SPECTRAL SHAPES OF $1^- \rightarrow 2^+$ AND $1^- \rightarrow 0^+$ BETA TRANSITIONS OF ^{194}Ir

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ABSTRACT

The spectral shapes of the two intense beta groups of ^{194}Ir are studied with a thoroughly tested Siegbahn-Slatis beta ray spectrometer of the intermediate image type. The $1^- \rightarrow 2^+$ beta transition with an end point energy of 1921 ± 2 KeV and the $1^- \rightarrow 0^+$ beta transition with its end-point energy 2251 ± 2 KeV are surprisingly statistical in spite of their high log ft. values. The 1921 KeV beta transition cannot be analysed under modified B_{ij} approximation and the shapes of the two beta transitions are of identical nature. The beta transitions are in accordance with ξ-approximation supporting the earlier results.

INTRODUCTION

^{194}Ir decays to ^{194}pt with a half-life of 17 hours. A spin sequence of $1^- \rightarrow 2^+$ and $1^- \rightarrow 0^+$ was established[1] for the first inner and ground state beta transitions.

The 1920 KeV beta component from ^{194}Ir feeding the first excited state of ^{194}pt with 329 KeV energy has an intensity of 5·1% and log ft. value 9·2. The ξ-value ($\alpha Z/2R$) for this is 10·4 and is much greater than $(W_0 - 1) = 3{\cdot}758$, where, W_0 is the end-point energy expressed in $m_0 c^2$ units. The criterion for the applicability of ξ-approximation, $\xi \gg W_0 - 1$ is well fulfilled in this case. The directional correlation of the 1920 KeV beta-384 KeV gamma cascade shows from the results of Deutsch *et al.*[2] small beta-gamma anisotropy. Recently, Priyadarsini[3] reported zero anisotropy for this cascade. There has been only one measurement on the shape of the $1^- \rightarrow 2^+$ beta transition by Deutsch *et al.*[2] and the shape of the $1^- \rightarrow 0^+$ beta transition with a log ft. value of 8·2 has not yet been measured. The large log ft. value and a possible deviation from ξ-approximation indicate the possibility of the application of modified B_{ij} approximation for the $1^- \rightarrow 0^+$ beta transition. In order to check the applicability of the modified B_{ij}-approximation, conclusive evidence as to whether the spectrum shape factor is energy-independent is necessary. For this purpose a shape analysis of the two beta transitions is carried out.

EXPERIMENTAL DETAILS AND RESULTS

^{194}Ir sources are supplied by Bhabha Atomic Research Centre, Bombay, in three consignments, each time irradiating samples of iridium at CIRCUS reactor. There, we found strong contamination of ^{192}Ir. Since the maximum beta energy in the decay of ^{192}Ir is only 662 KeV, there will be no interference with the present studies. Sources are prepared on aluminised mylar foils of thickness ~ 180 μg/cm^2. Insulin is used for uniform spreading of the source.

The Siegbahn-Slatis beta ray spectrometer, presently used, has been described by Nagarajan *et al.*[4,5] with an emphasis on its adaptability for the studies of small-order deviations in shape factors of ^{90}Y and ^{198}Au. The present mode of analysis of beta spectra has also been given by Nagarajan *et al.*[5].

The beta spectrum is scanned in steps of ~ 15 KeV from 1,500 KeV to 2,300 KeV only in the singles mode of operation of the spectrometer. Background at each measurement point is taken, taking the advantage of the special provision of the present spectrometer for closing the central baffle of the spectrometer thus shielding the detector from the source without disturbing the vacuum. A computer program 'FERMKURI' takes care of the corrections due to half-life, and other instrumental effects like back-scattering correction, correction due to finite resolution, etc. 'FERMKURI' also incorporates the electron radial wave functions of Bhalla and Rose[6] and the screening corrections due to Buhring[7].

A current setting is adjusted corresponding to 1900 keV and the count rate is followed for five half-lives. A least squares fit of the data yields $17 \pm 0{\cdot}04$ hrs. for the half-life of ^{194}Ir.

Analysis of $1^- \rightarrow 0^+$ Beta Transition

There is only a region of 350 KeV for the analysis of $1^- \rightarrow 0^+$ outermost beta transition. The exact end-point energy for this beta group from the physical behaviour of the shape factor plot $[N/p^2F\ (Z,\ W)\ (W_0 - W)^2$ *vs* energy (where W_0 is the end-point energy) near $W_0]$ the end-point energy was found to be 2251 ± 2 KeV. This exact end-point energy is used in a further analysis through a computer program 'SHAPFIT' and the experimental points are found to fit very well with a shape factor of the form $K\ (1 + aW)$ with $a = 0{\cdot}03 \pm 0{\cdot}06$. Three such runs with sources of different diameter are taken. The results of the three runs are given in Table I. The shape factor plot due to one of the runs is given in Fig. 1.

