SPECTRAL SHAPE OF THE K-FORBIDDEN BETA TRANSITION OF ^{152}Eu

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ABSTRACT

The K–forbidden beta transition of ^{152}Eu has been studied in detail for its beta spectral shape employing an intermediate image beta ray spectrometer. A detailed analysis in terms of $C(W)/C_B$ Vs W where C. is the modified B_{ij} shape correction factor, for different values of D and W_0 is made. The highest energy ($3^- \rightarrow 2^+$) beta group is found to exhibit large deviation from statistical shape and is well fitted into modified B_{ij} shape with an endpoint energy of 1481±2 keV. The value of D is obtained as 6±1. The shape factor results are discussed combining with the beta-gamma angular correlation data.

INTRODUCTION

K-FORBIDDENNESS is characterised by the fact that the K-selection rule of the Bohr Mottelson[1], $|K' - K| \leqslant \lambda \leqslant |K' + K|$ slows down (rather than forbids) the transition where K is the rank of the nuclear matrix element. The ground state of the ^{152}Eu nucleus is characterised as $J\pi$ $K = 3\text{–}3$ state with the intrinsic structure.

$$X_\Omega = (3/2\,[411] + 3/2\,[521])_\Omega = 3$$

The beta transition reaching the first excited level of the daughter nucleus ^{152}Gd is classified as K-forbidden. The large log ft value of this transition supports this classification. Bogdan and Lipnick[2] pointed out that a great similarity would exist between the same states of ^{152}Eu and ^{160}Tb nuclei and gave a common interpretation for these beta transitions and studied the K-forbiddenness by introducing mixtures of states with different K-values in the initial and final states. A detailed analysis of the shape of the most energetic beta group of ^{152}Eu has been carried out in the present work.

The beta-gamma directional correlation of the cascade 3^- (β-) 2^+ (γ) 0 in ^{152}Eu was investigated by many authors (Appalacharyulu *et al.*[3]; Bertheier and Lipnik[4]; Dulaney *et al.*[5], Wilkinson *et al.*[6], Manthuruthi *et al.*[7]) and the beta-gamma anisotropy was reported to be large. Schneider *et al.*[8], reported unique shape for this beta group of ^{152}Eu. Langer and Smith[9] measured the shape and fitted with $C(W)Wl = q^2 + \lambda_2 p^2 + 5 \pm 2$. Subsequent to the Langer's[9] measurement there has been no experimental determination of the shape of the highly forbidden beta transition. A remeasurement of the shape of this beta group is undertaken taking into account all the above considerations.

Mode of analysis.—So far in the published literature, the sensitive dependence of the shape factor on the end point energy has not been considered for once forbidden unique and modified shapes. In modified B shapes; theoretical shape factor has a quadratic dependence on W_0, the end-point energy, unlike the usual non-unique case (Morita[10], Matumato[11]) and the magnitude of the parameter D can appreciably alter if W_0 is not appropriate for the particular run. The unique and modified B shapes rise somewhat steeply near W_0. As W_0 is increased, the slope of the shape factor C(W) starts falling and when W_0 exceeds the correct value, the curve exhibits a point of inflexion and thereafter curves down for higher values of W_0.

Here in the present analysis a program computes the plot of the 'shape-factor $C(W)/C_B$ Vs for various values of W_0 where $C = q^2 + 9\,L_1/L_0 + D$. The shape factor C(W)/C is linear and it is energy independent for an appropriate choice of W_0 and D whereas the linear shape $C(W)/C_B$ Vs W curves up or down near W_0 when W_0 is changed from its correct value. The change in D shifts its low energy side up or down thereby changing its slope. For correct values of W_0 and D, the slope of the curve vanishes. In fitting the experimental shape $N/P^2F(Z, W)$ $W_0 - W)^2$ with the analytical expression $q^2 + 9\,L_1/L_0 + D$ where $q^2 = (W_0 - W)^2$, a perfect correlation is expected between W_0 and D. This type of rigorous mode of analysis is adopted in the present case.

EXPERIMENTAL DETAILS

The ^{152}Eu source used in the present work is obtained as $EuCl_3$ in HCl solution from Atomic Energy Establishment, Harwell, England; made of enriched ^{151}Eu sample by neutron irradiation. The sources are prepared by evaporating very small drops of the active solution on mylar foils of thicknesses ~ 180 $\mu g/cm^2$. Insulin is used to help uniform spreading of the source.

