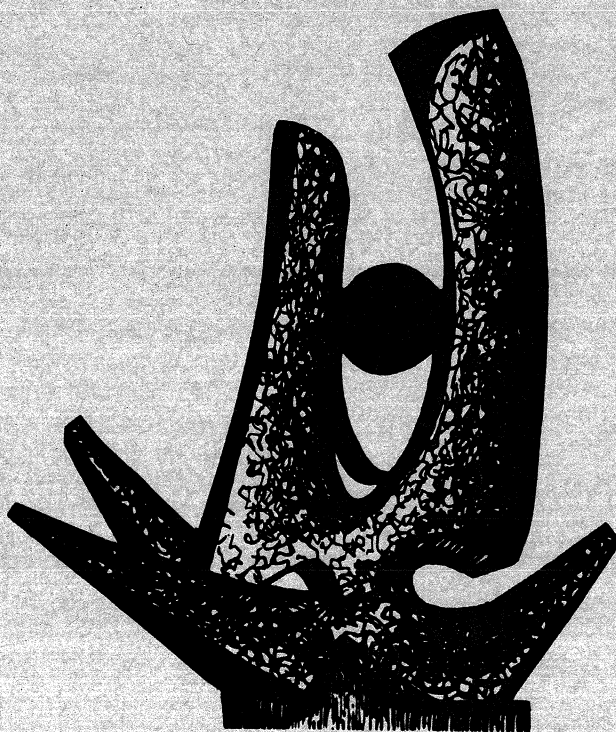


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DECAY BRANCHING RATIOS

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ABSOLUTE MEASUREMENTS OF ANOMALOUS ϵ/β^+ DECAY BRANCHING RATIOS

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ABSTRACT

Absolute values of ϵ/β^+ decay branching ratios for decay of ^{145}Gd to 12 levels in ^{145}Eu have been measured. These measurements are all shown to deviate substantially from the calculated ϵ/β^+ ratios of Gove and Martin. Skew ratios (exp/theor) are found to range from 1.5 to 40. These "anomalies" are ascribed to second-order corrections to allowed decay which have not been included in the calculations.

In a previous letter¹ we reported exciting evidence of large anomalous ϵ/β^+ decay branching ratios, relative to theoretical predictions,² for ^{145}Gd and ^{143}Sm decays. These were not absolute but relative measurements, so we were forced to normalize our results to fast transitions where the ratio was assumed to be normal. The anomalies were proven, but this in itself made the normalization procedure somewhat suspect.

We have now completed absolute measurements of the ϵ/β^+ decay branching ratios for ^{145}Gd decay. Thin sources were prepared by deposition on mylar tape at the nozzle of a helium-jet recoil transport system.³ Annihilation radiation and K x rays were counted in a 7.6-cm \times 7.6-cm NaI detector, and coincident γ rays tagging the ϵ/β^+ -fed levels in ^{145}Eu were detected in a large⁴ Ge(Li) detector. The source was surrounded by a plastic annihilator to insure total annihilation at the source. The two energies were recorded along with the coincidence time on magnetic tape for off-line analysis. The NaI pulse-height spectra in coincidence with γ rays depopulating the 808.5- and 1757.8-keV level in ^{145}Eu are presented in Fig. 1. The relative efficiency ratio between the x-ray region (45 keV) and 511 keV was measured, using internal γ -ray sources,⁵ to be 2.00 ± 0.14 . This compares favorably with the predicted value⁶ of 1.95, which is corrected for window thicknesses.⁷ The ϵ/β^+ ratios were then determined for various transitions by incorporating well-known fluorescence yields⁸ and $\epsilon(K)/\epsilon(\text{tot})$ ratios⁸ to obtain the total electron-capture intensities. The transitions to the 1041.9-, 1757.8-, and 1880.6-keV levels in ^{145}Eu were measured sufficiently accurately to be used as primary absolute ϵ/β^+ ratios. Using the more extensive x- γ and β^+ - γ coincidence data referred to in our earlier paper,¹ the absolute ϵ/β^+ ratios to other levels were then calculated. These results are presented in Table I.

