A Modified Semi Empirical Formula for α Decay Half-lives of Transactinide Elements. (Z=104 to Z=118)

R. Heera Shree[1],* S. Mahadevan[1]
[1]*Department of Sciences, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, Amrita University, India*

*Email:heerashree1996@yahoo.in

Abstract

Around 160 isotopes of Transactinide Elements (Z=104 to Z=118) which are all in the Super Heavy Elements (SHE) category was included in the computation of α decay half-life using a modified Semi Empirical formula. The modification was done in the Semi Empirical formula suggested by G Royer and H F Zhang [1] for the calculation of α decay half-life. The Q_α values used are the experimental Q-values for α decay. The formula thus developed could reasonably reproduce the experimental log $T_{1/2}$ values of α decay.

Introduction

The production, identification and study of Super Heavy Elements (SHE) have become so exciting field in Nuclear Physics. It has been possible to synthesize nuclei up to Z=118 in the laboratory. There are several methods [1], [2], [3], [4], [5] for calculating α decay half-life and Q-values. Many empirical relationships which connect α decay half-life to Q, Z and A were proposed [1], [4]. In this work, the Semi Empirical formula developed by G Royer and H F Zhang [1] for the calculation of α decay half-life is modified after analyzing for 160 systems.

Formula

Modified formula that is used in the present work is given as

For even Z even N:

$$\log_{10} T_{\frac{1}{2}} = -37.8791-0.4203A^{\frac{1}{6}}\sqrt{Z} + \frac{1.36215Z}{\sqrt{(Q_\alpha)}}$$

For even Z odd N:

$$\log_{10} T_{\frac{1}{2}} = -19.0782-1.1251A^{\frac{1}{6}}\sqrt{Z} + \frac{1.3891Z}{\sqrt{(Q_\alpha)}}$$

For odd Z even N:

$$\log_{10} T_{\frac{1}{2}} = -13.2832-1.1439A^{\frac{1}{6}}\sqrt{Z} + \frac{1.2555Z}{\sqrt{(Q_\alpha)}}$$

For odd Z odd N:

$$\log_{10} T_{\frac{1}{2}} = 0.4304-1.8552A^{\frac{1}{6}}\sqrt{Z} + \frac{1.4080Z}{\sqrt{(Q_\alpha)}}$$

were Z is Atomic Number, A is Mass Number and Qα is experimental Q-value for α decay.

The Q-value used in this work is obtained from the NNDC website [6].

Results:

The results for 27 systems are represented in Fig. 1-4. Most of the results are found to be in good agreement with experimental values of log $T_{1/2}$ of α decay.

Fig. 1 Comparison of log $T_{1/2}$ values obtained using modified semi empirical formula and experiment for even Z even N:

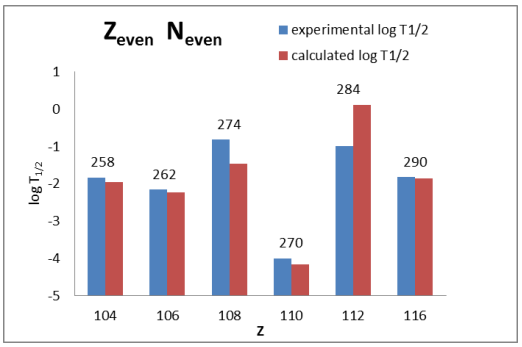


Fig. 2 Comparison of log $T_{1/2}$ values obtained using modified semi empirical formula and experiment for even Z odd N:

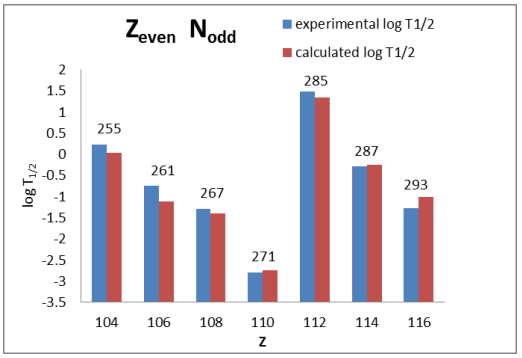


Fig. 3 Comparison of log $T_{1/2}$ values obtained using modified semi empirical formula and experiment for odd Z even N:

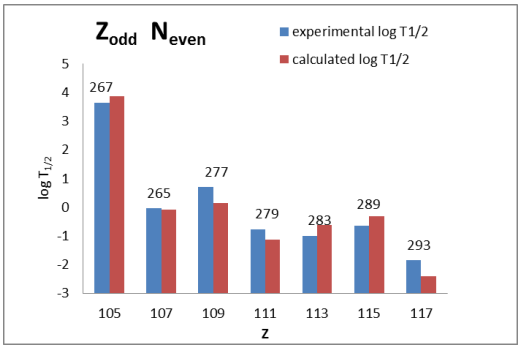
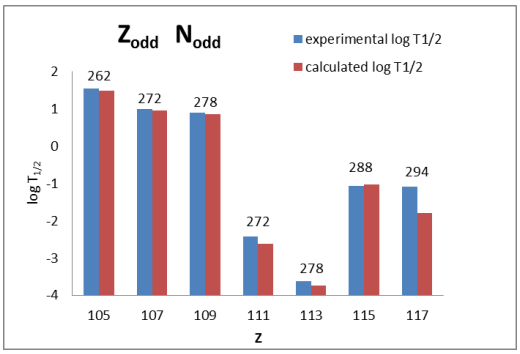


Fig. 4 Comparison of log $T_{1/2}$ values obtained using modified semi empirical formula and experiment for odd Z odd N:



References

[1] **G. Royer and H. F. Zhang**. "Recent α-decay half-lives and analytical expression predictions including super heavy nuclei". *Phys. Rev. C*, 77(037602), 2008.

[2] P. Prema, **S. Mahadevan**, C. S. Shastry, A. Bhagawat, Y. K. Gambhir, *Study of Alpha Decay of Super heavy elements using S-Matrix and WKB methods*, International Journal of Modern Physics E, Vol. 17, No. 4, (2008), pp.611-629.

[3] **S. Mahadevan,** P. Prema, C. S. Shastry and Y. K. Gambhir, *Comparative Study of Half width Calculations using S-Matrix and WKB methods.* Phys. Rev. C, Vol.74 (2006), 57601-1-4.

[4] V. E.Viola and G. T. Seaborg. "Nuclear systematics of the heavy elements II, lifetimes of alpha, beta and spontaneous fission decay". J.Inorg.Nucl.Chem., 28:741,1966

[5] Basudeb Sahu. "Analytical Expression for the α decay half-life and understanding the data including very long life-times and super heavy nuclei" *Phys. Rev, C*, 78(044608), 2008.

[6] https://www.nndc.bnl.gov