L_1+1j_1j)\\&+Q_1F_k(L_1+1L_1+1j_1j)\}\\&\times\{(1-Q_2)F_k(L_2L_2j_2j)\\&\pm2[Q_2(1-Q_2)]^{1/2}F_k(L_2L_2+1j_2j)\\&+Q_2F_k(L_2+1L_2+1j_2j)\}\,,\end{aligned}\tag{2}$$

where $Q_i=\delta_i^2/(1+\delta_i^2)=(L+1)$-pole mixture, the subscripts on the Q's refer to the gamma rays in the cascades (see Table I), and

TABLE I. Proposed quadrupole mixtures of gamma-ray transitions.

Gamma-ray energy (keV)	Q	Magnitude of quadrupole mixture	δ	Levels	Spins
281	Q_1	0.993 ± 0.004 (E_2 or M_2)	+	*a–c*	$\frac{7}{2}-\frac{9}{2}$
72.9	Q_2	0.978 ± 0.017 (E_2)	+	*b–c*	$\frac{9}{2}-\frac{9}{2}$
277.2	Q_3	0.735 ± 0.095 (E_2)	−	*c–d*	$\frac{9}{2}-\frac{7}{2}$
178.4	Q_4	0.373 ± 0.078 (E_2)	−	*e–b*	$\frac{7}{2}-\frac{9}{2}$
327.7	Q_5	0.962 ± 0.009 (E_2)	+	*b–f*	$\frac{9}{2}-\frac{7}{2}$
178.4	Q_4	0.962 ± 0.009 (E_2)	+	*e–b*	$\frac{7}{2}-\frac{9}{2}$
327.7	Q_5	0.373 ± 0.078 (E_2)	−	*b–f*	$\frac{9}{2}-\frac{7}{2}$
178.4	Q_4	0.903 ± 0.033 (E_2)	−	*e–b*	$\frac{7}{2}-\frac{9}{2}$
327.7	Q_5	0.391 ± 0.078 (E_2)	+	*b–f*	$\frac{9}{2}-\frac{7}{2}$
178.4	Q_4	0.391 ± 0.078 (E_2)	+	*e–b*	$\frac{7}{2}-\frac{9}{2}$
327.7	Q_5	0.903 ± 0.033 (E_2)	−	*b–f*	$\frac{9}{2}-\frac{7}{2}$
178.4	Q_4	0.910 ± 0.060 (E_2)	+	*e–b*	$11/2-\frac{9}{2}$
327.7	Q_5	0.880 ± 0.060 (E_2)	+	*b–f*	$\frac{9}{2}-\frac{7}{2}$

$$\delta_i^2=\frac{\text{intensity of }(L+1)-\text{pole radiation}}{\text{intensity of }(L)-\text{pole radiation}}$$

for the ith transition, and the F_k values have been tabulated[10] for given spin sequences and multipole mixtures.

Corrections were made for the finite solid angle of the detectors using the results given by Marion[11] for 2-in. and 3-in. NaI crystals. Experimental errors on the A_2 and A_4 coefficients were determined according to the method of Rose.[12]

The correlation for the 178.4/327.7-keV cascade of Eu^{149} was performed three times: twice with solid samples and once with a liquid. The 3-in. crystal was placed 10 cm, and the 2-in. crystal 7 cm from the center of the source. Coincidence data were collected at the angles, $\theta=90°$, 105°, 120°, 135°, 150°, 165°, and 180°. Figure 5 shows the coincidence rate versus θ for one of the solid sample runs. The continuous curve drawn through the experimental points is a least-squares fit to a power series in $\cos\theta$. The experimental coefficients obtained from the two solid and one liquid source measurements agreed within the experimental error. Averaging the results of the separate measurements and correcting for geometry, we obtain

$$A_2=-0.3977\pm0.0398\,,\quad A_4=+0.1220\pm0.0244$$

for the correlation coefficients. The errors assigned to the coefficients are twice the standard deviation. This was done to attempt to include all reasonable interpretations of the results.