A Siegbahn–Slatis beta ray spectrometer of intermediate image focussing type is used at its best operating conditions. The details of the spectrometer and its best suitability for precision measurements were discussed by Nagarajan *et al.*[12]. The efficiency of the well type plastic detector used is unity down to 50 keV and the back scattering effect is 0·2% at 80 keV. The arrangement of baffles for distortionless operation, the fidelity of spectral distribution and the correct mode of analysis are described by Nagarajan and Reddy[13].

The gamma background is very high for ^{152}Eu source, but the background subtraction at every measurement point by closing the central baffle of the spectrometer accounts for this very accurately. The high energy portion of the ^{152}Eu beta spectrum is scanned in steps of approximetely 8 keV. A relatively weak source is used in order to eliminate the interferences from the highest beta group of ^{152}Eu whose intensity is only 0·1%; thus reducing the tail of the beta spectrum from ^{152}Eu.

SHAPE ANALYSIS OF THE $3^- \rightarrow 2^+$ BETA TRANSITION

The Fermi–Kurie (F.K.) plot is constructed for the experimental points incorporating the Fermi functions due to Bhalla and Rose[14] and the screening correction due to Buhring[15]. The resolution, correction and back-scattering correction are done by the computer program FERMIKURI. The F.K. plot revealed the existence of a high energy tail which indicates the presence of a beta transition with end point energy approximately 1840 keV. Infact Larson *et al.*[16] analysed the very weak third forbidden transition in ^{152}Eu with weak sources and found the end-point energy to be 1827 keV. Since the impurity of the ^{154}Eu source dominates the intensity of the third forbidden weak beta transition of ^{152}Eu, it will be reasonable to subtract the influence of the ^{154}Eu contamination by assuming a statistical shape for this transition. Although the 1840 keV transition of ^{154}Eu has non-statistical shape, its very feeble intensity will not affect the results even if the shape is taken as statistical.

The F.K. plot of the 1840 keV transition with allowed shape is extrapolated down to low energies and subtracted from the gross-spectrum of ^{152}Eu using the relation $Y_2 = \sqrt{Y^2 - Y1^2}$ where Y2 is the ordinate of the F.K. plot of the composite spectrum and Yl is the ordinate of the F.K. plot of the 1840 keV component. The resulted spectrum is analysed for shape analysis from 1050 keV to 1480 keV. The F.K. plot as shown in Fig. 1 is drawn which shows an approximate energy of 1480 keV. A program BETASHAP plotted the shape factor $N/P^2F(Z, W)(W_0 - W)^2$ Vs W varying W_0 in steps of 2 keV below and above 1480 keV. Near W_0, the shape factor slightly curves down for end-point energies higher than the exact end-point energy. Since judging the shape factor in this manner is difficult, an analysis of C(W)/C Vs W is undertaken in Fig. 2. A rigorous analysis as explained in section: 2 is carried out and are shown in Figs. 2, 3 and 4 for one of the runs.

