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IB intensities in EC decay of ^{125}I

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Abstract : The internal bremsstrahlung (IB) spectrum from the allowed electron capture (*e.c.*) decay of ^{125}I leading to the 35 KeV level of ^{125}Te was studied using a 2" × 2" NaI (Tl) scintillation detector and a PC based multichannel analyser The unfolding method was applied for deriving true IB spectrum, and a modified Jauch's plot was drawn in view of intense $2p$ -capture admixed with $1s$ Through an iteration technique, the $1s$ end-point energy was determined as 80 ± 1 6 keV The intensities evaluated on the basis of Glauber and Martin (*GM*) and Intemann theories coincided with the experimental intensities for most part of the IB spectrum

Keywords : Internal bremsstrahlung spectrum, end-point energy, intensities

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The IB theories, experimental methods and procedures of analysis were extensively reviewed by Bambynek *et al* [1]. When the transition energy is low, the IB is admixed with $1s$, $2s$, $2p$ and $3p$ and in such cases, a modified Jauch's plot as suggested by Bambynek *et al* [1] and as reported by Babu and Rama Rao [2], (Sr) Little Flower *et al* [3] is to be adopted instead of a simple linearised Jauch's plot. The e.c. decay of ^{125}I → ^{125}Te has a low transition energy. Wapstra and Gove's [4] mass tables show a value of 147 5 ± 1.0 keV (taken from e.c. measurements), while Wapstra and Audi's [5] revised tables show a value of 177 ± 2 keV (from the available IB values) for the ground-to-ground state decay energy of ^{125}I → ^{125}Te. (Sr) Little Flower *et al*'s [3] IB theoretical intensities, the only ones available in literature, did not agree with the theoretical estimates. With a view to testing the agreement or otherwise of the experimental and theoretical IB intensities, it was felt desirable to remeasure the end-point energy and re-estimate the intensities The results obtained in the present work appeared in the *Proc. of Conference* [6]

The IB detector (integral assembly of 2" × 2" NaI (Tl) scintillator coupled to an RCA 4523 photomultiplier), a PC based MCA (MC 1002) and the electronic assembly, all supplied by Nucleonix, Hyderabad were used in the present investigations. The details of the experimental set-up were given in Ref [6].

The decay scheme of ^{125}I to ^{125}Te is well established [7]. ^{125}I decays (100%) to the 35 keV level of ^{125}Te without any ground-to-ground transition. This is an allowed transition with $\Delta J = 1$ and without any change in parity ($5/2^+ \rightarrow 3/2^+$). When ^{125}Te comes to its ground state from 35 keV level, a γ-ray of energy 35 keV is emitted. In addition, K-X-rays of 28 keV are also emitted from this isotope.

A carrier-free and nearly point source of 5 μCi activity of ^{125}I supplied from BRIT, BARC, Bombay was used in the present investigations. The spectra with and without the source were recorded alternatively and the counts were pooled up for a total period of 70 hours each. The raw IB spectrum obtained after subtracting the background and the pile-up counting rates arising due to the presence of strong 35 keV and 28 keV X-rays from the measured counting rate, was analyzed from 40 keV to 105 keV. Following Liden and Starfelt [8] procedure, the true IB spectrum was obtained as shown in Figure 1. The modified Jauch's plot $\{[N(E)]/[E \times R_{1s}(E) \times f(E)]\}^{1/2}$ vs E as shown in Figure 2 was drawn for obtaining 1s endpoint energy (Q_{1s}). Here,

$$f(E) = 1 + \frac{P_{L\,\mathrm{II-III}}}{P_k} \times \frac{[Q_{2p}]^2}{R_{1s}(E)} \times \left[1 + \frac{K_{kx}}{(q_{1s} - E)}\right]^2 ,$$

$R_{1s}(E)$=0.43 evaluated using Intemann's [9] expression, $[P_{L\,\mathrm{II-III}}]/P_k = 0.254 \pm 0.005$ taken as an average of the two consistent available values from Leutz and Zeigler [10] and

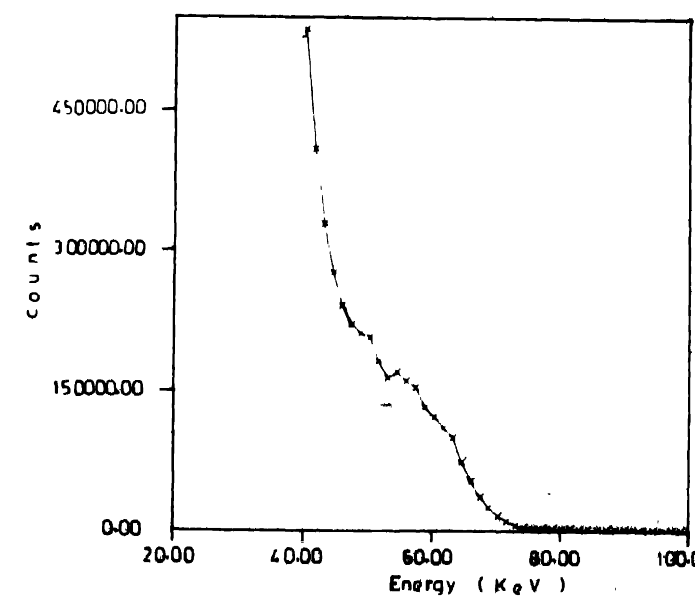

Figure 1. True IB spectrum of ^{125}I.

