Decay properties of ^{243}Fm using relativistic mean field approach

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Introduction

The rise in atomic number (Z) of a nucleus by every single unit assemble it unstable against the fission [1]. This is the reason that high Z value has lower life-time than that of smaller Z one. Mostly, α-particles are released from the ground state of formed superheavy elements (SHE) because γ-decay has shorter life-time than the α-decay. That's why the SHEs generally decay through α-emission and called as α-emitters, during this decay process some of the known nuclei are formed whereas few unknown nuclei are also noticed. The super-heavy elements can be synthesized mainly by two methods : cold fusion and hot fusion reactions [2]. For SHE, the probability of getting magic or doubly magic isotopes intensify the stability region. Different experimental efforts are taken in various laboratories in Darmstadt (GSI), Berkeley and Dubna for synthesis of larger Z-nuclei. The α-decays study give a detail idea of nuclear structure such as ground state energies, half-lives, nuclear spin-parities, shell effects, nuclear deformation and shape co-existence [3] of various synthesized nuclei.

We have studied the alpha decay properties such as α-decay energy and its corresponding decay half-life for ^{243}Fm decay chain within the framework of Relativistic Hartree Bogoliubov model with density-dependent DD-ME2 parameter set. We have taken Viola-Seaborg, Royer and Universal decay law formulae for half-life calculations from the estimated Q-values. All our calculated results are compared with the finite range droplet model results and experimental data.

1. Theoretical Formalism

The three different formulae as Viola-Seaborg [4], Royer [5] and universal decay law (UDL) [6] for half-life calculations are respectively

$$log_{10}T^{\alpha}_{1/2}(VS) = (aZ+b)\frac{1}{\sqrt{Q}}+cZ+d+hlog\ , \quad (1)$$

$$log_{10}T^{\alpha}_{1/2}(R) = a + bA^{1/6}\sqrt{Z} + \frac{cZ}{\sqrt{Q}}\ , \quad (2)$$

$$log_{10}T^{\alpha}_{1/2}(UDL) = aZ_dZ_\alpha\sqrt{\frac{A}{Q_\alpha}} + b\sqrt{AZ_dZ_\alpha(A_d^{1/3}+A_\alpha^{1/3})} + c, \quad (3)$$

where a, b, c,d and hlog are constants.

2. Result and Discussions

We have analysed the decay energy and half-lives for ^{243}Fm-decay chain using Relativistic Hartree Bogoliubov (RHB) model with DD-ME2 parameter [7] and these values are compared with FRDM results [8] and experimental data [9]. The $T_{1/2}$ are evaluated using above three formulae shown in Fig. 1 and calculated Q-values are determined from the binding energy of parent and daughter nuclei given in Table I. Our Q-values give a minute difference with FRDM results and the experimental data. From Fig. 1, maximum half-life is noticed at A=231(Z=94, N=137) signifying it to be shell-closure nucleus and minimum

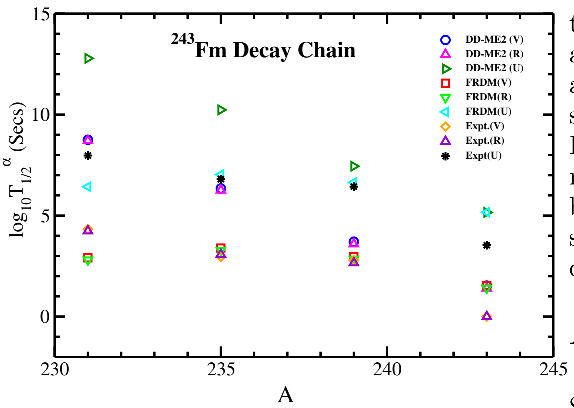

FIG. 1: $T_{1/2}$ values for ^{243}Fm-decay chain using RHB(DD-ME2) compared with FRDM results and experimental data.

half-life has seen at A=243(Z=100, N=143) indicating that it is shell stabilised. Among three formula that we have taken into our consideration, Royer formula give minimum and UDL produce maximum half-lives for this decay chain and consistent with FRDM predictions and experimental data.

TABLE I: The Q_α values for ^{243}Fm-decay chain for DD-ME2 parameter which is compared with FRDM results and experimental data.

Nucleus	Q_α (in MeV)		
	DD-ME2	FRDM	EXPT.
^{243}Fm	8.429	8.246	8.717
^{239}Cf	7.418	7.616	7.668
^{235}Cm	6.574	7.286	7.340
^{231}Pu	5.881	7.196	6.839

3. Conclusion

We have calculated the Q-values and half-life for ^{243}Fm-decay chain using RHB(DD-ME2) and compared with FRDM predictions and experimental data. The decay energy study show a small difference between our results and the compared ones. It is noticed that maximum and minimum half-lives found at ^{231}Pu and ^{243}Fm which manifest that they are shell-closure and shell-stabilised nuclei respectively. We got minimum half-life using Royer formula and maximum using UDL formula. The details study including more number of decay chains like ^{245}Fm and ^{247}Fm with some other parameter sets will be communicated shortly to any referred journals.

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