Analysis of $1^- \rightarrow 2^+$ Beta Transition

The outermost beta transition corrected for its shape is subtracted from the gross-spectrum of ^{194}Ir with an end-point energy of 2251 ± 2 KeV using the relation $Y_2 = \sqrt{Y^2 - Y_1^2 C_1}$ where Y_2 and Y_1 are the ordinates of the outer and inner beta groups in the 'FERMI-KURIE' plots. The resulting spectrum from 600 keV and 1920 KeV is subjected shape analysis[4]. The

TABLE I
Shape factor results $1^- \rightarrow 0^+$ beta transition of ^{194}Ir

Run No.	End-point energy (KeV)	C(W)/K
1	2251 ± 2	1 + (0 026 ± 0 06) W
2	2250 ± 2	1 + (0 032 ± 0 06)W
3	2251 ± 2	1 + (0·025 ± 0·06)W

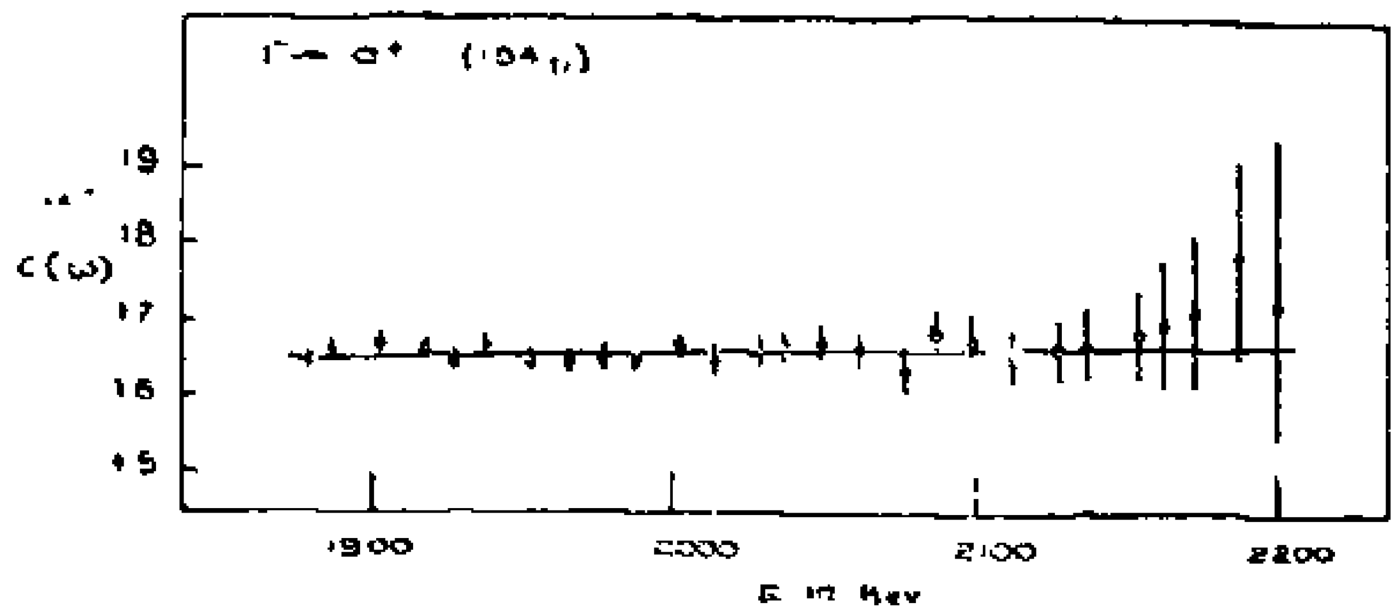

FIG. 1. The shape factor plot of the 2250 KeV beta transition of ^{194}Ir. Solid line is the least-square fit with C (W) = K (1 + aW) where a = + 0·0266 ± 0·058.

'BETASHAP' has given an exact end-point energy of 1920 ± 2 KeV. The experimental points are once again found to be in accordance with statistical shape in this case also, fitting into a shape of the form K (1 + aW) with a = 0·025 ± 0·04 with E_0 = 1920 ± 2 KeV. The shape factor plot for one of the runs is shown in Fig. 2. The error bars also include a factor of 1·25 due to the subtraction of the outer beta group. The results for the three runs are given in Table II