Correlation data for the 281/277.2 and 72.9/277.2-keV cascades are shown in Figs. 6 and 7. By gating at 280 keV, both correlations could be measured simultaneously. Two runs were made, one with a solid and the other with a liquid sample. Angular increments of 15° and 30° were used to cover the range of 90°–180°. The source to detector distance was 5 cm for the 3-×3-in. crystal, and 4 cm for the 2-×2-in. crystal. These relatively large solid angles were necessitated by the low coincidence-counting rates. The experimental coefficients for the liquid and solid measurements were compared and found to be in good agreement. Averaging the liquid and solid data, and correcting for geometry,

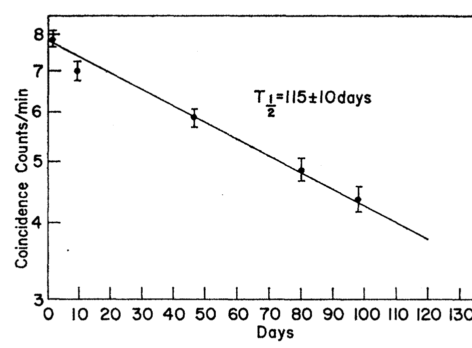

FIG. 4. Semilog plot of 277.2/281-keV coincidence count rate versus time.

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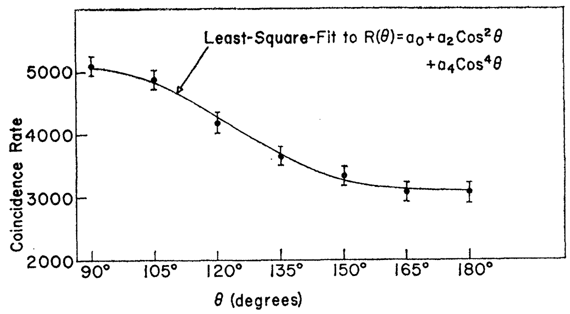

FIG. 5. Coincidence rate versus θ for 178.4/327.7-keV correlation.

the 281/277.2-keV coefficients are

$$A_2=-0.1391\pm0.0181\,,\quad A_4=0.2177\pm0.0653;$$

and for the 72.9/277.2-keV correlation,

$$A_2=0.1474\pm0.0221\,,\quad A_4=-0.2667\pm0.0800.$$

An attempt was also made to measure a correlation between the 327.7- and the 22.5-keV gamma rays. This could have given information regarding the spin of the first excited state at 22.5 keV. Thin liquid and solid sources, the 3-in. NaI crystal, and a 4-atm proportional counter with a thin window were utilized for this measurement. Coincidence data were taken at 30° intervals. Due to the low coincidence counting rate, the statistics of the individual points were about $\pm5\%$. A least-squares fit to the data gave a straight line within the experimental errors.

The experimental coefficients, not corrected for geometry are, for the solid source,

$$A_2=0.0021\pm0.0252\,,\quad A_4=0.0008\pm0.0210;$$

and for the liquid,

$$A_2=0.0071\pm0.0310,\quad A_4=-0.0080\pm0.0331.$$

Due to the large errors on the A's, an accurate comparison of the liquid and solid data is impossible. No statement can therefore be made regarding the attenuation of the correlation and for this reason the results were not used in the final interpretation.

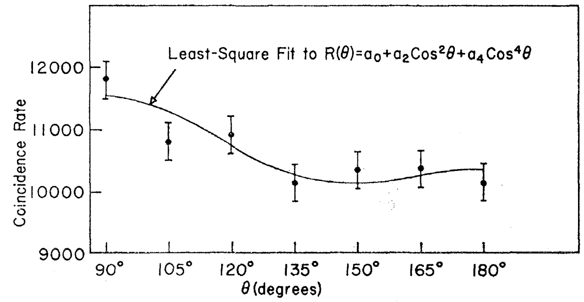

FIG. 6. Coincidence rate versus θ for 281/277.2-keV correlation.

Interpretation of Results

The excited states in Sm^{149} (see Fig. 8) which are the subject of the present investigation, are populated by five K-capture branches from Eu^{149}. Log ft values (assuming a disintegration energy of 800 keV) are found to be around 7.5 for the decays which populate the 22.5-, 277.2-, 350.2-, and 528.6-keV levels. This value for the log ft probably indicates that these groups are first forbidden transitions.

The shell model predicts an $f_{7/2}$ state for the ground state of Sm^{149}. Measurements[5–7] confirm this spin assignment. It therefore seems reasonable to assume the ground state of Sm^{149} is $f_{7/2}$ and to assign an odd $(-)$ parity to this state.

The conversion-electron measurements of other investigators[1,2] indicate that the 277.2-, 178.4-, 327.7-, 350.2-, 72.9-, and 22.5-keV gamma rays contain some $M1$ radiation. Thus, one can assign an odd parity to all the excited states of Sm^{149}, with the exception of the 558.3-keV level.

