Study of Charge radii for superheavy nuclei at Z=124

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Introduction

The charge radii are also the most essential properties of atomic nucleus along with nuclear masses. The study of charge radii of symmetric nuclear matter, contains an important information on saturation density. The charge radii also governed by nature of nuclear forces as well as nuclear many-body-dynamics. There are notable efforts have been performed for measuring the charge radii during the past decade[1, 2]. The laser spectroscopy can measure the change in charge radii significantly within the isotopic chain. But this technique measures the root-mean-square(rms) charge radii r_{ch} is less satisfactory because of lower precision of determination in muonic spectra. Except uranium, there are no experimental data for the absolute nuclear charge radii for $Z > 83$. The calculated rms charge radii have the deviation level of ≈0.03fm from the experimental one[3]. Thus, calculation of differential of mean-square (ms) charge radii within the isotopic chain become a significant quantity. With the increase of neutron number in the isotopic series an evolution of charge radii can be observed which may be defined as pull on the proton states generated by neutrons gradually added to the nuclear system. In the present work, we have studied differential charge radii within CDFT frame work in superheavy region of nuclear chart. Study reveals the shape evolution connections with the differentail charge radii within the isotopic chain. Here, we have performed the calculation for the even-even nuclei of isotopic chain of Z=124.

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Theoretical Formalism

Most of the systematic study of the shell structure of superheavy nuclei using DFT during the beginning of past decade indicates that the physics of superheavy nuclei is more reliable in the DFT framework than micro-macroscopic approaches because of self-consistency effects which are absent in the latter approaches. The whole study is carried out in CDFT framework. It has been mentioned that, we have used relativistic self-consistent mean-field models with density dependent DD-ME2 [4] and DD-PC1 [5] parameters. The earlier studies using this standard model are very successful and provide an excellent predictions of different ground state and excited state properties[6–8].

The calculation of charge radii from corresponding point proton radii uses the relation

$$r_{ch} = \sqrt{< r^2 >_p + 0.64} \tag{1}$$

The differential mean square charge radius is given as:

$$\delta < r^2 >_p^{N,N'} = r_{ch}^2(N) - r_{ch}^2(N') \tag{2}$$

where N' is the neutron number of reference nucleus.

Result and Discussions

We have calculated differential charge radii as a function of neutron number for isotopic series of Z=124 which have been shown in the Fig.1. The neutron number N=184 is taken as reference nucleus in the present calculation. Fig.2 represent the β_2 deformation of the isotopic series. Both the functional (DD-ME2 and DD-PC1) gives very similar results for differential charge radii ($\delta < r^2 >$) except at N=182. $\delta < r^2 >$ increases gradually up to N=180 after that decreases up to N=184

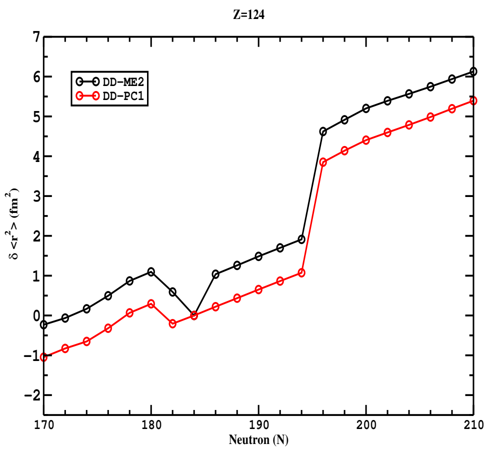

FIG. 1: The value of $\delta < r^2 >^{N,184}$ calculated within the functionals DD-ME2 and DD-PC1 of the isotopic chain of Z=124 is plotted as function of neutron number

for DD-ME2 while for DD-PC1 it decreases at N=182 only. The sharp increment are observed at N=184 and N=194 for DD-ME2 functional. DD-PC1 functional shows sudden increase in $\delta < r^2 >$ at N=194. The variation behavior of $\delta < r^2 >$ is also reflects in Fig.2 that we get exactly spherical behavior at N=184 for both the functional. The DD-PC1 shows somehow some different behavior around 182. For both the functional, we got sharp downfall at N=194 in Fig.2 i.e, system going moderately oblate (β_2=-0.20) to highly oblate (β_2=-0.45) state and this transition is clearly reflects in Fig.1 as sharp increment. Both the graph is consistent to each other.

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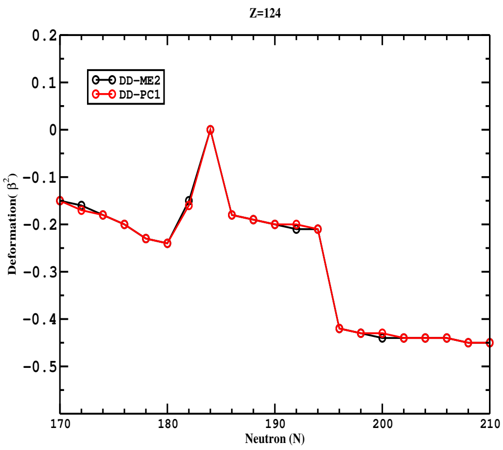

FIG. 2: The β_2 deformation calculated within the functional DD-ME2 and DD-PC1 for the isotopic chain of Z=124.

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