Smith and Lewis [11], Q_{2p} evaluated from GM theory and K_{kx} = difference in binding energies of 2p and 1s electrons of ^{125}Te = 28.47 keV taken from Shirley *et al* [12] were used for obtaining the modified Jauch's plot. Through successive iterations, the $1s$ endpoint energy was determined as 80 ± 1.6 keV. A maximum error of 2% was assigned which may arise due to errors in counting statistics, other systematic errors during unscrambling of the spectrum and the error in $[P_{L\,II\text{-}III}]/P_K$. Taking the K-shell binding energy of 33.17 keV from Shirley *et al* [12] the transition energy to the ground level of ^{125}Te was deduced as 148.17 ± 1.6 keV.

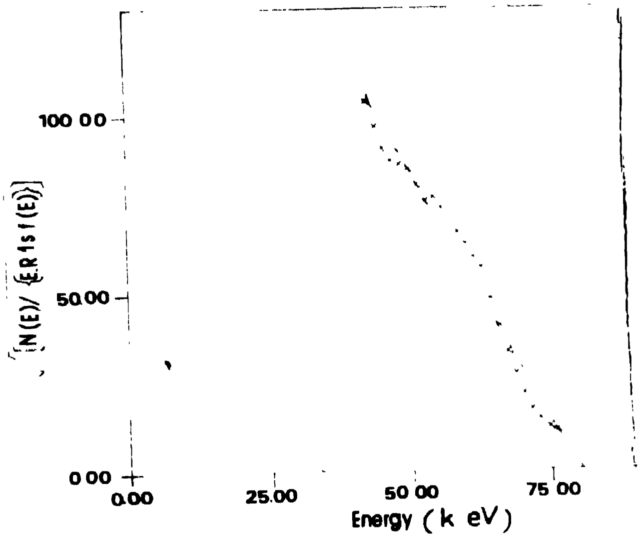

Figure 2. Jauch's plot of ^{125}I (The intercept of the least-squares fitted straight line yielded q_{1s} = 80±1.6 keV.)

The presently measured value of decay energy agrees fairly well with that of Wapstra and Gove [4] and deviates somewhat (by about 30 keV) from the earlier IB estimates [5]. Among the earlier IB measurements, only (Sr) Little Flower *et al* [3] have considered $2p$ IB, while others determined the endpoint energy from a simple Jauch's plot [1]. (Sr) Little Flower *et al* [3] adopted folding technique for their analysis of IB spectrum. Laneman and Bond [13] pointed out that the end-point energy values derived from such a fitting procedure can vary even as much as 25 keV with different assumed spectral shapes. It may also be noticed that (Sr) Little Flower *et al*'s evaluation of experimental IB intensities did not agree with the theoretical GM intensities. This prompted us to adopt the unfolding method for determining the $1s$ endpoint energy, which is also in accordance with the recommendations of Bambynek *et al* [1] for the procedures of IB analysis.

Integrated experimental IB intensities per K-capture e.c. decay were evaluated and compared with corresponding theoretical estimates. The Morrison–Schiff (MS) theoretical $1s$ intensities were multiplied with R_{1s} = 0.43 and the screening correction S_{1s} = 0.96 obtained from MG theory. Similarly, the GM $2p$ theoretical intensities were multiplied with the screening correction S_{2p} = 0.67 of MG theory. These two are added up with their weightage factors P_k and P_L. The values thus obtained are shown in Table 1. The main sources of error in the experimental intensities arise from the uncertainties in the source strength evaluation (10%), errors in counting statistics (1 to 2% in the range from 40 keV to 70 keV and 5 to 10% above 70 keV) and also systematic errors associated with corrections applied to unfold the spectrum (2%). Thus, a total error of 14% was assigned on the experimental intensities for the ranges of energy 40-105 keV and 60-105 keV and 20% for the range 80-105 keV. The error in the theoretical intensities were due to the uncertainties of 2% in P_L/P_K and of 2% uncertainty in end-point energies. Thus, a total error of 4% was assigned to the theoretical estimates It can be noticed from Table 1 that the experimental intensities agree fairly well with theoretical estimates in a wide range of energy except near the endpoint energy. With a sufficiently large number of counts in the range above 80 keV also, better agreement with the theory might be achieved. A good agreement with the theory for the most prominent part of the IB spectrum in the present investigations is in accordance with the observations of Sanjeevaiah and Sanjeevaiah [14] and Kader *et al* [15] and is against the observations made by (Sr) Little Flower *et al* [3].

Table 1. Integrated theoretical and experimental IB intensities.

Sl No	Range of energy (KeV)	$(N_{1s})_{Th}$	$(N_{2p})_{Th}$	$(N_{Total})_{Th}$	$(N)_{exptal}$
1	40-105	3.224×10^{-4}	1.555×10^{-2}	$(3.514 \pm 0.141) \times 10^{-3}$	$(3.145 \pm 0.44) \times 10^{-3}$
2	60-105	5.44×10^{-5}	2.274×10^{-3}	$(5.195 \pm 0.208) \times 10^{-4}$	$(4.575 \pm 0.641) \times 10^{-4}$
3.	80-105	-----	2.81×10^{-4}	$(2.81 \pm 0.56) \times 10^{-4}$	$(1.043 \pm 0.209) \times 10^{-5}$

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