BETA DECAY OF ^{166}Ho

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ABSTRACT

The 27 hour beta decay of ^{166}Ho has been studied with a 35 cc Ge (Li) detector and an intermediate image beta ray spectrometer for an accurate analysis of the gamma spectra and beta spectra to estimate precise relative intensities of gamma lines and to search for any new gamma lines. The β spectrum is used to determine the exact end-point energies, intensities and log ft values of different beta groups. The possibility of a beta feeding to the 2^+ excited state at 787 KeV of ^{166}Er is ruled out.

INTRODUCTION

THE ground state decay of ^{166}Ho (27 *h*) populates the ground state and five excited states of the even-even deformed nucleus ^{166}Er. The gamma emission in the decay of ^{166}Ho was investigated by Marklund *et al.*[1] and Cork *et al.*[2] Cork *et al.* reported a 470 KeV gamma ray observed in their scintillation spectrum. They did not present any spectrum and gave no value for the intensity of the 970 KeV gamma ray A later investigation was by Burson *et al.*[3] using a 2 c.c. planar Ge (Li) detector, the results of which, in general, did vary from the earlier reports. There are also considerable discrepancies in the reported results on the end-point energies, intensities and log ft. values of different beta groups of ^{166}Ho.

The availability of a large volume Ge (Li) detector in this laboratory prompted the present investigation on the relative gamma intensities of gamma rays, in the decay of ^{166}Ho. The gamma spectrum in this decay is reinvestigated with a 35 c.c. Ge (Li) detector with an aim of performing more accurate measurements on the relative gamma intensities and to search for the possible existence of weak gamma lines hitherto unobserved and to determine the extact beta group emergies intensities and log ft values with the help of the beta spectral data from the meqsurements on an intermediate image beta ray spectrometer.

γ-Spectrum: Experimental details and results.—The stable isotope of helmium which has a thermal neutron cross-section of ~65 barns was irradiated at the Research Reactor, CIRUS of Bhabha Atomic Research Centre, Bombay. The isotope was obtained in the form of helmium trichloride in hydrochloric acid solution. The gamma spectra are recorded with a ND-512 analyser at regular intervals of 27 hours to identify the gamma rays belonging to the decay of ^{166}Ho. Ten days after the present work, a background run is taken over the entire energy range to obtain the background as well as the presence of long lived impurities in the source. The detector was calibrated earlier[4] for relative photopeak efficiency using gamma rays from ^{152}Eu and ^{124}Sb. These data are used to deduce the relative photon intensities. The absolute intensity of the 1367 KeV transition is assumed from the earlier accurate measurement of Gline *et al.*[5]. The K-conversion coefficient and K/L ratio of the 80 KeV transition is taken from the Nuclear data Sheets and used in the calculation of the transition intensity of the 80 KeV gamma ray.

Figure 1 shows a typical gamma spectrum recorded in one of the runs. As can be seen from the gamma spectrum, no new gamma rays are observed following the decay of ^{166}Ho. A careful search is made for detecting the presence of possible weak gamma rays corresponding to the decay of 1830 KeV state to the 1460 and 1663 KeV states, but no such gamma rays have been observed in the present work.

