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Lawrence Radiation Laboratory
UNIVERSITY OF CALIFORNIA
LIVERMORE

DECAY OF ^{155}Tb TO LEVELS IN ^{155}Gd

R. A. Meyer

R. Gunnink

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DECAY OF ^{155}Tb TO LEVELS IN ^{155}Gd *

R. A. Meyer and R. Gunnink

Lawrence Radiation Laboratory, University of California
Livermore, California

ABSTRACT

The electron capture decay of ^{155}Tb has been studied by gamma ray spectroscopy. By using a Compton suppression spectrometer and a high resolution Ge(Li) detector (full width at half maximum of 530 eV for a 60 keV gamma ray) approximately 80 gamma rays have been detected in the decay of isotopically separated ^{155}Tb . The energies of the more intense peaks have been measured to a precision of 40 eV. The energy of the gamma rays below 350 keV are found to be in agreement with the corrected conversion electron data of Kormicki et al.(1).

*Work performed under the auspices of the U. S. Atomic Energy Commission.

INTRODUCTION

The nucleus $^{155}_{64}\text{Gd}_{91}$ has a deformation which is at the beginning of the strongly deformed region of mass $150 < A < 190$. Consequently it might be expected that the level properties will be transitional in nature. One such effect would be the strong mixing of orbitals in the description of levels as well as the possibility of higher lying states with even smaller deformation. These possibilities have been considered recently by several authors (1,2,3,4). In order to properly describe these levels and subsequently calculate the correct transition probabilities, one must have a precise measure of the decay properties of the levels as well as the electron capture probability to the various levels. A detailed study of the gamma ray spectrum from the ^{155}Tb decay will yield information on both these properties. We have undertaken this measurement using several recently developed Ge(Li) systems.

EXPERIMENTAL

Several sources were prepared by bombardment of enriched ^{154}Gd with 14 MeV protons using the Livermore and Berkeley cyclotrons. The targets were brought into solution by standard techniques and passed through a rare earth ion exchange column. The carrier free Tb fraction was collected. This was followed by isotopically separating the ^{155}Tb activity from other Tb isotopes which might have been present (5).

Several Ge(Li) detectors were used in this work. For the energy measurements two 6 cc Ge(Li) systems were used. For the intensity determination two separate series of measurements were made, one for low energy and one for high energy gamma rays. For the low energy gamma rays measurements were made on a 5 mm thick Ge(Li) detector equipped with a 0.25 mm Be window and a resolution of 525 eV at 59 keV. For gamma rays with energy above 250 keV a Compton suppression spectrometer was also employed. This system is discussed elsewhere (6). For the measurement of high energy gamma rays a 30 cc Ge(Li) system was used. All these systems used 4096 channel analyzers.

RESULTS AND DISCUSSION

The gamma ray energies were determined by internal calibration using IAEA standards. The data were reduced by using the Gunnink-Niday code (7).

The results are given in Table I. Intensity measurements were made on all the systems mentioned (for details of their calibration see Ref. 8). We report here only the intensity values of gamma rays below 400 keV; these are given in Table II. The more complete set of data will be published elsewhere. Using the gamma ray energies, recent reaction studies (3) and decay scheme studies (1,4) we assign the following energies to the more strongly populated levels in ^{155}Gd : 59.96, 86.44, 105.22, 117.91, 266.47, 268.42, 286.96, 325.94, 367.47, 427.11, 488.59 and 592.10 keV.

The gamma ray intensities were used to calculate the conversion coefficients for the transitions detected by Kormicki *et al.* (1) and Harmatz *et al.* (9). The electron intensities from Harmatz *et al.* gave consistent conversion coefficients. Unfortunately the more complete measurement of electron intensities by Kormicki *et al.* (1) gave conversion coefficient values which become consistently worse in agreement as the energy of the electrons increased. We assumed that their film calibration curve was incorrect. A correction curve was calculated by using the more intense transitions with known multipolarities in conjunction with the theoretical conversion coefficient values of Hager and Seltzer (10). The remaining corrected electron intensities were then used to calculate the conversion coefficients. These values are given in Table III. Further analysis of the log ft values must await the more complete set of data containing the weaker transitions as well as the higher energy gamma ray measurements. Final analysis of the data is in progress and will be published at a later date (11).

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TABLE I

Energy Calibration of Gamma Rays in the Decay of
 ^{155}Tb to ^{155}Gd

E_γ (E in keV)	ΔE_γ	E_γ	ΔE_γ
59.96	0.006	239.49	0.010
86.44	0.003	262.26	0.004
100.98	0.03	268.56	0.004
105.22	0.03	281.06	0.012
148.55	.005	321.83	0.016
161.19	0.02	340.67	0.013
163.20	0.03	348.79	0.013
180.08	0.03	367.36	0.006
200.40	0.009	427.16	0.024
208.04	0.044	450.78	0.08
216.02	0.016	505.60	0.125
220.70	0.030	559.32	0.040
227.00		592.16	0.040
226.89	0.130	614.86	0.033
235.05	0.05		

