α- decay half lives of Superheavy nuclei from energy systematics

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Introduction

α-decay is an important decay mode for superheavy nuclei (SHN). New superheavy elements are suitably identified through their α-decay chains. In view of this, α-decay half life becomes an important quantity for the study of SHN. Besides semi classical estimates of this quantity, there are some empirical relations available in literature to calculate α-decay half lives. A suitable empirical formula with minimum number of parameters is essential for this purpose. α-decay half lives mostly depend on the decay energies. In the present work, we have correlated the experimental α-decay half lives with the decay energies. We have adopted a method following the works of Brown [1] and Budaca et al. In fact, [2]. Budaca et al. have modified the Brown fit formula for α-decay half lives

$$\log_{10} T_{1/2} = a\ Z_d^b\ Q_\alpha^{-1/2} + c. \qquad (1)$$

In Brown formula, the parameter b is taken to be 0.6. But Budaca et al. have fitted this parameter from a set of experimental data. In the present work, we have analysed the dependence of the $log_{10}T_{1/2}$ on the exponent parameter b for 81 SHN with Z ranging from 104 to 112 and N ranging from 158 to 166 and obtained that b should be 2/3. Considering this value of b, we have fitted the values of other parameters such as a and c separately for even-even, even-odd, odd-even and odd-odd nuclei. In our fitting procedure, the experimental values of $\log_{10} T_{1/2}$ are taken from Refs.[2, 3].

TABLE I: Calculated parameters for e-e, e-o, o-e, o-o and for all nuclei from Z = 104-112.

Nuclei	a	c	adj. R-square	rms in %
even-even	7.440	-54.823	0.9998	0.26
even-odd	7.102	-51.669	0.99989	0.18
odd-even	6.979	-50.840	0.99125	1.35
odd-odd	6.892	-49.853	0.99994	0.104

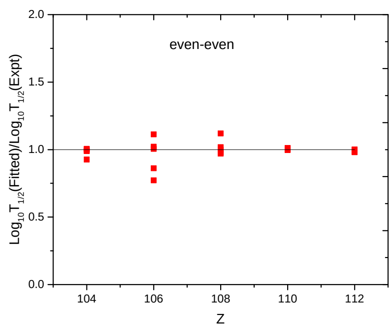

FIG. 1: The ratio $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}}$ plotted against the proton numbesr for even-even nuclei. The straight line represents a best fit to this ratio against Z.

Experimental data fit

In a linear fitting procedure we obtained the parameters a and c for all the four sets

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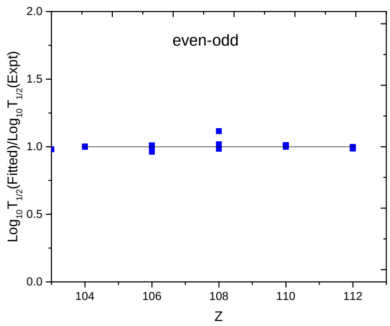

FIG. 2: The ratio $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}}$ plotted against the proton numbers for even-odd nuclei. The straight line represents a best fit to this ratio against Z.

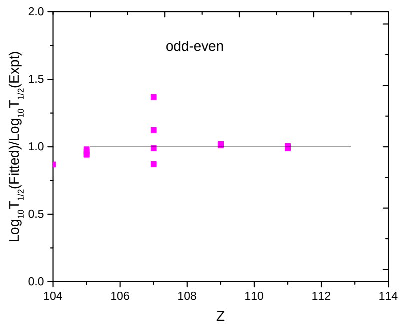

FIG. 3: The ratio $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}}$ plotted against the proton numbers for odd-even nuclei. The straight line represents a best fit to this ratio against Z.

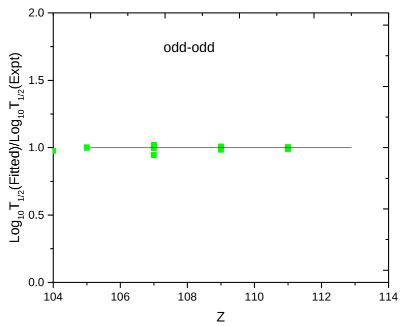

FIG. 4: The ratio $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}}$ plotted against the proton numbers for odd-odd nuclei. The straight line represents a best fit to this ratio against Z.

of nuclei separately. The fits are judged by the respective root mean square (rms) values. The fitted parameters along with the respective rms values are given in Table I.

In order to test the reliability of our fitting, we have compared our predicted values from the newly fitted formulae with the experimental values. In Figures 1, 2, 3 and 4, the ratio $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}}$ have been plotted against the proton numbers of the respectively for even-even, even-odd, odd-even and odd-odd nuclei. A closer agreement with the experimental data is shown by a horizontal line at $\frac{(\log_{10} T_{1/2})_{fitted}}{(\log_{10}(T_{1/2})_{expt.}} = 1$. Data points lying exactly on the horizontal line signifies an exact agreement with experimental data and a departure from this horizontal line signifies the non agreement with the experimental values.

Conclusion

α-decay half lives of 81 super heavy nuclei have been fitted in a Brown fit formula to extract the constant parameters separately for even-even, even-odd, odd-even and odd-odd nuclei. The fitting shows an excellent agreement with the experimental values. However departure from exact fitting occurs at $Z = 106$ for even-even nuclei and $Z = 107$ for odd-even nuclei. For odd-odd and even-odd nuclei, the fitted values match well with the experimental values.

References

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