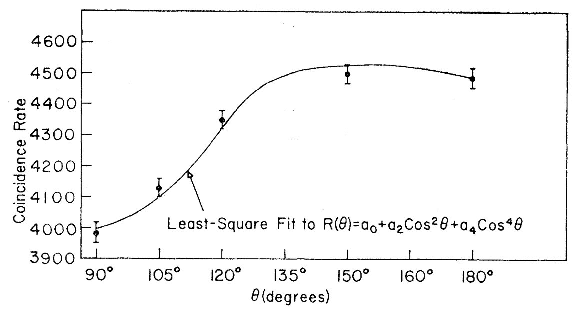

FIG. 7. Coincidence rate versus θ for 72.9/277.2-keV correlation.

The lifetime of the 558.3-keV level is probably less than 1×10^{-6} sec, since it was not observed in delayed coincidence with the samarium x ray using a coincidence circuit with a resolving time of about 1 μsec and a delay of 1 to 2 μsec. One would, therefore, expect the 558.3-keV transition to be of multipole order not greater than $L=3$.[10] This implies a spin not greater than 13/2.

The three levels involved in the 72.9/277.2-keV correlation are b, c, d, (see Fig. 8). The spin of level d is $\frac{7}{2}$. The conversion-electron references[1,2] show that both the direct transition from b to d and the transition from c to d contain $M1$ radiation. Therefore, the spin change, ΔJ, must be 0 or ±1. Then levels b and c both can have possible spins of $\frac{5}{2}$, $\frac{7}{2}$, or $\frac{9}{2}$. There are, therefore, nine possible spin sequences for the 72.9/277.2-keV cascade. Since the experimental A_4 of this correlation is not equal to zero, it must be assumed that both transitions of the cascade have some $E2$ radiation. Using Eq. (2) one obtains

$$A_4=F_4(2,2,j_b,j_c)F_4(2,2,j_d,j_c)Q_2Q_3\,, \tag{3}$$

where Q_2 and Q_3 are the multipole mixtures of the 72.9- and 277.2-keV gamma rays, respectively. The nine

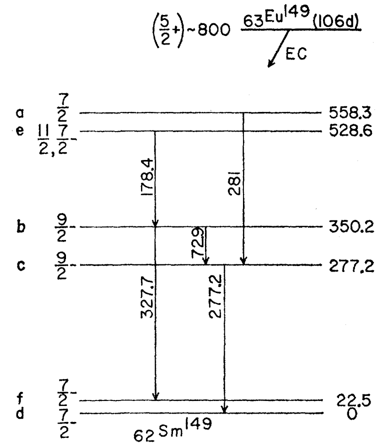

FIG. 8. Decay scheme with pertinent gamma ray cascades and showing proposed spins.

possible values of A_4 were calculated and compared with the experimental value. There are only two possible spin sequences which can satisfy A_4 experimentally: $(b,c,d)=\frac{5}{2}, \frac{7}{2}, \frac{7}{2}$ or $\frac{9}{2}, \frac{9}{2}, \frac{7}{2}$.

Let us now consider the 178.4/327.7-keV correlation. The levels involved are designated e, b, f on Fig. 8. The conversion-electron results[2] indicate that the f to d and e to b transitions contain $M1$ radiation. Using the same argument as in the 72.9/277.2-keV correlation, one finds that level f can be assigned spin values of $\frac{5}{2}, \frac{7}{2}, \frac{9}{2}$, and level e can have spin values of $\frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \frac{9}{2}, 11/2$. The experimental A_4 is not zero; therefore, both transitions contain $E2$ radiation. Using the possible spins for levels e and f, and the fact that level b can have a spin of $\frac{5}{2}$ or $\frac{9}{2}$, and that both the 178.4- and the 327.7-keV transitions have $M1$ content, twelve possible expressions for A_4 were calculated giving an expression analogous to (3). Comparing the values for these expressions with the experimentally determined A_4, it was found that only four of the spin sequences are possible, $(e,b,f) = (\frac{5}{2}, \frac{5}{2}, \frac{5}{2})$, $(\frac{7}{2}, \frac{9}{2}, \frac{7}{2})$, $(\frac{9}{2}, \frac{9}{2}, \frac{9}{2})$, or $(11/2, \frac{9}{2}, \frac{7}{2})$.