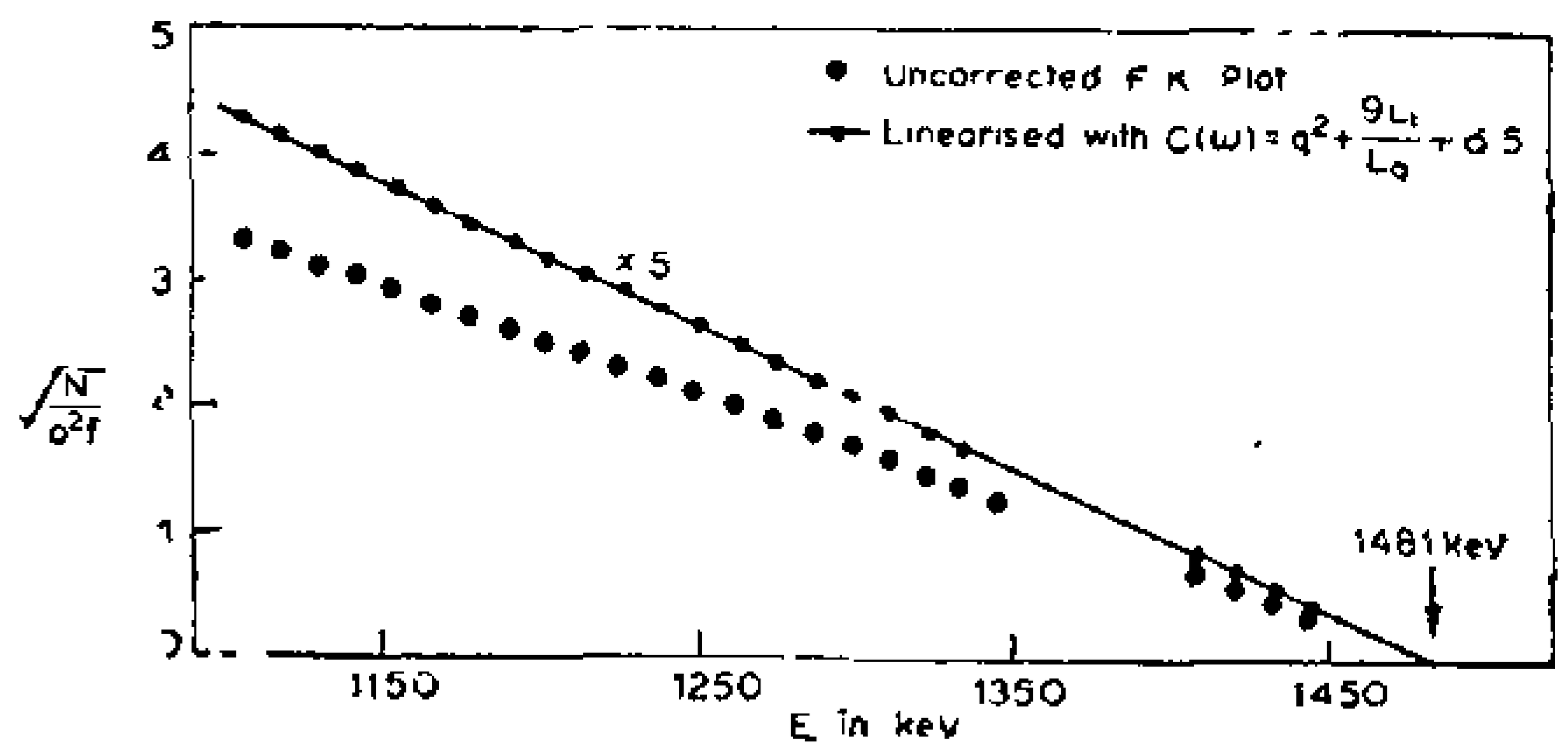

FIG. 1. Fermi-Kurie plot of the $3^- \rightarrow 2^+$ transition in the decay of ^{152}Eu.