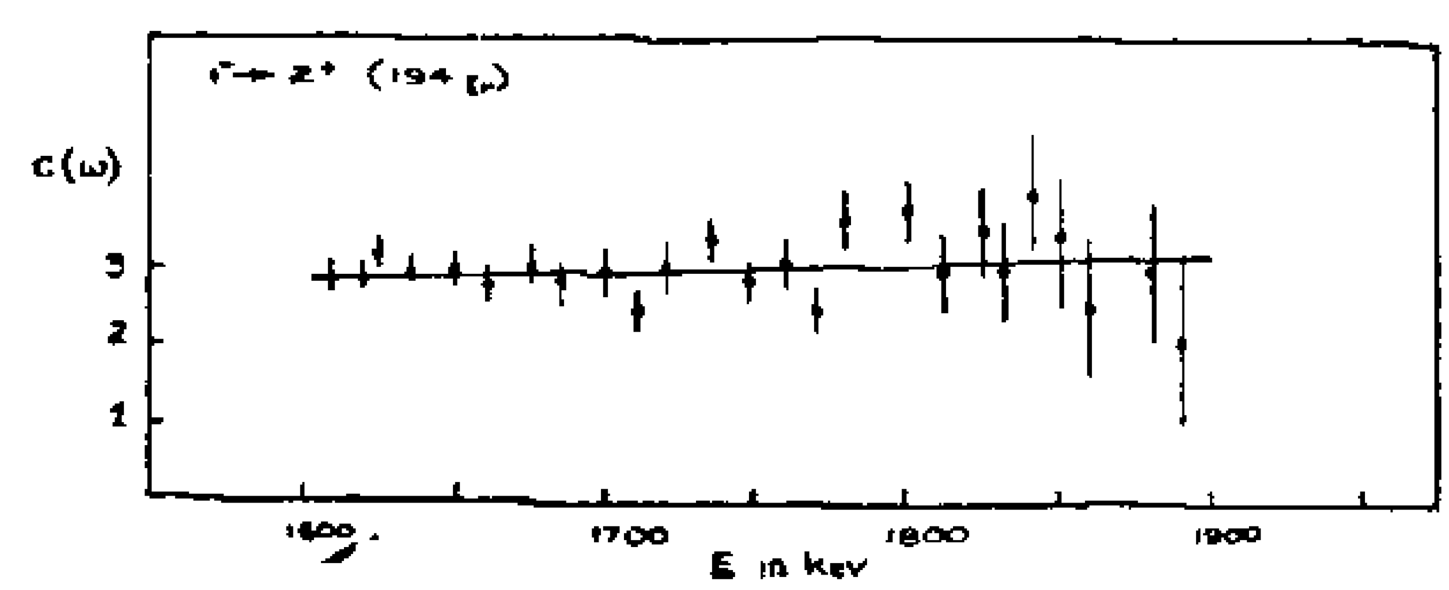

FIG. 2. Shape of the 1920 KeV beta transition of ^{194}Ir. Solid line is the least-squares fit with C(W) = C (1 + aW) with a = 0.031 ± 0·038. The error bars include a factor of 1·25 due to the subtraction of outer beta group.

TABLE II
Shape factor results of $1^- \rightarrow 2^+$ beta transition of ^{194}Ir

Run No.	End-point energy (KeV)	C (W)/K
1	1920 ± 2	1 + (0·031 ± 0 04) W
2	1920 ± 2	1 + (0 022 ± 0 04) W
3	1920 ± 2	. + (0·023 ± 0 04) W

DISCUSSION

The log ft. values of the main beta transitions, of 8·2 and 9·2, suggest the assignment of negative parity to the ground state of ^{194}Ir and hence the first forbidden nature of the two beta transitions. The shape of the 1920 KeV beta transition is statistical within the experimental errors. In an analysis employing modified B_{ij}-approximation[9,10], the shape factor is expected to have a unique component. Hence the modified B_{ij}-approximation cannot be applied in this case.

From the present measurements within the experimental accuracy, the shape factors of both the $1^- \rightarrow 2^+$ and $1^- \rightarrow 0^+$ beta transitions are fitting into the same shape factor form C (W) = K (1 + aW) and at the same time exhibiting statistical nature. Since the B_{ij} matrix element cannot contribute to $1^- \rightarrow 0^+$ beta transition and since the shapes are identical, it can be said that the shape of the $1^- \rightarrow 2^+$ beta transition is not determined by B_{ij} matrix element. This is also supported by the angular distribution measurements of Brewer *et al.*[8], wherein the unique matrix element B_{ij} in the $1^- \rightarrow 2^+$ beta transition to the 3·28 KeV level of ^{194}pt is small or zero.

In fact, the equality of the shape factors of the inner and the outer beta branches is not unexpected in the framework of the rotational model assuming the same matrix elements to contribute for beta transitions to various members of a rotational band. In order to arrive at a better physical understanding of the present measurements, an analysis of the data in terms of the matrix elements is required.

From the present measurements of the beta spectral shapes and from the angular correlation measurements of Priyadarsini[3], it may be concluded that 1920 KeV beta transition of ^{194}Ir follows the ξ-approximation[11]. It is normally difficult to obtain nuclear matrix elements of the beta transition following ξ-approximation unless the number of available experimental observables (data on different types of polarisation) is large.

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