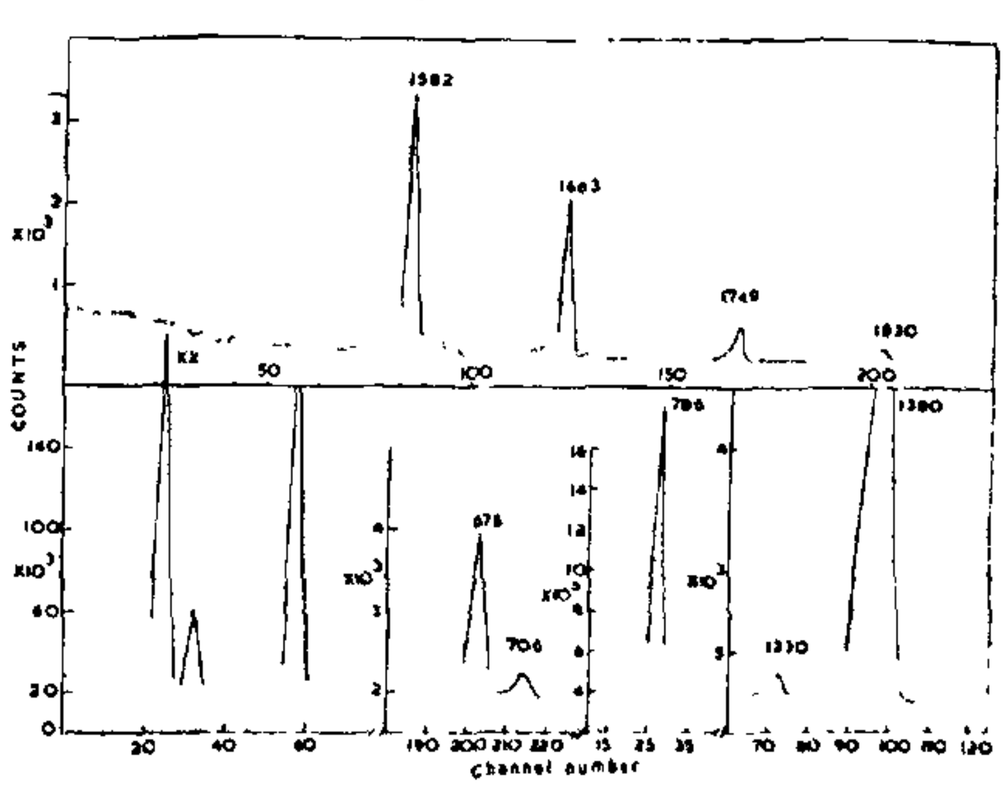

FIG. 1. Gamma spectrum of ^{166}Ho taken for different regions with 35 co Ge (Li) detector.

Table I summarises the present results on the relative gamma intensities along with the earlier results; there is a good agreement between the two sets of data except in the case of the intensities of the 1830 and 1663 KeV gamma transitions. The present results failed to locate a beta branch of observable intensity to the 2^+ excited state at 787 KeV which is also confirmed from the present beta-gamma coincidence measurements.

Beta Spectrum: Experiment and Results.—A Siegbahn-Slatis beta ray spectrometer with plastic well type detector used in the investigation is described

TABLE I

Relative intensities of gamma rays in the beta decay of ^{166}HO

Gamma energy (KeV)	Relative photon intensities	
	Present work	Burson *et al.*[3]
80.6	6·55 ±0·3	6·2 ±0·4
675·0	0 032 ±0 002	0 03 ±0 002
707·0	0 021±0 001	0 019±0 003
786 0	0·011 ±0 005	0 015 ±0 003
1380 0	0·93 (std.)	0·93 (std.)
1582 0	0·20 ±0 01	0·19 ±0·009
1663 0	0 0092±0 004	0 12 ±0 006
1749 0	0 028±0 0017	0 031±0·001
1830 0	0 0075±0·005	0·0093±0 0007

elsewhere[6] and is suitably modified[7] for $\beta-\gamma$ coincidence measurements. The sources used are of 200 $\mu g/cm^2$ thick and 2 mm in diameter and are prepared by evaporation of the source on zapon films. The beta spectrum is scanned roughly in steps of 12 KeV upto 1850 KeV. The background is taken at every measurement point. In the present measurement the first inner beta group in coincidence with the 80 KeV gamma ray is scanned. The Fermi-Kurie analyses of the coincidence and the cross-spectra has resulted in the end-point energies of 420 ± 4, 1771 ± 2 KeV and 1845 ± 2 KeV for three beta groups. A further subtraction of the 420 KeV beta group from resulting gross-spectrum has revealed a fourth beta group (which is not shown in Fig. 2) with an end-point energy of 230 ± 4 KeV. No evidence could be found for a weak beta with an end-point energy of 1070 KeV feeding the 787 KeV level which has also been confirmed from our gamma spectrum. The Fermi-Kurie analysis of the ^{166}Ho beta spectrum is shown in Fig. 2.