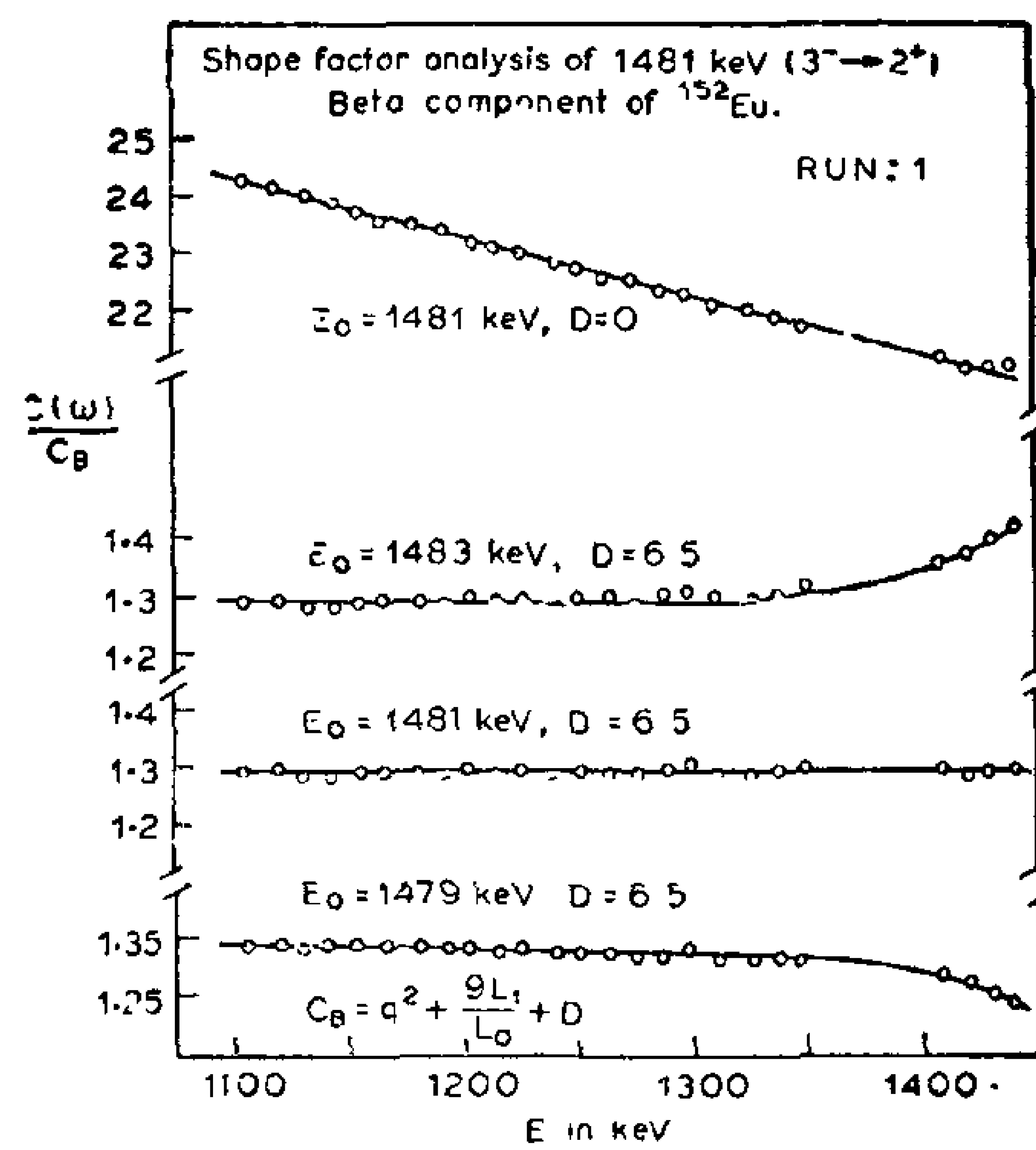

FIG. 2. Shape factor analysis of 1481 keV. ($3^- \rightarrow 2^+$) beta component of ^{152}Eu for run : 1. The behaviour of shape factor curve corrected for the "modified ", shape factor" $C = q^2 + 9L_1/L_0 + D$ is more sensitive to changes in w_0 and D than C(W) Vs E.

A similar analysis is also performed for the second run and the results are given in Table I.

