BETA SPECTRUM OF ^{143}Ce

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ABSTRACT

The beta spectrum of the 37 hour negatron decay of ^{143}Ce has been analysed employing a Siegbahn-Slatis beta ray spectrometer and slow-fast coincidence system using sources from enriched ^{142}Ce samples for exact end point energies, intensities and log ft values of different beta groups. The results are incorporated in a decay scheme.

INTRODUCTION

THE negatron decay of the 33hr. ^{143}Ce was extensively studied and the prominent levels of ^{143}Pr were well established. However, there has been no detailed beta spectrum analysis of the ^{143}Ce isotope. The reported information on the beta groups feeding different levels in ^{143}Pr, their end point energies, intensities and log ft values are only from the gamma-spectroscopic investigations. Gopinathan[1] reported the end point energies of the two intense beta groups feeding the 57 keV and the 351 keV levels in ^{143}Pr as 1400 keV and 1110 keV. Megli *et al*[2] obtained from their gamma-spectroscopic data, the values of 1380 and 1093 keV for the two intense beta groups. Sunyar's[3] analysis of their gamma-spectral data gives 1408 and 1174 keV for the above two beta groups. Thus even in the available data on the end point energies of the most intense beta groups, as can be seen from Table I, there is a vast disparity. Such is also the case with their intensities and log ft values. The reported results on the intensity of the outermost beta group is 38·4% according to Gopinathan *et al*[1], 29·0% as per Megli *et al*[2] and 51·05% due to Sunyar *et al*[3]. Similarly in the case of the beta feeding, the 351 keV level of ^{143}Pr, the intensities are widely varying, *viz.*, 41·5% as per Gopinathan *et al*[1], 53·0% due to Megli *et al*[2] and 36·94% according to Sunyar[3].

Hence a detailed analysis of the beta spectrum of ^{143}Ce has been carried out both in the singles and coincidence studies in order to get complete data on the exact end point energies, intensities and log ft values of the different beta groups.

EXPERIMENTAL DETAILS AND RESULTS

Enriched ^{142}Ce stable isotope with 92·77% enrichment is obtained from Oak Ridge National Laboratory, Tennessee, U.S.A. in the form of cerium oxide. ^{142}Ce (25 mg.) is irradiated at the CIRUS reactor of Bhabha Atomic Research Centre, Bombay, each time getting the required activity of the ^{143}Ce isotope. Three such irradiations have been carried out. Sources are obtained as cerium chloride in dilute hydrochloric acid, in three consignments. Sources are prepared on mylar foils of thickness 150 $\mu g/cm^2$. Insulin is used to define the perfect source diameter. Typical source diameters are 2 mm.

The most intense 294 keV gamma is fixed on the gamma channel of the Siegbahn-Slatis beta spectrometer described by Nagarajan *et al*[4] and suitably modified[5] for beta-gamma coincidence studies. The resolution of the gamma detector [NaI(Tl)] employed is 10% for the 661 keV gamma rays. The beta spectrum in coincidence with the 294 keV gamma is scanned in steps of roughly 25 keV from 750 keV onwards to avoid the interference from inner beta-gamma cascades. The count rate is corrected for halflife and for beta-gamma angular correlation due to Raju *et al*[6]. The resolving time of the coincidence circuit is reduced to $2T = 0{\cdot}03$ μ sec to improve the true to chance coincidence ratio, particularly near the end point energy of the beta spectrum. The coincidence spectra are recorded repeatedly. The Fermi-Kurie plot after its correction for any shape deviation has resulted an end-point energy of 1110 ± 2 keV from a computer program.

In the singles mode of operation of the spectrometer, the beta spectrum is scanned down from 200 keV to the end point energy of the highest energy beta group in steps of 20 keV. The half-life corrected spectrum is used for the analysis into different beta groups. Using the spectral shape[5] of the outermost beta group, the spectrum is corrected for its shape for the 1404 keV beta group. The shape corrected spectrum is then subtracted from the total beta spectrum. This resulting spectrum is again corrected for the small order shape deviation[7] of the second beta group with an end-point energy of 1110 keV obtained from the coincidence measurements. This resulted

