Q-alpha values in Superheavy elements using Relativistic mean field model

R. N. Panda[1],* B. K. Sahu[2], Mahesh K. Sharma[3], and S. K. Patra[4]
[1]*Department of Physics, ITER, Siksha O Anusandhan University, Bhubaneswar-751 030, India*
[2] *Manikeswari College, Garh Tumulia, Sundargarh-770 024, India.*
[3]*School of Physics and Materials Science,*
Thapar University, Patiala - 147 001, India and
[4]*Institute of Physics, Sachivalaya Marg, Bhubaneswar-751 005, India.*

I. INTRODUCTION

The development of nuclear models are essential tools for the study of nuclear properties of all nuclei including the shortest-lived species in the nuclear chart. The Relativistic Mean Field (RMF) model is one of the leading model, which can be used to study the bulk properties as well the half-lives of different nuclei.

In complete fusion reaction experiments superheavy elements (SHE) with Z = 112-118 and their daughter isotopes have been produced [1]. The decay properties of these elements revealed a significant enhancement in their stability against decay. In this regard alpha decay is one of the important decay mode of these elements. Many of the known superheavy nuclei decay on this mode and properties of this decay identify the decaying nuclei. Nuclei beyond Z = 114, decay by a sequence of alpha particle emissions [2]. The α particles are emitted from the ground/excited state of a newly formed superheavy elements as half-lives of γ decay of low-lying excited states are less than the α-decay half-lives of corresponding levels. Q_α values are the main factors in determining the half-life in particular for the search of new elements. The Q_α energy is obtained from the masses of the respective nuclei.

In the present contribution, first we calculate the structural properties, such as binding energy (BE), root mean square charge radius r_{ch}, matter radius r_m and quadrupole deformation parameter β_2 for few SHE with Z = 109-119 in RMF formalism . Then we have compared the alpha-decay properties of these nuclei with other theoretical prediction and experimental data.

*Electronic address: `rnpanda@iopb.res.in`

II. THEORETICAL FRAMEWORK

The successful applications of Relativistic Mean Field (RMF) formalism both in finite and infinite nuclear systems make more popular of the formalism in the present decades. The use of RMF are well documented and details can be found in Ref. [3, 4]. The energy released in an α decay of a nucleus with Z protons and N neutrons is given by

$$Q_\alpha = BE(Z,N) - BE(Z-2,N-2) - BE(2,2) \quad (1)$$

Where BE(Z, N) is the binding energy of the parent nucleus, BE(Z-2, N-2) is the binding energy of the daughter nucleus after the emission of an α particle and BE(2, 2) is the binding energy of the α particle(^4He).

III. RESULT AND DISCUSSION

First we calculate the bulk properties, such as binding energy (BE), root mean square charge radius r_{ch}, matter radius r_m and quadrupole deformation parameter β_2 for the Z= 109-119 isotopes with the RMF formalism using NL3* parameter set.

TABLE I: Binding energy (BE), charge radius (r_{ch}), quadrupole deformation parameter β_2 and Q_α values obtained from RMF(NL3*) formalism. The BE and Q_α are in MeV and charge radius in fm.

A	Z	BE	r_{ch}	β_2	Q_α
277	109	2007.2	6.272	0.406	9.15
279	110	2019.3	6.295	0.366	9.6
281	111	2027.1	6.347	0.423	9.38
283	112	2035.8	6.322	0.354	10.08
285	113	2047.5	6.364	0.448	9.91
287	114	2054.9	6.332	0.287	11.32
289	115	2065.0	6.264	0.492	10.79
291	116	2073.9	6.354	0.266	10.03
293	117	2085.3	6.396	0.49	10.74
295	118	2091.6	6.376	0.259	10.85
297	119	2098.5	6.346	0.410	11.02

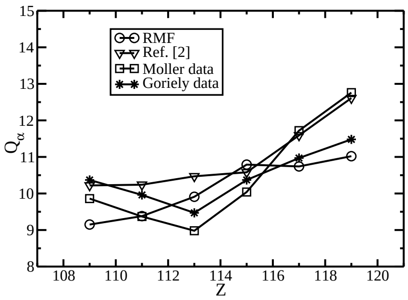

FIG. 1: Comparison of Q$_\alpha$ (in MeV) values with other predictions and data.

The results of our calculations are presented in TABLE I. Then we estimated Q_α for all these isotopes using the BE values. Our predicted results are compared with Ref. [2], Möller data [5] and Goriely data [6] which are shown in Fig.1. From the figure, we observe that the Q_α obtained from RMF(NL3*) formalism are comparable with the results of other calculations Ref. [2] and experimental data [5, 6]. A further inspection of the results suggest that, the present results have some scope to improve. This refinement can be done by imposing a better pairing scheme as well as the insertion of Pauli blocking etc. in the calculations.

IV. SUMMARY AND CONCLUSION

In summary, the bulk properties like BE, r_{ch} and β_2 for Z = 109-119 isotopes have been calculated using the RMF (NL3*) formalism and also investigated Q_α for these considered isotopes. We found that our results are comparable with other calculations as well as available data. Further investigation for more isotopes in heavy mass region may provide better description regarding a detail analysis.

References

[1] Yu. Ts. Oganessian et al., *Phys. Rev. C* **79**, 024603 (2009).

[2] P. Jachimowicz, M. Kowal and J. Skalski, *Phys. Rev. C* **89**, 024304 (2014)

[3] S. K. Patra and C. R. Praharaj, *Phys. Rev. C* **44**, 2552 (1991).

[4] R. J. Furnstahl, B. D. Serot, and H. B. Tang, *Nucl. Phys. A* **615**, 441 (1997).

[5] P. Möller, J. R. Nix, W. D. Myers and W. J. Swiatcki, *At. Data Nucl. Data Tables* **59**, 185 (1995).

[6] S. Goriely, N. Chamel and J. M. Pearson, *Phys. Rev. C* **82**, 035804 (2010).