Several new, weaker transitions are reported in Table I which were not discussed in our previous paper. These transitions were known at that time, but the decay scheme was not then certain enough to discuss them. The Q_ϵ value for ^{145}Gd decay has been measured as 5311 ± 120 keV,⁹ and, using this value, theoretical ϵ/β^+ ratios were calculated² for the ^{145}Gd decays. These values are compared with the measured values in Table I and indicate that indeed all of the values are anomalous. A skew ratio V (exp/theor) is defined to show the extent of the anomaly.

The extent to which these data differ from calculations is striking. Although some of the newly-presented transitions might be first forbidden, such anomalies cannot be explained by the usual theoretical assumptions. Recently, we have found great success in explaining these anomalies in terms of second-order contributions to the allowed calculations. It appears that hindered transitions can have strong interference effects on the ϵ/β^+ ratio. These effects are most prominent in higher- Z nuclei where the nuclear radius is large. Indeed, ϵ/β^+ skew ratios even larger than the ones discussed here are probable. The second order effects may also explain a small, well-known anomaly in the ^{22}Na ϵ/β^+ ratio.¹⁰ Detailed information on these calculations will appear in a forthcoming publication.

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- ³For a description of this system, see K. L. Kosanke, M. D. Edmiston, R. A. Warner, R. B. Firestone, Wm. C. McHarris, and W. H. Kelly, *Nucl. Instr. Meth.* 124 (1975).
- ⁴18% efficiency at 1333 keV relative to that of the NaI(Tl) detector at a source distance of 25 cm.
- ⁵A γ ray source containing ^{109}Cd , ^{57}Co , ^{139}Ce , ^{137}Cs , and ^{60}Co supplied by the National Bureau of Standards and a separate thin ^{137}Cs source were used for this calibration.
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Table I. Absolute ϵ/β^+ Decay Branching Ratios For ^{145}Gd

Level in ^{145}Eu	Allowed Transition	ϵ/β^+ Ratio		Skew Ratio (exp/theor)
		Experiment	Calculated ^a	
808.5	Yes	18 \pm 8	0.45 \pm 0.04	40
1041.9	Yes	0.84 \pm 0.05	0.57 \pm 0.07	1.5
1567.3	b	36 \pm 18	0.95 \pm 0.10	38
1599.9	b	12 \pm 6	0.99 \pm 0.11	12
1757.8	Yes	1.97 \pm 0.09	1.18 \pm 0.14	1.7
1761.9	b	2.5 \pm 0.8	1.20 \pm 0.15	2.1
1845.4	b	43 \pm 21	1.31 \pm 0.17	33
1880.6	Yes	2.41 \pm 0.12	1.37 \pm 0.17	1.8
2048.9	b	4.0 \pm 1.0	1.72 \pm 0.24	2.3
2113.9	b	10 \pm 4	1.90 \pm 0.29	5.3
2494.8	b	4.8 \pm 0.5	3.41 \pm 0.61	1.4
2462.2	b	8.2 \pm 0.9	4.45 \pm 0.95	1.8

^aN. B. Gove and M. J. Martin, Nucl. Data, Sect. A 10, 205 (1971). Calculated for $Q_e = 5311$ keV.

^bThese are most likely allowed transitions from log ft information, but we cannot yet make definite assignments.

FIGURE CAPTION

Figure 1 NaI(Tl) coincidence spectra for the 1757.8- and 808.5-keV gates in the decay of ^{145}Gd to ^{145}Eu . Note that the γ^{\pm} peak is severely depressed in the 808.5-keV gated spectrum, although normal decay-energy calculations would predict it to be much larger in that spectrum than in the 1757.8-keV gated spectrum. It should also be noted that β decay to states deexciting through the 808.5-keV state accounts for nearly all of the γ^{\pm} peak but only about half of the K x-ray peak.