TABLE I

Comparison of beta spectral data due to different authors

Beta Transition	Present work			Gopinathan *et al.*			Sunyar *et al.*			Megli *et al.*		
	Energy (keV)	%	log ft.	Energy (keV)	%	log ft.	Energy (keV)	%	log ft.	Energy (keV)	%	log ft.
	..	..	..	65	0·2	5·5	41	0·02	5·6	..	..	..
	..	..	..	..	..	..	58	0·05	5·8	83	0·02	6·8
	..	..	..	300	1	6·0	279	0·6	7·0	307	0·39	7·4
	405±7	..	..	..	..	..	378	0·1	8·2	404	0·07	8·5
	515±5	2·5	7·5	520	2·6	7·3	502	1·7	7·4	528	1·15	7·5
	740±4	10	7·0	735	6·2	7·0	710	16	7·0	743	10·3	7·2
	..	..	..	..	..	..	..	..	..	974	0·045	9·9
	1110±2	41	7·3	1110	41·5	7·2	1093	53	7·1	1174	36·9	7·3
	1404±2	39	7·8	1400	38·4	7·7	1387	29	7·8	1408	51·05	7·6

in a third group with end-point energy of 740 ± 4 keV. A subsequent subtraction analysis of the Fermi-Kurie (Fig. 1) plot has resulted in beta groups with energies 515 ± 5 and 405 ± 7 keV. The present results on the end point energies of intensities and log ft values of different beta groups are given in Table I along with the earlier results. Beta groups with end point energies below 200 keV could not be analysed due to the falling of the efficiency of the plastic detector in the spectrometer. However, its efficiency could be maintained unity down to 100 keV under special improved conditions.

The data on the beta groups and the results on a subsequent internal conversion measurements[5] are incorporated in a decay scheme as in (Fig. 2). This detailed and accurate beta spectrum analysis of ^{143}Ce has provided very accurate end point energies of the beta groups, their intensities and log ft values.

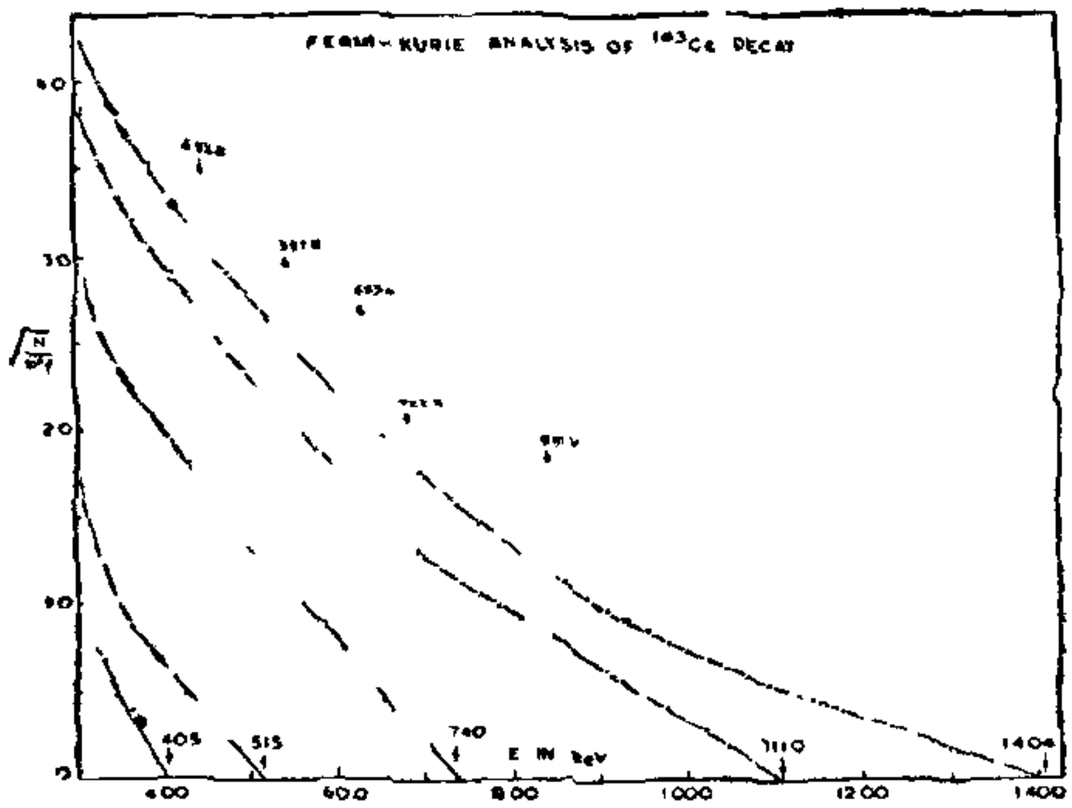

FIG. 1. Fermi-kurie analysis of the 33 hr. beta decay of ^{143}Ce shape corrected high energy beta groups are used for subtraction from the gross spectrum.

