# Theoretical studies on the alpha decay chains of even- odd isotopes of Z=119 nuclei

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## Introduction

There has been significant progress in the experimental and theoretical studies of superheavy nuclei. Elements up to Z = 118 has been synthesized using advanced experimental techniques. Synthesis of superheavy elements takes place through two types of fusion reactions, namely hot and cold fusion reactions. In laboratories, attempts to synthesize isotopes Z = 119 and 120 are in progress. The possibility of the formation of the superheavy nucleus $^{299}119$ was brought out by Zagrebaev et al. [1] where they studied the decay properties, namely, α, β, and spontaneous fission

In the present paper, the α-decay chains of various even-odd isotopes of Z = 119 in the mass range 284 ≤ A ≤ 300 have been studied using different mass tables [2-5].

## Theory

In this paper, we have chosen five different mass tables [2-5], which have already been proved to be the best choices for calculating the decay energies in superheavy region. We have used the equation,

$$Q_{gs\to gs} = \Delta M_p - (\Delta M_\alpha + \Delta M_d) + k(Z_p^\varepsilon - Z_d^\varepsilon) \quad (1)$$

Here ΔMp, ΔMd, and ΔMα represent the mass excess of the parent, daughter, and the α particle respectively. For obtaining the mass excess values we have used the mass tables of Koura et al. (KTUY) [2], Hartree-Fock-BSC model (HFBCS) [3], finite range droplet model (FRDM) [4], WS3 and the Weizsäcker-Skyrme formulas with radial basis function (WS3+RBF) [5]. The *Q* value must be positive for α decay to occur.

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Here, FRDM is a macroscopic-microscopic model and HFBCS is a pure microscopic model. The half-lives are calculated for all the *Q* values obtained with different mass tables using the analytical formula of Royer [6], the universal curve (UNIV) [7], and the Viola-Seaborg semiempirical formula (VSS) relationship [8].

## Results & Discussion

An extensive study on the possibilities of α decay from the even-odd isotopes of the superheavy element Z = 119 in the range 284 ≤ A ≤ 300 has been performed using different mass models and different empirical formulas. The calculation of *Q* value plays an important role in the correct estimation of decay half-lives. For calculating the *Q* values, different mass tables are available. The electron screening effect has been included in Eq. (1) by the term $k(Z_P^\varepsilon - Z_d^\varepsilon)$ which represents the correction, where k = 8.7 eV and ε = 2.517 for nuclei with Z ≥ 60. Half-lives are sensitive to decay energies. The α-decay half-lives of the above isotopes of Z = 119 has been calculated using the analytical formula of Royer [6], the universal curve (UNIV) [7], and the Viola-Seaborg semiempirical formula (VSS) [8].

The details of the results obtained in the case of two isotopes namely $^{284}119$ and $^{294}119$ are plotted in graph. We have plotted the *Q* value computed using different mass tables versus mass number for these two isotopes and is shown in Fig. 1. The difference in the *Q* value using different mass tables is evident from the plot. There have been many theoretical studies demonstrating the sensitivity of *Q* value to the mass model. The plot indicates a discrepancy in *Q* values as we move towards heavier region. Previous studies shows that the discrepancy between the experimental and the calculated *Q* value is minimum while using the Hartree-Fock-BCS (HFBCS) mass model, hence we have

represented the values of half-lives with the *Q* values computed using HFBCS in Fig. 2 for the selected isotopes $^{284}119$ and $^{294}119$. A detailed study of alpha decay chains of all possible even-odd isotopes of Z = 119 have performed by us, but only a small part of our work is presented in this paper.

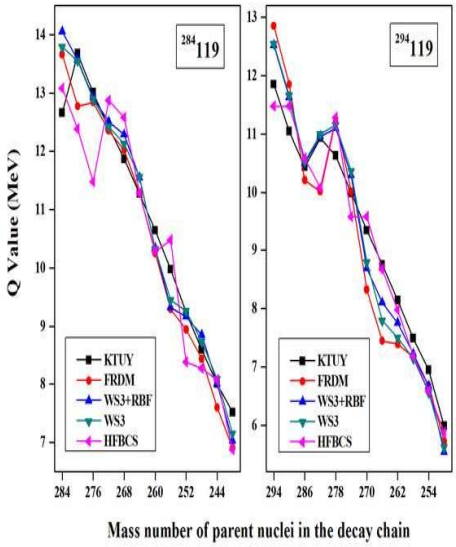


**Fig. 1** Comparison of calculated *Q* values using five different mass models for the isotopes in the decay chain of $^{284, 294}119$.

## Conclusion

The α-decay properties of the even-odd isotopes of Z = 119 in the mass range 284 ≤ A ≤ 300 are extensively studied. The *Q* values of the isotopes in the decay chain are calculated using five different mass models, including FRDM, KTUY, HFBCS, WS3 and WS3+RBF.

The discrepancies in the calculation of *Q* value using different mass models are evident from the paper. Models of same nature will give the same trend in the predictions of the *Q* value. For a theoretical comparison of half-lives, we have calculated the same using the analytical formula of Royer, the universal curve (UNIV), and the Viola-Seaborg semiempirical (VSS) relationship. We hope that our studies will be helpful in the future experimental investigations for the isotopes of Z = 119.

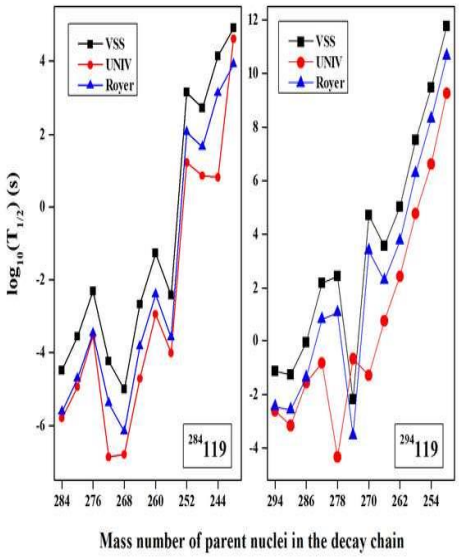


**Fig. 2** Comparison of $\alpha$ decay half-lives evaluated with the *Q* values using five different mass models for the isotopes in the decay chain of $^{284, 294}119$.

## References


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