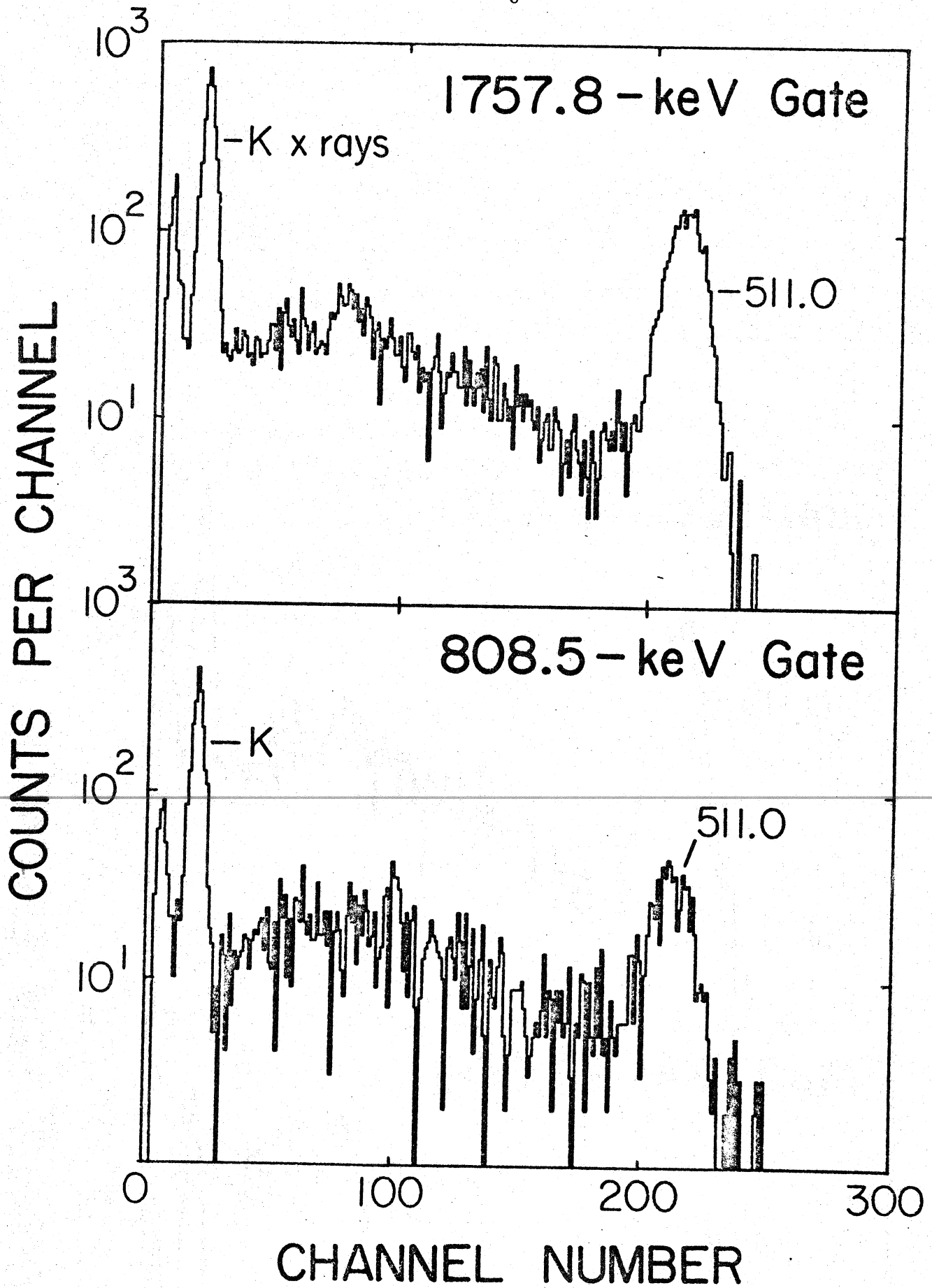


Figure 1