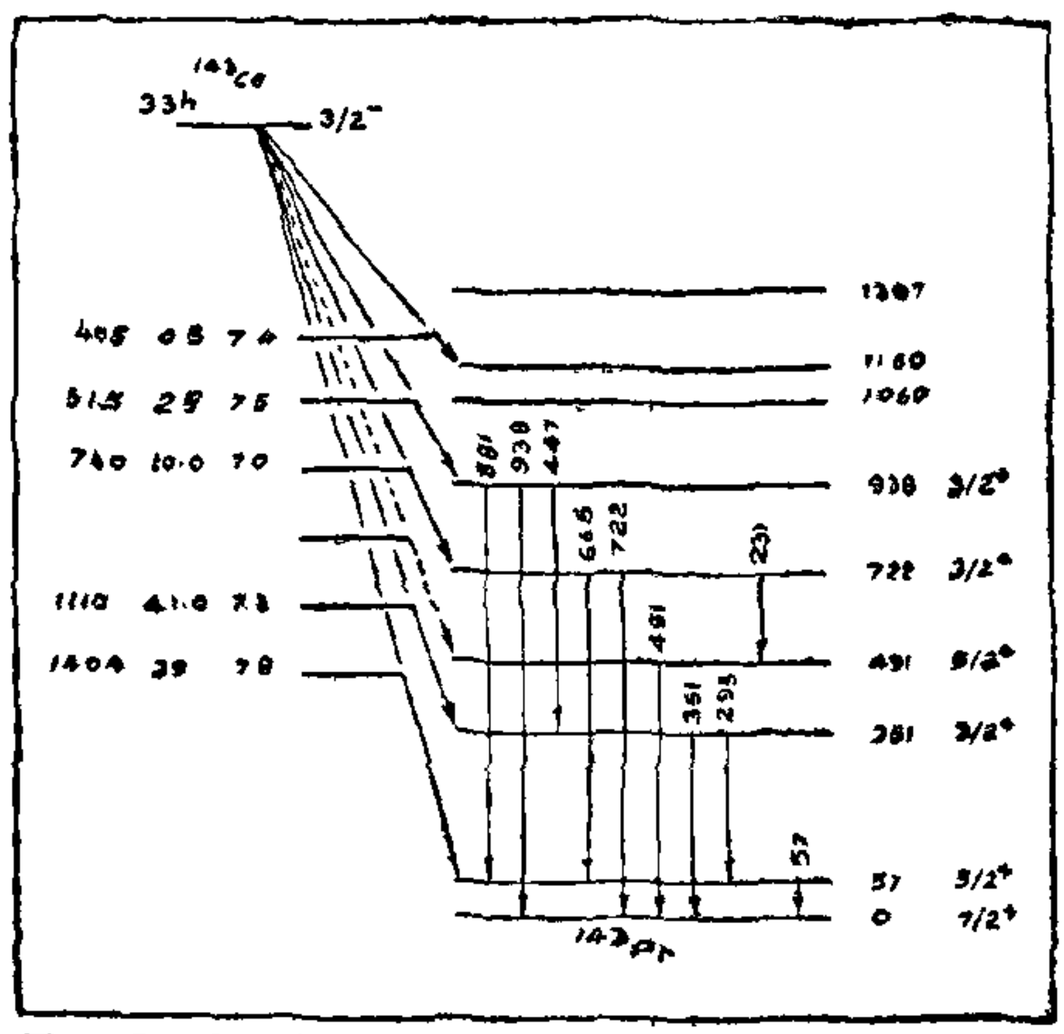

FIG. 2. Partial decay scheme of ^{143}Ce. The beta energies, log ft values and spins of the indicated levels are incorporated from the present measurements.

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