Changing Statistics of Log ft Distribution in Shell Model

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Introduction

We have made an updated survey of Logft values for $\beta^{\pm}$ and electron capture (EC) transitions in nuclei all over the periodic table including exotic neutron and proton rich ones. About 10000 Logft values have been collected, and the previous number was about 3900. This kind of survey was done more than two decades back. In the meantime, several advancements in experimental facilities made it possible to study more precisely the comparative half-lives of $\beta^{\pm}$ and EC transitions of super allowed, allowed, and various forbidden categories. In Table 1, we have presented a summary and classification of allowed transitions only and compared them with the previous survey [1].

The number of transitions in each category has changed noticeably, particularly in the allowed categories.

Results and Discussion

One can study the statistical features associated with each category if the sample size is sufficiently large. Generally, a Gaussian distribution is fitted to the histogram of Logft versus frequency (number of Logft with a certain fixed bin size).

The distribution is characterized by a peak, where a maximum number of Logfts occur, and a width. Such a distribution is shown in Fig.1 for allowed Gamow-Teller (GT) transitions in a set of sd shell nuclei which contains highly neutron rich ones. We have noted that the Logft values measured for very weak branches mostly lie away from a Gaussian fit. We have not taken those into our set for the plot in Fig. 1. But still, it seems that there is a scope for better statistical analysis by using a distribution which apart from centroid and width, consists also of third (skewness) and fourth (excess) moments. Work in this regard is in progress.

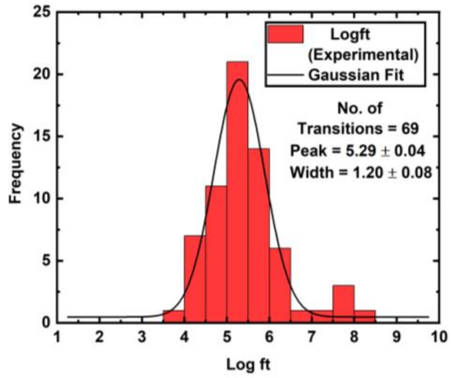

Fig. 1 Experimental Logft distribution with bin size =0.3.

To test the predictability of statistical properties of Logft distribution by the empirical interactions in the sd shell, we have performed shell model calculations, using OXBASH [2] and NushellX [3] codes with different interactions, to obtain ft values of 67 allowed Gamow-Teller transitions. The ft ($ft_{1/2}$) value for a beta transition is given by the expression

$$ft = \frac{6177 sec}{\left(\frac{g_A}{g_V}q\right)^2 B(GT)+B(F)} \qquad (1)$$

Where g_A and g_V are axial vector and vector coupling constants and Q (q) is the GT quenching factor. Here f is the leptonic phase space factor. We have obtained the reduced GT and F(Fermi) matrix element squared B(GT) and B(F) from Shell Model (SM) calculations with W and CW (1+2)-body empirical Hamiltonians available with the SM codes. We have used the global quenching factor Q=0.77 for the GT transitions as shown in Eqn. (1). Then we plotted in Fig. 2, as in Fig. 1, Logft versus frequency and fitted with a Gaussian distribution to obtain the centroid and width as shown. One can then compare two figures.

Table 1: Comparison of the present survey of Logft values collected from Ref. [4] in the allowed category with the previous one [1] shown within brackets. Column 1 represents the classification of the decay; in Column 2, the sample size is given; in columns 3 and 4 centroids and width for the Gaussian fit are shown; Minimum and Maximum Logft values are presented in the last two columns.

Transition Details	Sample Size	Centroid	Width	Min	Max
0+ ↔ 1+	1032 [714]	4.90 [5.3]	1.63 [2.7]	1.2 [2.9]	9.72 [7.2]
ΔJ=0, Δπ =no, not 0+→0+	1424 [548]	6.00 [6.3]	2.27 [1.1]	3.017 [4.1]	12.49 [10.6]
ΔJ=0, Δπ =no, even A	505 [196]	6.00 [6.5]	3.33 [1.2]	3.31 [4.1]	12.49 [10.6]
ΔJ=0, Δπ =no, odd A	919 [352]	5.80 [6.1]	2.27 [0.9]	3.02 [4.1]	11.562 [8.5]
ΔJ=1, Δπ =no, not 1+↔0+	3361 [1187]	5.70 [6.0]	2.57 [1.1]	2.56 [3.0]	14.50 [10.0]
ΔJ=1, Δπ =no, even A	1580 [485]	6.10 [6.1]	2.45 [1.1]	3.72[3.0	14.50 [10.0]
ΔJ=1, Δπ =no, odd A	1781 [702]	5.80 [5.9]	2.35 [1.0]	2.56 [3.5]	11.26 [9.1]

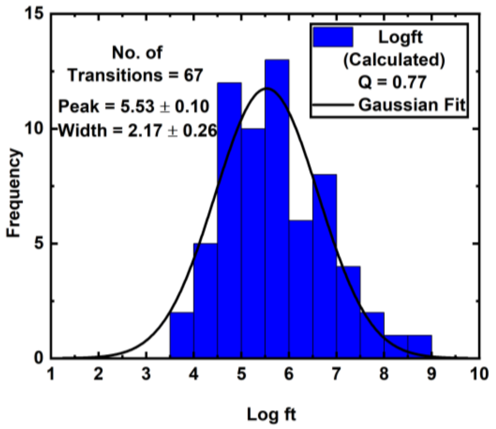

Fig. 1 Theoretical Logft distribution obtained with quenching factor Q=0.77 and bin size=0.3.

The centroid is well reproduced in SM calculation. However, the width is a bit larger in SM results. The number of Logft values at the Logft centroid is smaller in the theoretical result. However, the prediction by SM calculation is reasonable. We are improving upon the theoretical calculations further. We shall present also the statistical analysis of Logft distributions of other categories.

Acknowledgment

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References

[1] B. Singh *et al.*, Nucl. Data Sheets 84, 487 (1998).
[2] B. A. Brown *et al.*, MSU-NSCL report number 1289.
[3] B. A. Brown and W. D. M. Rae, Nuclear Data Sheets 120, 115 (2014).
[4] NNDC | National Nuclear Data Center (bnl.gov)