Superdeformation in Z = 120 superheavy nuclei

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Introduction

Significant progress has been made in the discovery of new superheavy nuclei in the last decade. Superheavy nuclei at the extreme end of the periodic table have been synthesized in the laboratory. The stability of nuclei in superheavy mass region came into existence when the extensive shell correction calculations were added to the liquid drop binding energy [1]. As it well known there was no existence of stable nuclides for Z ≥100 by the liquid drop model because of large coulomb repulsion. Various mocroscopic approachs such as non-relativistic density-dependent Skyrme Hartree-Fock (SHF) theory and that of MM type are used extensively to investigate the properties and structure of superheavy nuclei. In spite of impressive agreement with experimental data for the heaviest elements the theoretical uncertainties are large when extrapolating to unknown regions of the nuclear chart. Since in these nuclei the single-particle level density is relatively large, small shifting of single-particle levels can be crucial for determining the shell stability of a nucleus. So there is a need to design the new experiments with exotic radioactive beams to solve the problem of locating the precise island of stability.

Relativistic mean field (RMF) formalism

The relativistic Lagrangian density for a nucleon-meson many body system is expressed as [2],

$$\begin{aligned}\mathcal{L} &= \bar{\psi}_i\{i\gamma^\mu\partial_\mu - M\}\psi_i + \frac{1}{2}\partial^\mu\sigma\partial_\mu\sigma - \frac{1}{2}m_\sigma^2\sigma^2 \\ &- \frac{1}{3}g_2\sigma^3 - \frac{1}{4}g_3\sigma^4 - g_s\bar{\psi}_i\psi_i\sigma - \frac{1}{4}\Omega^{\mu\nu}\Omega_{\mu\nu} \\ &+ \frac{1}{2}m_w^2V^\mu V_\mu - g_w\bar{\psi}_i\gamma^\mu\psi_iV_\mu - \frac{1}{4}\vec{B}^{\mu\nu}\vec{B}_{\mu\nu} \\ &+ \frac{1}{2}m_\rho^2\vec{R}^\mu\vec{R}_\mu - \frac{1}{4}F^{\mu\nu}F_{\mu\nu} - g_\rho\bar{\psi}_i\gamma^\mu\vec{\tau}\psi_i\vec{R}^\mu \\ &- e\bar{\psi}_i\gamma^\mu\frac{(1-\tau_{3i})}{2}\psi_iA_\mu.\end{aligned}$$

We use the recently reported well known NL3* parameter set.

Results and discussion

We choose the range of mass number from A = 280 to 320 for including the neutron magic number N = 172 and 184 predicted in RMF formalism for superheavy region. The BE/A in RMF calculation are over-estimates the FRDM results by a constant factor. From the binding energy point of view, ^{296}120 and ^{298}120 are found to be most stable isotopes in this isotopic chain. The S_{2n} coincide remarkable well with FRDM except at mass A = 316 which may be due to some error in FRDM. The Fig. 2 reveals that the S_{2n} values decreases gradually with increase of neutron number, except for the noticeable kinks at A = 286 (N = 166) and 312 (N = 192) in RMF and no such behavior in FRDM. It is expressed from Fig. 3(b) in RMF results, we find highly deformed prolate solutions in the g.s. configuration for most of the isotopes near to high mass region which are strongly differ from the FRDM results.

Summary

It is conclude that the binding energy using RMF model are in good agreement with most reliable FRDM results and we observed most

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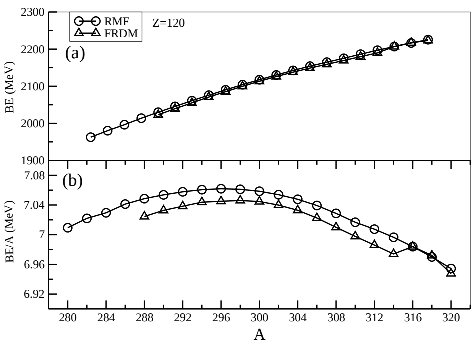

FIG. 1: (a) Total binding energy for $^{280-320}120$ nuclei in RMF and FRDM calculations. (b) BE/A for the superheavy isotopes $^{280-320}120$ obtained in both formalism.

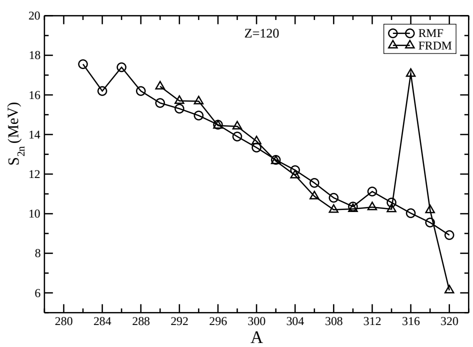

FIG. 2: S_{2n} for $^{280-320}120$ nuclei obtained from RMF calculations and compared with the FRDM results wherever available.

stable isotope is $^{296}120$. Two-neutron separation energy decreases with increasing of neutron number and RMF produces better result than FRDM for this series. Interestingly, most of the isotopes are superdeformed on their g. s. configuration and it may possible that the g.s. could be hyperdeformed because of shape-coexistence nature of nuclei.

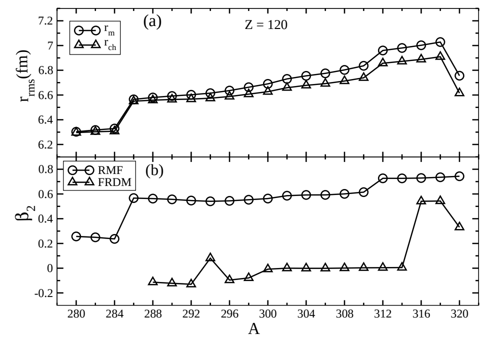

FIG. 3: (a)The rms radii r_m and charge radii r_{ch} for $^{280-320}120$ nuclei using RMF (NL3*) formalism. (b) a comparison of β_2 for Z =120 isotopic chain in both formalism.

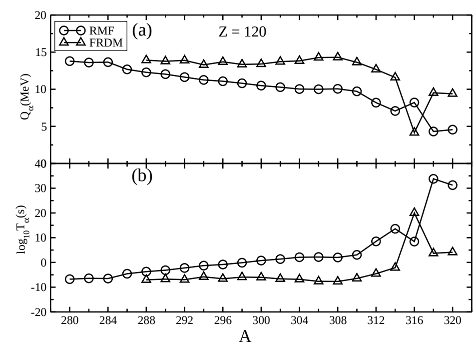

FIG. 4: (a)The Q_α energy for Z = 120 isotopic chain in RMF formalism and their comparison with most reliable FRDM results. (b) and half-life comparison for same isotopic chain.

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