TABLE II

Gamma Ray Intensities

E_γ	I_γ^*	ΔI_γ	E_γ	I_γ^*	ΔI_γ
18.66	2.01	0.24	161.19	109.8	1.1
25.10	0.91	0.09	163.20	176.9	1.8
26.47	14.88	0.74	171.97	0.96	0.09
45.32	64.79	0.17	175.19	1.77	0.10
57.93	7.92	0.37	180.00	297	6
59.96	47.53	0.83	181.64	16.8	0.2
61.49	0.70	0.08	182.11	4.4	0.2
99.03	3.23	0.04	200.40	9.50	0.09
101.19	7.93	0.28	203.50	1.48	0.24
102.6	0.4	0.2	206.44	6.66	0.48
105.31	1000	---	208.05	2.5	0.5
109.7	0.6	0.1	208.52	10.0	0.5
120.60	1.81	0.07	212.8	0.2	0.1
(124.3)	(0.5)	(0.03)	216.02	5.4	0.4
138.3	0.94	0.26	220.07	6.63	0.19
145.98	0.53	0.16	220.70	20.24	0.40
148.55	101.7	1.0	226.95	6.37	0.19
150.57	0.76	0.18	232.2	1.6	0.3
(153.5)	(0.7)	(0.3)	234.90	1.40	0.11
(155.1)	(2.0)	(1.0)	239.56	9.09	0.36
158.55	1.74	0.02	242.75	0.50	0.06
160.47	31.1	0.3	247.8	2.2	1.1

* Intensities are given relative to the 105.31 keV gamma ray being 1000.

TABLE II - Cont'd.

E_{γ}	I_{γ}^*	ΔI_{γ}
249.63	2.3	1.1
262.25	211.7	0.8
268.46	27.05	1.86
281.06	12.25	0.60
286.96	12.90	0.9
(295)	(0.6)	(0.4)
303.61	--	--
304.95	--	--
307	--	--
309.22	0.19	--
310.83	--	--
315.5	0.32	--
321.76	6.94	0.3
322.5	0.7	0.2
(327.5)	(0.7)	(0.9)
(330.1)	(1.8)	(0.9)
336.68	1.46	--
340.64	45.73	3.3
342.57	3.3	1.3
362.91	0.5	0.2
367.32	92.3	0.5
370.88	9.05	.2
383.33	0.96	--
390.43	0.62	--

TABLE III

Conversion Coefficients for ^{155}Gd

E_γ	I_K		I_γ	$\alpha_K(\text{Exptl})^*$
	Original	Corrected and Normalized		
101.16	62.0	13.45	--	--
102.61	4.6	1.00	--	--
103.38	8.3	1.80	--	--
105.32	1000	≈ 217	1000	≈ 0.217
~ 118	< 0.9	< 0.2	--	--
120.0	≤ 2.8	≤ 0.61	2.16	≤ 0.28
138	7.8	1.69	1.01	1.67
146	3.0	0.65	--	--
148	260	56.42	101.31	0.557
~ 150.6	≤ 7.7	≤ 1.67	--	--
158.6	2.9	0.63	--	--
160.6	46.0	10.09	31.1	0.324
161.3	192	42.10	109.8	0.38 ₃
162.6	2.9	0.63	--	--
163.3	336	73.78	176.9	0.41 ₇
175	≤ 3	≤ 0.7	4.42	$\leq 0.15_8$
180.09	375	95.48	296.0 ₅	0.32 ₃
181.79	4.9	1.26	16.82	0.075
181.96	6.1	1.56	4.38	0.35 ₆
193.28	~ 0.36	0.095	--	--
200	1.3	0.36	--	--
206	~ 0.72	0.20	--	--
~ 208.0		2.02	2.9	0.70

TABLE III - Cont'd.

E_{γ}	I_K		I_{γ}	$\alpha_K(\text{Exptl})^*$
	Original	Corrected and Normalized		
208.6	~0.33	0.09	11.4	~0.008
220.09	3.6	1.06	6.63	0.160
220.77	15.6	4.56	20.24	0.225
227.0	3.6	1.08	8.33	0.130
232	0.7	0.21	--	--
239	4.2	1.30	9.04	0.14 ₄
242.8	~0.4	~0.13	0.50	~0.26
246	~0.3	~0.09	--	--
248	0.6	0.189	--	--
261.34	0.62	0.202	--	--
262.35	82.8	27.08	212.2	0.128
268	1.1	0.37	26.70	0.014
281.08	2.0	0.67	11.97	0.056
287.05	3.4	1.17	12.33	0.095
310.1	~0.36	~0.13	--	--
321	~0.69	~0.25	6.94	~0.036
340	10.2	3.85	--	--
367.3	1.24	0.49	91.79	0.0087
367.7	0.78	0.31		
370.7	1.1	0.43	9.05	0.0475
402	~0.3	~0.13	2.88	~0.045
408	~0.3	~0.12	--	--
454.8	~0.2	~0.09	0.73	~0.12

*The conversion coefficients were calculated using the 105.32 keV transition as E1 multipolarity.

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P. C. Stevenson

G. Dorough

R. A. Meyer

R. Gunnink

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