Theoretical prediction of α-decay chains of $^{298,299}120$ superheavy nuclei

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Introduction

Recent progress on superheavy elements has attracted both theoreticians and experimentalists in nuclear physics.Among the newly discovered superheavy elements,there was an attempt to produce element Z=120 in the $^{244}Pu + {}^{58}Fe$ reaction by Oganessian *etal.* in Dubna[1].The successful experiments lead to the identification of new superheavy nuclei(SHN) along with their α-decay chains and half life time. Moreover,the main and the often observed decay mode of heavy system is α-emissions and end up with spontaneous fissions.Therefore,α-decay and spontaneous fission are to be considered as the experimental signatures of SHN and theoretical description is needed in characterizing the isotopes in superheavy region.

So,In this paper we report the α-decay and spontaneous fission of $^{298,299}120$ isotopes within Covariant density functional theory(CDFT) and relativistic mean field (RMF) theory for axially symmetric configuration.Moreover,we have calculated the ground state properties like the BE,rms radius,charge radius etc of the decay chains of $^{298,299}120$ isotopes which, we will be presenting in the workshop.

The Q_α Energy and the decay half-live T_α.

In our present work, α-decay half lives of $^{298,299}120$ isotopes are studied using the new improved self-consistent relativistic mean-field models, namely, a constrained relativistic mean-field (RMF) model[2] using the non-

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linear meson-nucleon interaction (NL3*) with BCS pairing, and the covariant density functional models[3]: the density- dependent meson-exchange model (DD-ME), and a density dependent point-coupling model (DD-PC). These calculations are done in axially symmetric configuration. Treatment of the pairing correlations have been taken care of as given in Refs.[2, 3] for respective models.

The Q_α energy and the half-life time are obtained from the relation given in Refs [4] To identify the mode of the isotopes under study,calculations on spontaneous fission(SF) half-lives of the corresponding nuclei have been performed in present paper.The relation used to calculate SF half-lives is given by Xu *et al.*[5].Moreover, On comparing the α-decay half lives with the spontaneous fission half lives, the mode of decay of the isotopes can be predicted, as the isotopes with smaller α-decay half-lives than spontaneous fission half-lives survive fission.
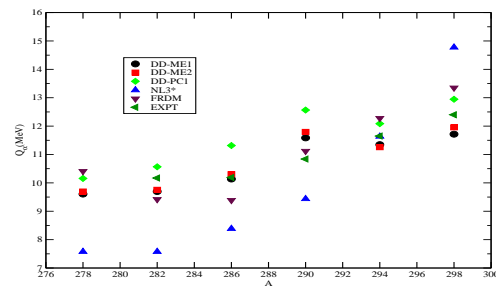

FIG. 1: Q_α values of $^{298}120$.

The α-decay series of $^{298}120$ nucleus

We present the nucleus $^{298}120$(N=178) for illustrating our calculations of the α-decay chain and the half-life time $T^\alpha{}_{1/2}$ using the above procedure.The calculated Q_α values and the $T^\alpha{}_{1/2}$ are shown in Fig.1 and Fig.2.
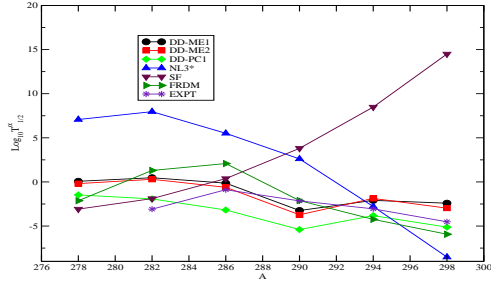
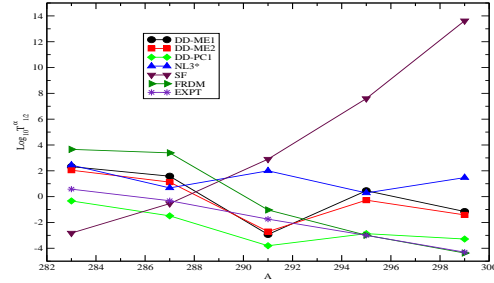FIG. 2: $T^{\alpha}_{1/2}$ values of $^{298}120$

FIG. 4: $T^{\alpha}_{1/2}$ values of $^{299}120$.

respectively. Our predicted results for both Q_{α} and T_{α} for the decay chain of $^{298}120$ are compared with the FRDM calculations as well as with the experimental result available[1]. we notice that the calculated values for both Q_{α} and T_{α} agree fairly well with the FRDM predictions,as well as with the other experimental results available.

We observe four α chains in case of DD-ME1 and DD-ME2 interaction, three α chains in case of FRDM and NL3*, and five α chains in case of DD-PC1 interaction from $^{298}120$. In the cases of $^{298}120$ the experimental Q_{α} values were available only up to the decay products of $^{286}114$,In Figs. 2 , we have plotted the α-decay half-lives evaluated by using these experimental Q_{α} values up to these decay products. The α-decay half-lives plotted for the remaining decay products have been evaluated by using the Q_{α} values that were calculated by using the mass excess values taken from Refs.[6, 7].
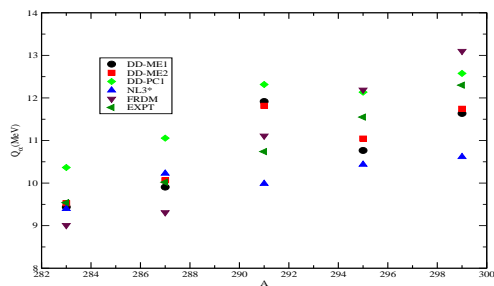
The α-decay series of $^{299}120$ nucleus

We present the nucleus $^{299}120$(N=179) for illustrating our calculations of the α-decay chain and the half-life time $T^{\alpha}_{1/2}$ using the same procedure.The calculated Q_{α} values and $T^{\alpha}_{1/2}$ are shown in Fig.3 and Fig.4. Our predicted results for both Q_{α} and T_{α} for the decay chain of $^{299}120$ are compared with the FRDM calculations as well as with the experimental result available[1].

we observe three α chains in case of DD-ME1,DD-ME2,NL3* and FRDM and four α chains in case of DD-PC1 interaction from $^{299}120$.The α-decay half-lives plotted for the remaining decay products have been evaluated by using the Q_{α} values that were calculated by using the mass excess values taken from Refs.[6, 7].

FIG. 3: Q_{α} values of $^{299}120$.

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