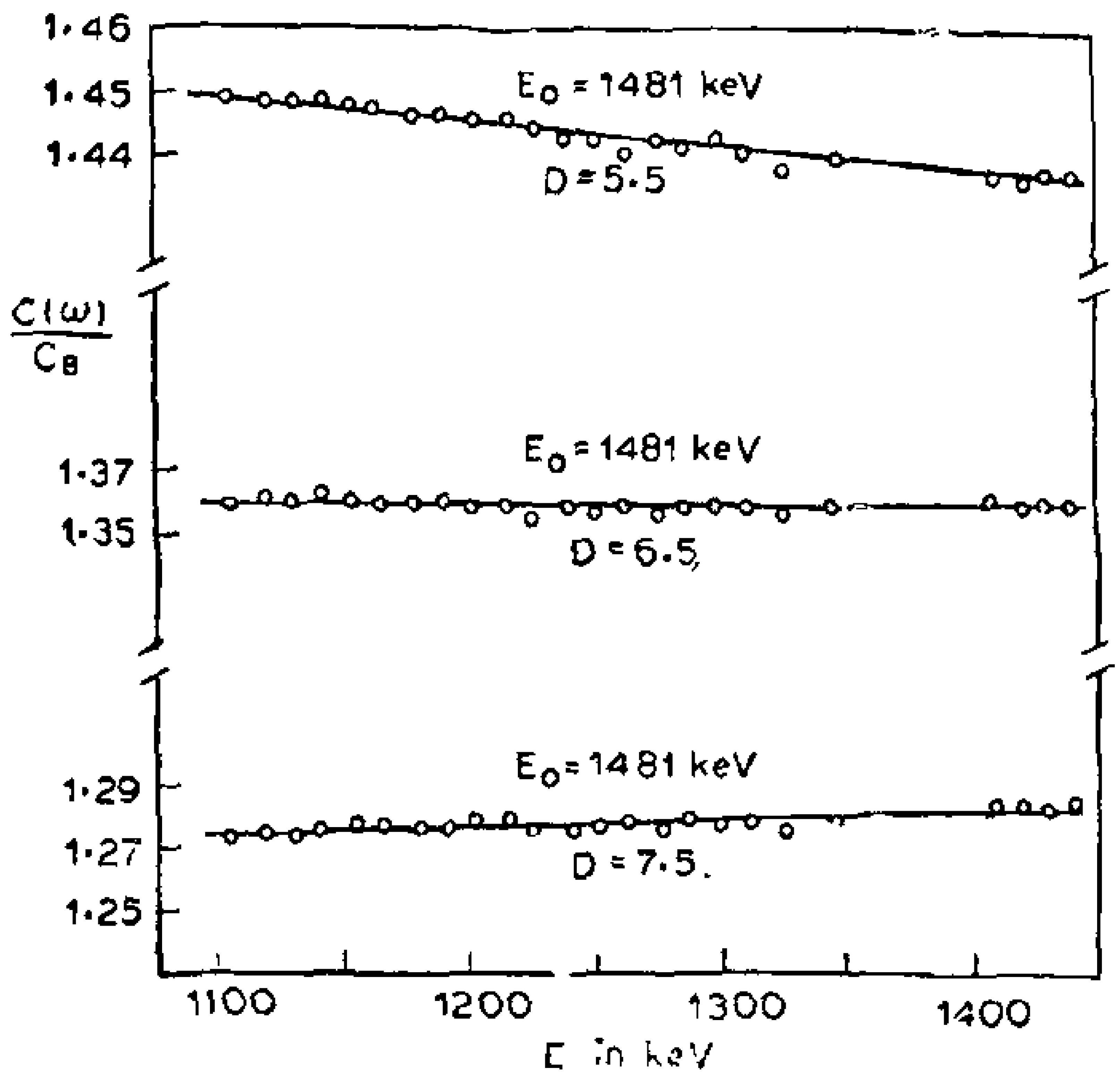

FIG. 3. The least square fitted straight line to the corrected plot has small positive and negative slopes for D = 7·5 and D = 5·5 the slope vanishes for D = 6·5.