Half life of ^{166}Ho.—The current setting of the present spectrometer is adjusted at 1600 KeV and the count-rate is followed for four half lives. A least square fit of the data yielded a half life of $(27 \pm 0·04)$ hours. This also ensures the absence of any other foreign activities in the sample.

Beta intensities and log ft values.—The intensities of the beta branchings are deduced from the present relative gamma intensities assuming a 0 93% decay of ^{166}Ho (0^-) ground state to the 0^+ excited state at 1460 KeV. The log ft values of the beta transitions are calculated using the recent tabulations[8] of log ft values, employing the beta end-point energies and the present gamma intensities. The results are presented in Table II along with the earlier results. The log ft values of the beta transitions leading to the two O^+ states of ^{166}Er are quite different. Further the log ft. value of the beta branch to the 1830 KeV state is indicative of an allowed sature, thus establishing the 1^- assignment to the 1830 KeV state. The present results are incorporated in a decay scheme shown in Fig. 3.

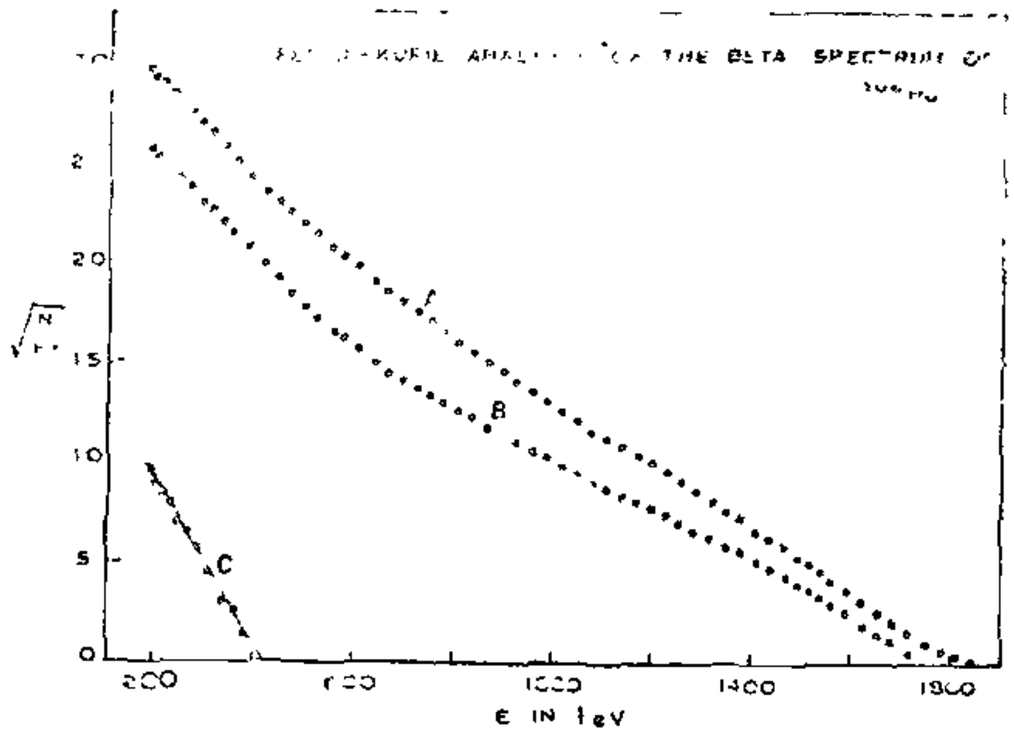

FIG 2. Fermi-kurie plots of the three beta groups of ^{166}Ho uncorrected for shapes A, F K plot of the total spectrum. B, F.K. plot of the coincidence spectrum of $(0^- \rightarrow 2^-)$ transition. C, F.K. plot of the resulting after the subtraction of the intense two beta components.