Proceeding further with the 178.4/327.7-keV correlation, we now consider the A_2 coefficient. A_2 is calculated from (2). If of the four possibilities for (e,b,f) we consider $(e,b,f)=(\frac{9}{2}, \frac{9}{2}, \frac{9}{2})$, then Eq. (2) becomes, $A_2=\Gamma(Q_4)\Gamma(Q_5)$ where $\Gamma(Q)=-0.4404+0.7156Q \pm 0.6030[Q(1-Q]^{1/2}$. $\Gamma(Q)$ is a double-valued function of Q since for a given value of Q, δ can be positive or negative. Figure 9 shows a plot of $\Gamma(Q)$ versus Q. Experimental values of A_2 range from -0.3579 to -0.4375. The largest negative value of A_2 obtainable is found by taking the product of the maximum value of $\Gamma(Q)$ from the $\delta-$ branch and the maximum value of $\Gamma(Q)$ from the $\delta+$ branch. This product is -0.2118 and thus it is impossible for $(e,b,f)=(\frac{9}{2}, \frac{9}{2}, \frac{9}{2})$ to satisfy the experimental correlation results.

The spin sequence $(e,b,f)=(\frac{5}{2}, \frac{5}{2}, \frac{5}{2})$, when analyzed in the same way as the sequence $(\frac{9}{2}, \frac{9}{2}, \frac{9}{2})$, is also found not to satisfy the experimental correlation results.

Let us consider the spin sequence $(e,b,f)=(\frac{7}{2}, \frac{9}{2}, \frac{7}{2})$, A_2 theoretical becomes $A_2=\gamma(Q_4)\gamma(Q_5)$, where $\gamma(Q) =0.3028-0.3225Q\pm 1.8708[Q(1-Q)]^{1/2}$. The value of A_4 calculated for this spin sequence is $A_4=0.3430Q_4Q_5$. Equating the theoretical A_4 to the experimental A_4 gives: $0.3430Q_4Q_5=+0.1220\pm 0.0244$ or $0.2845\leq Q_4Q_5 \leq 0.4267$. Similarly equating the experimental A_2 to the theoretical A_2 gives $\gamma(Q_4)(Q_5)=-0.3977\pm 0.0398$. Working simultaneously with these expressions we find that the spin sequence $(e,b,f)=(\frac{7}{2}, \frac{9}{2}, \frac{7}{2})$ satisfies the correlation results, provided that Q_4 and Q_5 assume one of the first four sets of values for Q_4 and Q_5 shown in Table I.

Now let us consider the remaining possible spin sequence $(e,b,f)=(11/2, \frac{9}{2}, \frac{7}{2})$. For this sequence A_2 theoretical becomes, $A_2=Z(Q_4)Y(Q_5)$, where $Z(Q) =0.1651+1.101Q\pm 1.5374[Q(1-Q)]^{1/2}$ and $Y(Q) =0.3028-0.3225Q\pm 1.8708[Q(1-Q)]^{1/2}$. Equating the experimental A_4 to the theoretical A_4, and the experimental A_2 to the theoretical A_2 and working simultaneously with these expressions, it is found that the spin sequence $(e,b,f)=(11/2, \frac{9}{2}, \frac{7}{2})$, satisfies the experimental results, provided Q_4 and Q_5 assume the last set of values given for Q_4 and Q_5 in Table I. Thus, from the 178.4/327.7-keV correlation unique spins of $\frac{9}{2}$ and $\frac{7}{2}$ have been assigned to levels b and f, respectively. It has also been found that the level e can have a spin of $\frac{7}{2}$ or 11/2.

In the analysis of the 72.9/277.2-keV correlations it was found that the spin sequence (b,c,d) can be either $(\frac{5}{2}, \frac{7}{2}, \frac{7}{2})$ or $(\frac{9}{2}, \frac{9}{2}, \frac{7}{2})$. However, the spin of level b has been found to be $\frac{9}{2}$. Therefore, the spin sequence (b,c,d) must be $(\frac{9}{2}, \frac{9}{2}, \frac{7}{2})$. At this point the spins of levels b, c, and f have been uniquely determined. In addition, the spin of level e has been found to be either $\frac{7}{2}$ or 11/2.