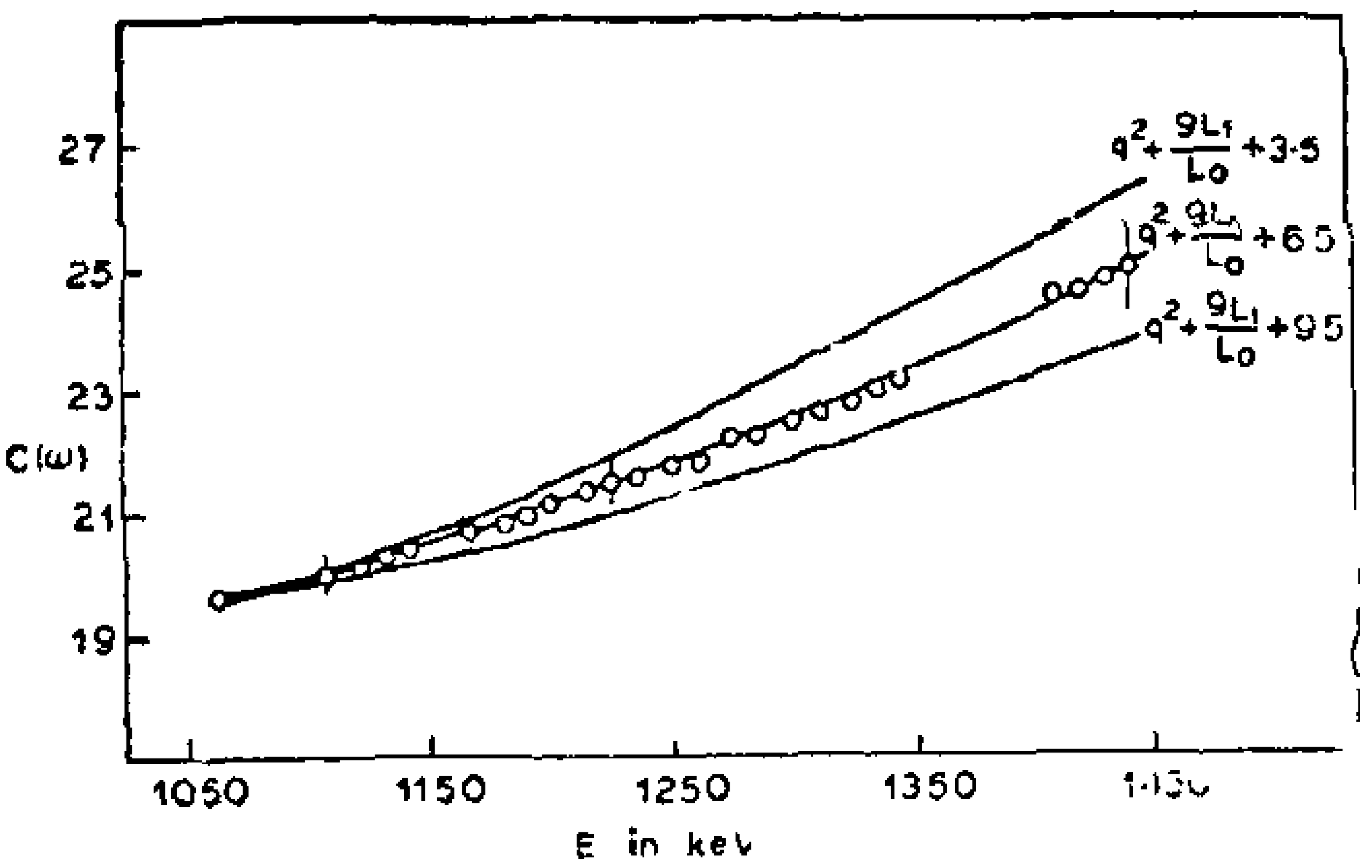

FIG. 4. Shape factor plot of $3^- \rightarrow 2^+$ beta transition of ^{152}Eu. The solid lines correspond to theoretical shapes for different values of D.

