Compilation and Evaluation of experimental α_K values of pure E2 transitions in the light of existing theoretical calculations

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Introduction

Most widely used Internal Conversion Coefficients (ICCs) data tables are those of Hager and Seltzer [1], Rosel et al [2] and Band and Trzhaskovskaya [3]. Although theoretical ICCs differ as a consequence of the model adopted by the authors, details of the physical assumptions, inadequate knowledge of some quantities involved in the computations and approximations made in the code, agreement among the calculated data can be remarkably good, varying by less than a few percent and generally less than 5%. Various analysts, Campbell and Martin [4], Raman et al [5] have pointed out the differences between equivalent tabulations and between calculated and experimental ICC values.

There are at least three credible ICC data tables. Differences among experimental and theoretical internal conversion coefficients have been discovered nearly thirty five years ago. The number of measurements were insufficient to decide whether the above mentioned discrepancy was a function of Z or energy or to look for nuclear structure effects. In a most recent compilation, Gerl et al[6] confirmed the above findings in a more exhaustive comparison in the case of most of the high multipole transitions and even recommended the BRICC [7] values as the correct theoretical values.

Methodology: In the present scenario, the acceptance of the BRICC values for theoretical ICCs as the right and correct ones has to be reconfirmed by considering a large amount of experimental data on pure multipole transitions like pure E2 transitions in order to avoid the possibility of any admixtures in the absence of exact mixing ratios, contributing to the deviations. Also till now all the comparisons have been made on limited experimental data. A thorough comparison of experimental ICCs with various theoretical calculations is possible only when one can have at least one set of complete data on pure multipole transitions available at one place.

In an attempt to fill this gap, experimental data on α_K values for pure E2 transitions in nuclei from Z = 23 to Z = 94 have been collected from the direct references making use of the ENSDF data base of Nuclear Data Group and the IAEA data base on nuclei and have been assembled as a complete compilation. In cases where more than one measurement is available, the weighted averages have been calculated using the NDS prescription. Experimental data with less than 10% uncertainty only have been considered and included in the compilation. E1 transitions are not considered, as, as a rule, they are often hindered strongly. All the data has been arranged according to increasing mass number of the nucleus. The references are given in Nuclear Data Sheets' format.

For the interpolation of Hager and Seltzer and Rosel theoretical α_K values the ICC code, ICC 2.0 [8] from LBL has been used. The program ICC 2.0 (Windows 95/NT) interactively calculates ICC values.

Analysis:

For detailed comparisons between experimental and the theoretical ICCs, experimental α_K values and weighted averaged experimental values (Adopted) with experimental uncertainty less than 10% have been selected for comparison with the theoretical values of Hager

and Selzer(1), Rosel et al.(2) and BRICC [7]. The relative percentage deviations (%Δ) have been calculated for each of the above theories using the standard definition. The analyzed data have been placed in Tables 1 and 2. The weighted averages of the experimental data and the global averages of deviations have been calculated using the Nuclear Data Sheets (NDS) prescription: If $x_1 \pm \Delta x_1$, $x_2 \pm \Delta x_2$, ….., $x_n \pm \Delta x_n$ are n independent measurements, Δx_i being the uncertainty in x_i , then the weighted average (weighted by the inverse square of the uncertainty) is given by $\bar{x} \pm \Delta\bar{x}$ where $\bar{x} = W \sum_1^n x_i/(\Delta x_i)^2$, $W = \frac{1}{\sum_1^n (\Delta x_i)^{-2}}$ and $\Delta\bar{x}$ is the larger of $(W)^{1/2}$ and $[W \sum_1^n \frac{(\Delta x_i)^{-2}(\bar{x}-x_i)^2}{(n-1)^{\frac{1}{2}}}$.

Table 1: Weighted average of percentage deviations ($\overline{\%\Delta}$) between experimental and theoretical αK values

Quantity	$\overline{\%\Delta}$		
	H & S [1]	Rosel [2]	BRICC [8]
α_K E2	-2.7(2)	-2.7(2)	-1.3(3)

Table 2: Weighted average of percentage deviations ($\overline{\%\Delta}$) between experimental and theoretical α_K values with respect to uncertainty percentage

Quant-ity	Uncert-ainty	$\overline{\%\Delta}$		
		H&S [1]	Rosel [2]	BRICC
α_K E2	< 1%	-2.5(3)	-2.5(7)	-1.1(6)
	< 3%	-2.4(3)	-2.4(3)	-1.1(4)
	< 5%	-2.4(3)	-2.4(3)	-1.1(3)
	< 7%	-2.3(2)	-2.4(2)	-1.1(2)
	< 10%	-2.3(4)	-2.3(3)	-1.0(3)

Weighted average of percentage deviations ($\overline{\%\Delta}$) between experimental and theoretical α_K values also have been calculated.

Rigorous comparisons between experimental and the various theoretical ICCs can be made by calculating the weighted average of percentage deviations for data classified in to different categories based on experimental uncertainties involved, viz <10%, <7% , <5%, <3% and <1% cases.

It can be seen from the above table that irrespective of the experimental error percentages of the data sets, the Hager and Seltzer and Rosel et al theoretical values are consistently lower by about 2.3 to 2.5% while with the BRICC values the deviation is only 1%. Considering the uncertainty in the interpolation code as 1%, BRICC theoretical values are consistently almost agreeing with experimental ICC values.

Whatever deviations that have been reported earlier have been brought down by the theoretical calculations of BRICC. No systematic deviations could be found in terms of transition energy, atomic number etc. We confidently recommend the BRICC tables for theoretical ICCs using BRICC code for interpolation. BRICC are the best theoretical ICC calculations. Now with the new theoretical calculation of BRICC, it has become possible to explain the systematic discrepancy problem raised by many authors over the years. If at all discrepancies exist in some case they are not systematic but can be attributed to multipole mixing.

References

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