Symmetry energy of (Z=120) isotopes within Relativistic Mean Field model

Abdul Quddus[1*] and S. K. Patra[3,4]
[1] *Department of Physics, Aligarh Muslim University, Aligarh - 202002, India*
[3] *Institute of Physics, Sachivalaya Marg, Bhubaneswar - 751005, India and*
[4] *Homi Bhaba National Institute, Anushakti Nagar, Mumbai 400 085, India.*

Introduction

In last few decades, several super-heavy nuclei have been synthesized in various laboratories around the globe. The last in the series is $Z = 118$ nucleus which has been synthesized at Dubna and named as Oganessium [1]. The quest for searching the existence of higher Z nuclei is still going on. A lot of theoretical predictions are reported about the stability of superheavy nuclei against the spontaneous fission, $\alpha-$ and $\beta-$decays, and neutron emission [2, 3]. The stability of an isotope increases when it is semi/doubly magic having a large shell correction energy. Beyond the proton number $Z = 82$ and neutron number $N = 126$, the next predicted magic numbers are $Z = 114, 120$, and 126 for the proton and $N = 172$ or 184 for the neutron [3]. The $Z = 120$ element which is one of the predicted magic number represents a challenge for future experimental synthesis since it is located at the limit of accessibility with available cold fusion reactions facility. Therefore, an accurate estimation of it's characteristics are essential from the theoretical side to guide future experiment.

In this report, we have presented the symmetry energy coefficient S for $Z = 120$ isotopes and the related quantities. The symmetry energy coefficient, skin thickness, pressure and curvature coefficient, which are generally termed as effective surface properties are studied here.

The symmetry energy coefficient, which is defined as the energy cost in converting asymmetric nuclear matter to symmetric one, plays a key role in determining the boundaries of drip line, to study the dynamics of heavy-ion collision, properties of neutron star *etc.* [4]. For a better understanding of the predicted properties of $Z = 120$ isotopes, we have also studied the surface properties of Pb isotopes as an guide-line in our investigation. We have used the recently predicted IOPB-I, G3, and FSUGarnet parameter sets within the relativistic mean field (RMF) model to calculate the bulk properties of these nuclei and compared the results with the widely used NL3 interaction [5]. The densities of the nuclei along with nuclear matter properties like symmetry energy coefficient, pressure and curvature coefficient within Bruckner potential are used as the input to coherent density fluctuation model (CDFM) to obtain the corresponding quantities of finite nuclei. The detail formalism of RMF and CDFM can be found in the Refs. [4, 5].

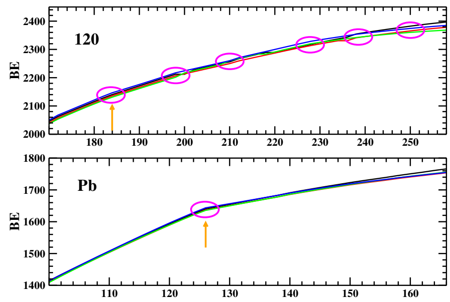

FIG. 1: Binding energy curve for the isotopic chain of $Z = 82$ and 120 nuclei.

Results and Discussions

First, we have calculate the bulk properties like binding energy and the root mean square radii of neutrons and protons and charge radius of the considered isotopes within the spherical RMF model. Along with the calculated properties, the binding energy (BE) of the $Z = 82$ and $Z = 120$ isotopes are shown in Fig. 1. A small kink in the lower panel of the figure is observed

*Electronic address: abdulquddusphy@gmail.com

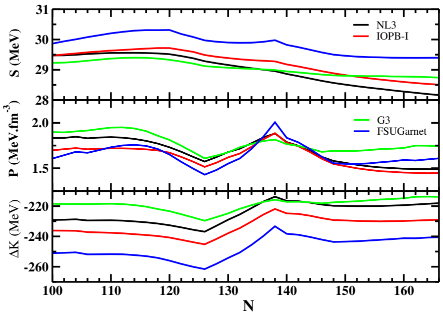

FIG. 2: The symmetry energy, pressure and curvature coefficient for the Pb isotopes.

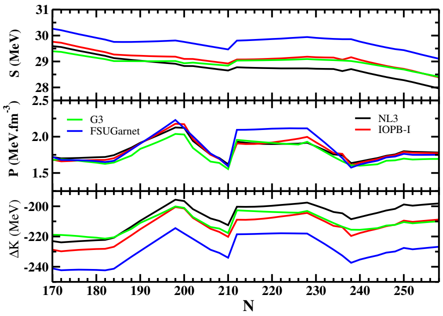

FIG. 3: The same as Figure 2 but for isotopic chains of $Z = 120$.

at $N = 126$ which is one of the magic number. On behalf of this observation, the small kinks in the upper panel of the figure can be attributed to the magicity of neutron number. Some of the kinks appear in the present calculations, confirm the earlier predicted neutron rich magic number. However, the BE curves are almost same corresponding to all the chosen force parameter sets.

By using the calculated densities as the input to CDFM, the weight function for the nuclei is calculated. The weight function is folded with the properties of nuclear matter to find the corresponding quantities of the finite nuclei. These properties are symmetry energy coefficient, pressure and curvature coefficient which are shown in Figs. 2, 3 for $Z = 82$ and 120 isotopes, respectively. It is clear from both of the figures that symmetry energy coefficient corresponding to FSUGarnet is maximum and for G3 minimum. This trend with respect to parameter sets get reversed in case of pressure and curvature coefficient. In addition, there are some humps in the pressure and curvature coefficient curves which can be interpreted due to the neutron magic number at or nearby the regions.

Conclusions

We have studied the bulk and surface properties of $Z = 82$, and 120 isotopes within RMF formalism by using FSUGarnet, IOPB-I, G3, and NL3 force parameters. More specifically, the symmetry energy coefficient, pressure and curvature coefficient are presented for the nuclei. These are calculated by importing the densities of the nuclei to CDFM. The kinks observed in the BE graphs are obtain at neutron magic numbers. To get more consistent results and for confirming the neutron rich magic numbers and the related effective surface properties, we are now extending the calculations to deformed model at various temperatures within RMF formalism.

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