The evaporation residue of $^{112-134}$Ba within relativistic mean field theory

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The phenomenon of nuclear fission was discovered about 75s year back, still many crucial features of its dynamics are yet to be explained. The exploration is possible when one can view such aspects from the microscopic theoretical point of view. Usually, the common methods used in such investigations are non-relativistic and relativistic self-consistent mean-eld theories. These theories are capable for finding the static fission path through entire potential energy landscape spanned over relevant degrees of freedom [1–3]. The extension of these model calculations for unstable nuclei up to the drip lines is still a challenge. We then choose the relativistic mean theory (RMF) to explore the origin of neck configuration, assumed to be preformed clusters in the fission state, i.e., the formation of elongated neck in the fission state of a nucleus.

First of all, we have presented the gross nuclear properties, like the binding energy, deformation parameter β_2, charge radius r_{ch} and the nucleonic density distributions for the isotopic chain $^{112-134}$Ba, using an axially deformed RMF theory with NL3 parameter set. We found prolate deformed ground-state solutions for Ba isotopes, which are consistent with the experimental data [4]. Analyzing the nuclear density distributions, the neck structure, i.e., the fission states of Ba-isotopes are identified. The effect of pairing from both constant gap ($\Delta_{n,p}$ and constant strength (G) approximations on the neck structure are also determined. Here, we have shown the neck structure of the fission state of ^{112,134}Ba in axially deformed coordinates for RMF (NL3) (*with and without pairing*) along with the color code with density ranges in Fig. 1.

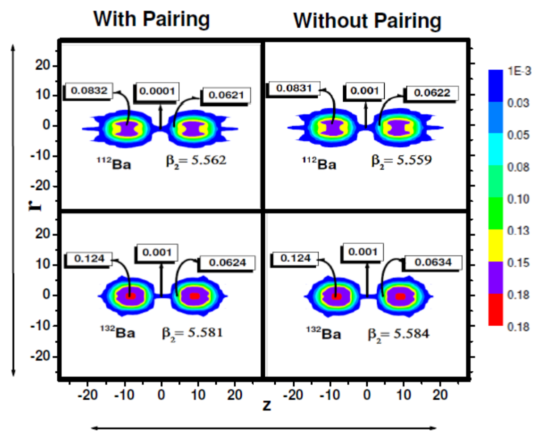

FIG. 1: The fission state of ^{112,134}Ba in RMF (NL3) for with and without pairing

The essential part of this study to resolve the ingredients of the neck region, which plays a key role in the fission process. We find that the neck of Ba-isotopes are built up of ^{4}He nuclei, which can be taken as the evaporation residue of their decay process [4]. Few of the results are given in Table-I. Experimentally, the evaporation residue of a decaying compound system consist of multiple neutrons, protons and α-particle. It will be interesting to measure the constituents of evaporation residues of hot Ba-isotopes formed in heavy-ion reactions.

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TABLE I: The RMF(NL3) results for neck configurations of $^{112-122}$Ba in the fission state giving the ranges of the neck and their Z and N constituents [4].

Nucleus	β_2	Range (r_1,r_2; z_1,z_2)	Z_{neck}	N_{neck}	Neck Nucleus
^{112}Ba	5.562	(±2.28; ±1.25)	2.07	1.91	^{4}He
^{114}Ba	5.561	(±2.28; ±1.25)	2.04	2.95	^{4}He
^{116}Ba	5.564	(±2.27; ±1.25)	2.05	2.03	^{4}He
^{118}Ba	5.564	(±2.27; ±1.26)	2.06	2.13	^{4}He
^{120}Ba	5.574	(±2.26; ±1.26)	2.08	2.08	^{4}He
^{122}Ba	5.575	(±2.26; ±1.26)	2.05	2.18	^{4}He

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