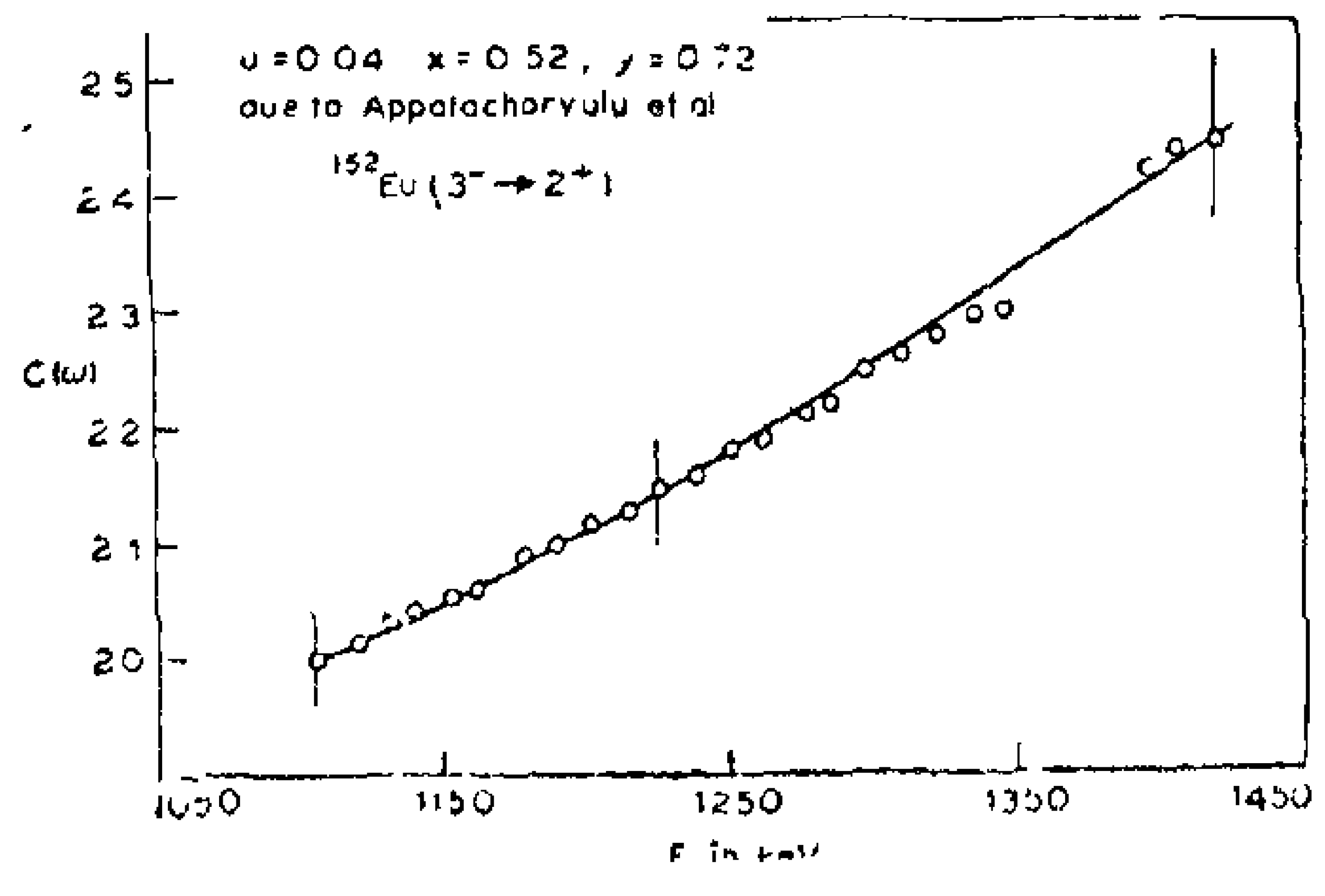

FIG. 5. Comparison of experimental shape factor of the beta transition of ^{152}Eu with the theoretical prediction of matrix element parameters due to Appalacharyulu, *et al.*