Proceeding to the 281/277.2-keV correlation involving the levels a, c, d the spin of level a remains to be determined. It was indicated above that the spin of level a is probably not greater than 13/2. However,

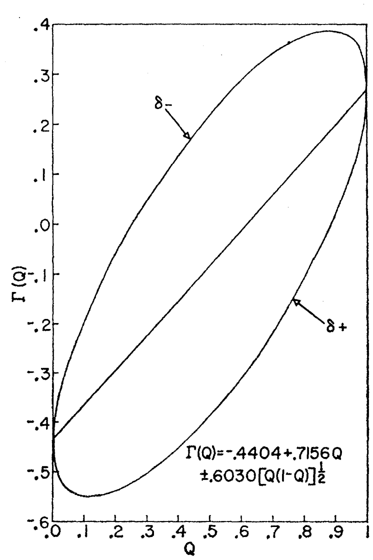

FIG. 9. Plot of $\Gamma(Q)$ versus (Q).

spins of $\frac{1}{2}$ up to 19/2 were considered in the interest of caution.

For changes in nuclear spin, ΔJ (involved in gamma-ray transitions) of 2 or greater, the transition is most often pure multipole of order $L=\Delta J$. For $\Delta J=0\pm1$, one can expect transitions with mixtures of dipole and quadrupole radiation which can be of comparable intensity.

Since no knowledge is given concerning the parity of level a, one must assume that the possible multipolarities of the 281-keV gamma-ray transition can be either electric or magnetic for a given L. The multipole mixture for the 281-keV gamma ray is designated by Q_1 and it is understood that whatever value is assigned to Q_1, it can be either electric or magnetic quadrupole.

Using the ten possible spin sequences for the (a,c,d) cascade and calculating theoretical A_4 coefficients, it is found that only two sequences $(a,c,d)=(\frac{1}{2}, \frac{9}{2}, \frac{7}{2})$ or $(\frac{7}{2}, \frac{9}{2}, \frac{7}{2})$ can be in agreement with the experimental value of A_4. To further determine the correct sequence, we equated the experimental coefficients to the theoretical coefficients. Working simultaneously with the resulting expressions, we found that only the spin sequence $(a,c,d)=\frac{7}{2}, \frac{9}{2}, \frac{7}{2}$ was possible.

The proposed spin assignments based on this angular correlation study are summarized in Fig. 8. Table I lists the quadrupole mixtures which are consistent with the experimental results.

IV. SUMMARY AND DISCUSSION

An investigation of the excited states of Sm^{149}, which are populated by the K-capture decay of Eu^{149}, has been undertaken in order to obtain information about the spins of the levels and the multipolarities of the de-excitation radiation. Interpretation of the results of directional correlations on three separate gamma-ray cascades has resulted in unique spin assignments to all but one of the Sm^{149} levels and the determination of possible multipole mixtures for the gamma rays involved.

By means of coincidence techniques and half-life measurement, the existence of a gamma-ray transition from the 558.3-keV level to the 277.2-keV level has been confirmed.

There is some disagreement between the multipolarities we have found and those determined by K/L ratio measurements.[1,2] These K/L ratios indicate that the 178.4-, 277.2-, and 327.7-keV transitions in Sm^{149} are substantially pure $M1$. However, Mihelich[13] has pointed out that the 277.2- and 327.7-keV transitions can have maximum $E2$ admixtures which range from 0 to 45% and 5 to 65%, respectively, and that the conversion-electron data for the 178.4-keV transition are not good enough to set a limit on the $E2$ admixture for that transition. Table I shows that a possible set of quadrupole mixtures for the 178.4- and 327.7-keV transitions are 90.3 ± 3.3 and $39.1\pm7.8\%$, respectively. Both these values are not inconsistent with the conversion-electron data due to Harmatz *et al.* Table I also shows that the quadrupole mixture of the 277.2-keV transition must be $73.5\pm9.5\%$, which is not in agreement with the conversion-electron data. However, the existence of the 281-keV gamma-ray transition between levels at 588.3 and 277.2 keV could make the K/L ratio for the 277.2-keV transition unreliable.

The present work has proposed spins for the excited states of Sm^{149} populated by K-capture decay from Eu^{149} of $\frac{7}{2}$ and greater. If one assumes the K-capture decay of Eu^{149} to be first-forbidden, and the ground-state spin of Eu^{149} to be $\frac{5}{2}$, then it is possible for the excited states of Sm^{149} populated by K capture to be as high as $\frac{9}{2}$. The spins proposed in this paper are, therefore, reasonable.

ACKNOWLEDGMENT

The authors wish to express their thanks to Dr. William W. Pratt for his helpful suggestions.

[13] J. W. Mihelich (private communication).