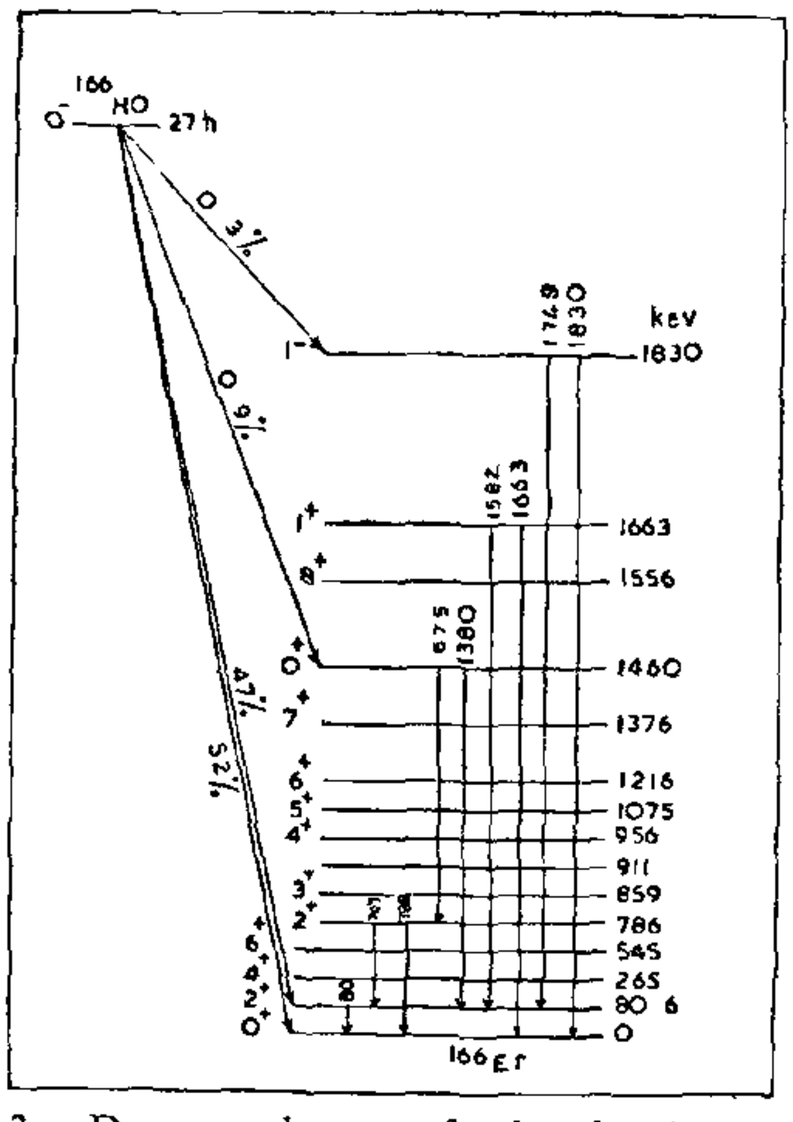

FIG. 3. Decay scheme of the levels of ^{166}Er populated from ^{166}Ho (27·0 h) incorporating the present results.

TABLE II

Data on the Beta groups in the decay of ^{166}Ho

Present work			Sunyar[9]		Graham *et al.*[10]		Cork *et al.*[2]		Funke *et al.*[11]	
Energy (KeV)	Int. %	Log ft.	Energy (KeV)	Int. %	Energy (KeV)	Int. %	Energy (KeV)	Int. %	Energy (KeV)	Int. %
230	0·3	7·12	230	0·3	..	..	230	2	210	0·8
420 ± 4	0·9	7·41	400	1·0	393	0·76	412	5	420 ± 2	3·7
..	..	..	..	..	..	..	869	9	690 ± 30	6·5
1771 ± 2	47·5	9·0	1760	74	1771	47·6	1756	37	1779 ± 30	33·4
1845 ± 2	52·0	9·1	1840	25	1854	51·6	1839	47	1859 ± 3	48·8

ACKNOWLEDGEMENTS

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