Adopted α_K value for the 661.6 keV M4 transition in ^{137}Ba

K. Vijay Sai [1]*, R. Gowrishankar[1], S. Deepa[2], Dwarakarani Rao[2] and K. Venkataramaniah[1]

[1] *Department of Physics, Sri Sathya Sai Institute of Higher Learning, Prasanthi Nilayam, 515134, A.P*
[2] *Department of Physics, Sri Sathya Sai Institute of Higher Learning, Anantapur Campus, 515001,A.P.*
* email: kvijaysai@sssihl.edu.in

Introduction

In one of our earlier works (J. Gerl et al. [1]), we had presented the compilation of all the available experimental Internal Conversion Coefficients (ICC) data of the High Multipole transitions (L > 2). This article presents further analysis of some of the data presented in [1], taking into consideration the various averaging techniques for determining an adopted value for one of the most researched α_K value of 661 keV M4 transition in ^{137}Ba.

To determine the best method of deriving a recommended or adopted value (along with an associated uncertainty) from a discrepant data set, has been a significant problem faced by many of the data evaluators. Several authors [2] had addressed this problem earlier. A particular reference is the radio-nuclide half-life data [2]. Similar analysis is carried out at SSSIHL, and we present here our preliminary results, with reference to the adopted α_K value of the 661 keV M4 transition in ^{137}Ba. This analysis, besides confirming the best averaging technique that can be employed, also compares the theoretical ICC calculations [3], such as BrIcc (FO), BrIcc (NH), HsIcc and RpIcc while emphasizing the need for precise experimental data.

Analysis

21 of the experimentally published α_K values reported [1] for the 661 keV M4 transition in ^{137}Ba, as shown in Table 1, have been considered in our present work, for arriving at the adopted α_K value. We had made use of the Visual Averaging Library tool from the ENSDF analysis and utility programs of NNDC [4]. This is an analysis tool that can be used to determine a recommended value for a measured quantity based on a sequence of measurements. User has an option to select from 8 different averaging methods and the tool can also be used to identify outliers. The other option that is available is to compare the average value obtained using all the 8 methods, based on the χ^2 and critical χ^2 values (Table 2) at 95% confidence limit.

Table 1: Experimental α_K values of the 661 keV M4 transition in ^{137}Ba. References in the last column are as per the key number given in NSR.

Expt. $\alpha_K$value	Expt. Method	Reference
0.097 (3)	IEC	1951Wa19
0.095 (5)	IEC	1952He18
0.096 (5)	PBS	1954Az01
0.092 (6)	PBS	1954Wa14
0.11 (1)	IEC	1955Dr43
0.095 (8)	CEL	1957Mc34
0.0976 (55)	PBS	1958Yo01
0.093 (6)		1959Hu12
0.095 (4)	IEC	1961Hu12
0.093 (3)	PBS	1962Da05
0.0933 (2)		1963Le20
0.0894 (1)	AEG	1965Me03
0.092 (9)	IEC	1965Ra12
0.094 (5)		1966Hu02
0.0916 (5)	CT	1969Ha05
0.0901 (11)		1973LeZJ
0.0922 (22)		1973Wi10
0.0888 (7)		1978Ch22
0.093 (3)		1978Gr09
0.0881 (5)	PBS	1983Be18
0.0904 (5)	NPG	1992Ne04

Experimental methods used in determining the ICCs (as given in Table 1) are:
IEC - Internal–External Conversion method
PBS - Peak-to-Beta Spectrum method
CEL - Coulomb Excitation and Lifetime method
AEG - Absolute Electron Gamma method
CT - Coincidence Technique
NPG - Normalised Peak-to-Gamma method

A detailed description of these methods is given in *Experimental methods for the determination of ICCs*, in: Internal Conversion Process, ed. by J.H. Hamilton [5].

As mentioned earlier, the Visual Averaging Library consists of a collection of averaging procedures for the purpose of data evaluation.

- Limit of Statistical Weights Method is a procedure adopted by the IAEA in the Coordinated Research Project on X-ray and gamma-ray decay standards. Nichols [6].
- Normalized Residuals Method is from James et al. [7].
- Rajeval Technique is from Rajput et al. [8].
- Detailed description of the Mandel-Paule method, Rukhin and Vangel [9] .

The experimental values of 0.11(1), 0.0894 (1) and 0.0881 (5) are excluded as per the outlier rejection criterion of Chauvenet's [4].

Table 3: Theoretical ICCs using the BrIcc v2.3S conversion coefficient calculator for the 661 keV M4 transition in ^{137}Ba.

		M4			
Shell	**E(ce) in keV**	**BrIccFO**	**BrIccNH**	**HsIcc**	**RpIcc**
Total		0.1124 (16)	0.1115 (16)	0.109 (4)	0.114 (4)
K	624.22	0.0915 (13)	0.0907 (13)	0.093 (3)	0.093 (3)

Table 2. χ^2 and critical χ^2 values at 95% confidence limit for the average α_K value.

	χ^2/(N-1)	**Critical χ^2/(N-1)**	**Average α_K value**
Unweighted Average	-	-	0.0936(10)
Weighted Average	17.61	1.57	0.0902 (4)
LWM	Unweighted mean		0.0928(33)
Normalised residuals	2.6	1.57	0.0895 (2)
Rajeval Technique	1.26	1.60	0.0915 (4)
MBR	35.8% confidence		0.0920(25)
Bootstrap	53.13	-	0.0924(13)
Mandel-Paule	24.37	-	0.0912(16)

Conclusions:

As can be seen from Table 2, the average α_K value of 0.0915 (4) from the Rajeval technique can be considered as the most recommended or adopted value, as the χ^2 value is well within the range of critical χ^2 value. A comparison from the tabulated theoretical ICC values from BrIcc v2.3S conversion coefficient calculator [3] also confirms the BrIccFO α_K value of 0.0915 (13) for the 661 keV M4 transition in ^{137}Ba. Similar analyses are being performed on many more transitions where extensive data is available.

References

[1] J. Gerl et al., At. Data Nuc. Data Tab.,94 (2008) 701
[2] Desmond MacMohan et al., Appl. Radiat. Isot. 60 (2004) 275
[3] http://bricc.anu.edu.au/
[4] http://www.nndc.bnl.gov/nndcscr/ensdf_ pgm/utility/vavglib/
[5] In Proc. Internal Conversion Process, ed. by Hamilton, J.H., North-Holland, 1975
[6] Nichols, Appl. Radiat. Isot. 60 (2004) 247
[7] James et al., Nucl. Instr. and Meth. A 313 (1992) 277
[8] Rajput et al., Nucl. Instr. Meth. Phys. Res. A 312 (1992) 289
[9] Rukhin and Vangel, J. Am. Stat. Assoc. 93, (1998) 303