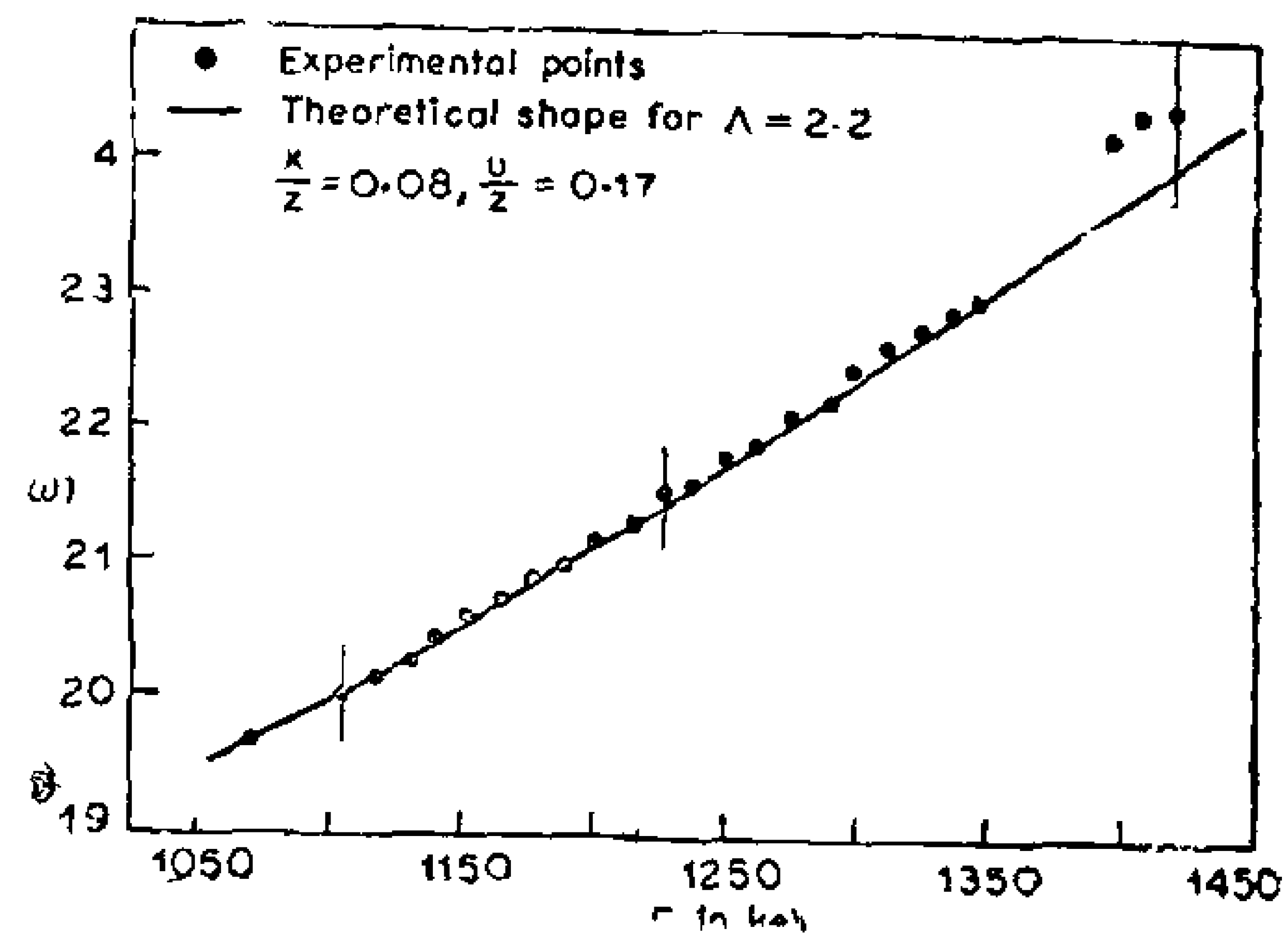

FIG. 6. Comparison of the shape factor of the ($3^- \rightarrow 2^+$) beta transition with the theoretical predictions of single particle matrix elemest parameters.

TABLE I

Shape factor data on $3^- \rightarrow 2^+$ *transition of* ^{152}*Eu*

Author	Run No.	E (keV)	D
Present work	1	1481±2	6·5±1
	2	1481±2	6±1
Langer and Smith	1	1483±7	5±2
Schneider	1	1492	Unique shape

DISCUSSION

A non-unique first forbidden beta transition exhibits a shape resembling nearly that of a first forbidden unique transition when the tensor type matrix element $\int B_{ij}$ can no longer be neglected as in the normal first forbidden transitions obeying ξ-approximation. Under such conditions, the shape can be analysed with the modified B_{ij} form Morita[10] $C(w) = q^2 + 9L_1/L_0 + D$ where $D = 12Y^2$. Even though an experimental shape can be simulated by any suitable combination of matrix element parameters (Kotani[17]) an analysis under 'modified B_{ij}-approximation' gives the relative strength of $\int B_{ij}$ with respect to Y. The present analysis yields $Y^2 = 0{\cdot}5 \pm 0{\cdot}08$. On account of the good statistical accuracy of the present measurements, it permits a clear distinction between the energy dependence predicted by the matrix element sets of different authors.

Using the assumption of Ahrens and Feenberg[18] ($\Lambda \approx 1$) where Λ is the CVC ratio, Dulaney *et al.*[5], obtained a well defined solution for the matrix elements parameters x and u. However, the solution obtained in this case was in sharp disagreement with the modified B_i approximation. The solution obtained with $A = 2 \cdot 5$ was in general agreement with the modified B_i approximation. The energy dependence of shape factor due to the best set of matrix elements reported by Bhattacharjee *et al.*[21], and due to the first set of matrix elements due to Manthuruthil[7] do not follow the present shape factor. Those due to Appalacharyulu[3] who employed the formalism of Buhring[19,20], in which the finite nuclear size effect and the higher order effects are included is in good agreement as shown in Fig. 5.

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SPECTROPHOTOMETRIC STUDY ON THE COMPLEXATION REACTION OF PALLADIUM(II) WITH BUTAPERAZINE DIMALEATE

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Abstract

Butaperazine dimaleate forms a red coloured 1 : 1 complex with palladium(II) in hydrochloric acid-sodium acetate buffer. The complex exhibits absorption maximum at 490 nm with molar absorptivity $3 \cdot 5 \times 10^3$ litre mole^{-1} cm^{-1}. Beer's law is valid over the concentration range 0·2–17·0 μg/ml.

Introduction

In the present communication, the authors propose the reaction of butaperazine dimaleate (BPDM) with palladium(II) for the spectrophotometric determination of palladium(II). The method offers the advantages of simplicity, rapidity, selectivity and wider range of determination without the need for extraction.

Experimental

Reagents

A stock solution of palladium(II) was prepared by dissolving 0·9980 g of palladium(II) chloride (M/s Johnson Matthey Chemicals, London) in 1 litre of 0·1 M HCl and was standardized gravimetrically by the dimethylglyoxime method[1]. A 0·2% solution of BPDM was prepared in hot double distilled water and stored in an amber bottle in a refrigerator. Sodium acetate-hydrochloric acid buffers were used. Beckman spectrophotometer Model DB was used for absorbance measurements.

Procedure for the Determination of Palladium(II)

An aliquot of the stock solution containing 5·0–425 μg of palladium, 5 ml of hydrochloric acid-