The $\alpha-$decay properties of ^{296,298,300,302,304}120 using relativistic mean field formalism.

A. S. Pradeep[1*] and M. Bhuyan[2,3†]

[1] *Department of Physics, Hyderabad Institute of Technology and Management, Hyderabad, Telangana, 502401, India*
[2] *Department of Physics, Faculty of Science, University of Malaya, Kuala Lumpur, 50603, Malaysia and*
[3] *Institute of Research and Development, Duy Tan University, Da Nang 550000, Vietnam*

Introductions: The efforts to synthesize new elements and examine its structural properties have been going on with the support of self-consistent microscopic theoretical models. In general, a superheavy element predominantly undergoes sequential α-decay(s) and bears a great chance to test different nuclear phenomena. The self-consistent Hartree-Fock or Hartree calculations based on Skyrme, Gogny and non-linear relativistic mean field model with all possible mesons interactions has been proved to be successful theoretical frameworks to predict the structural properties of exotic nuclei including superheavy. At variance with the non-relativistic, and relativistic mean field model with various conventional parameter sets typically predicted Z = 120 with N = 182 (184), as the possible candidates for spherical shell closures in the island of superheavy nuclei [1] and references therein. Great success has been achieved during the last two decades in the experimental synthesis of superheavy nuclei (SHN) identified through the $\alpha-$decay chains. Up to now the dominant decay modes of SHN are $\alpha-$decay by following spontaneous fission [2]. The prime objective is to study the possible decay chains of ^{296,298,300,302,304}120 using axially deformed relativistic mean-field (RMF) formalism for NL3 and NL3* parameter sets.

Theoretical Framework The relativistic mean field model is one of the microscopic approaches to solve the many body problem through the interacting meson fields. The model predicts ground and intrinsic excited states structural properties of finite nuclei throughout the the nuclear landscape. The details of the RMF model and their parametrizations can be found in Ref. [3, 4] and references therein. The relativistic mean-field equations are solved self-consistently by taking different inputs of the initial deformation. The BCS pairing approach is adopted to account the pairing correlation to deal the open shell nuclei. To get the convergence of the ground state solutions, calculations are performed for $N_F = N_B = 18$. The number of mesh points for Gauss-Hermite and Gauss-Lagurre integration are 20 and 24, respectively are used in the present calculations.

Results and Discussions: The Q_α energy is obtained from the relation [5]: Q_α (N, Z) = BE (N, Z) - BE (N-2, Z-2) - BE (2, 2). Here, BE (N, Z) is the binding energy of the parent nucleus with neutron number N and proton number Z, BEv(2, 2) is the binding energy of the $\alpha-$ particle (^{4}He), i.e., 28.296 MeV, and BE (N-2, Z-2) is the binding energy of the daughter nucleus after the emission of an $\alpha-$particle. The binding energies of the parent and daughter nuclei are obtained from the RMF formalism for NL3 and NL3* parameter sets. From these BE, we evaluate the Q_α energy, which further used to obtain the respective half-lives (T_α). Here we have used various decay formulas for a few selective chains, $^{296}120 \rightarrow {}^{252}$Cf, $^{298}120 \rightarrow {}^{254}$Cf, $^{300}120 \rightarrow {}^{256}$Cf, $^{302}120 \rightarrow {}^{258}$Cf, and $^{304}120 \rightarrow {}^{260}$Cf. In the Fig. 1, we have shown the obtained

*Electronic address: `draspradeep@gmail.com`
†Electronic address: `bunuphy@um.edu.my`

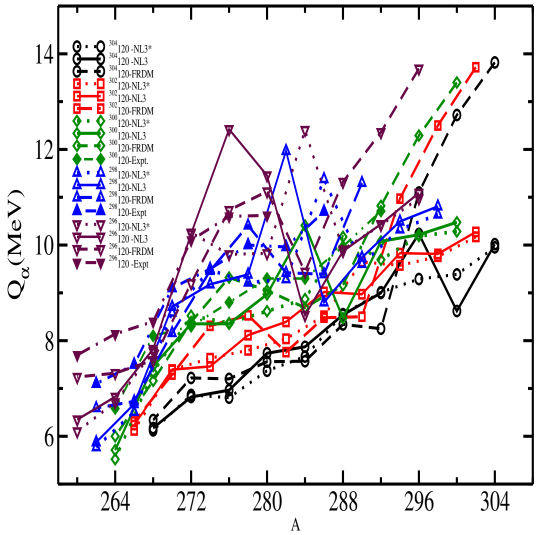

FIG. 1: The RMF (NL3 and NL3*) Q_α energy for $^{296}120 \rightarrow {}^{252}$Cf, $^{298}120 \rightarrow {}^{254}$Cf, $^{300}120 \rightarrow {}^{256}$Cf, $^{302}120 \rightarrow {}^{258}$Cf, and $^{304}120 \rightarrow {}^{260}$Cf along with the FRDM [5], and the experimental data [6], wherever available.

Q_α values for NL3 and NL3* parameter sets compare with the macroscopic-microscopic finite range droplet model (FRDM) predictions [5] and experimental data [6], wherever available. From the figure, one can notice that all the results from NL3 and NL3* parameter sets are almost very close values with the available experimental data and FRDM predictions except a few nuclei. Although a small difference in the Q_α values among the experimental and calculated values, the half-life $T_\alpha^{1/2}$ are obtained by using the Q_α values for NL3 and NL3* parameter sets differ significantly from the experimental data. In this context, we have used various half-life $T_\alpha^{1/2}$ formulas to obtain the $T_\alpha^{1/2}$ for $^{296}120 \rightarrow {}^{252}$Cf, $^{298}120 \rightarrow {}^{254}$Cf, $^{300}120 \rightarrow {}^{256}$Cf, $^{302}120 \rightarrow {}^{258}$Cf, and $^{304}120 \rightarrow {}^{260}$Cf and establish possible correlations.

Acknowledgments: This work has been supported by FAPESP Project Nos.(2014/26195-5 & 2017/05660-0),INCT-FNA Project No. 464898/2014-5, the 973 Program of China (Grant No. 2013CB834400), the Chinese Academy of Sciences (Grant No. KJCX2-EW-N01), and by the CNPq-Brasil.

References

[1] M. Bhuyan and S. K. Patra, Mod. Phys. Lett. A **27**, 1250173 (2012).

[2] Yu. Ts. Oganessian, Nucl. Phys. News 23, 15 (2013).

[3] B. D. Serot and J. D. Walecka, Adv. Nucl. Phys. **16**, 1 (1986).

[4] M. Dutra *et al.*, Phys. Rev. C **90**, 055203 (2014).

[5] P. Mõller *et al.*, At. Data Nucl. Data Tables **59**, 185 (1995); ibid. **66**, 131 (1997).

[6] G. Audi *et al.*, Nucl. Phys. A **729**, 337 (2003)