Surface properties of Z=124 isotopic series.

Tasleem Ahmad Siddiqui[1],* Abdul Quddus[1], and Shakeb Ahmad[1,2]
[1] *Department of physics, Aligarh Muslim University, Aligarh - 202002 India and*
[2] *Physics Section, Women's College, Aligarh Muslim University, Aligarh- 202002, India*

Introduction

The nuclear symmetry energy is defined as the energy required to convert to neutron to proton or vice-versa. It is one of the important quantity in the nuclear physics which plays its role from heavy-ion collision to neutron star [1, 2]. The current experimental facilities such as RIB and analytical observations on probe for the symmetry energy of nuclear matter have stirred up the interest in nuclear symmetry energy.

The some of the basic feature of equation of state (EoS) of nuclear matter are resolved with the help of measurments of nuclear masses, densities, and collective excitations. The EoS have got the asymmetry properties due to difference of neutron and proton numbers and become more elusive to date. In this situation, the improved perceptive of isospin-dependent aspects of asymmetric nuclear matter and density dependence of the nuclear symmetry energy become the primary objectives of present studies.

The nuclear symmetry energy is not measurable directly through experiment but it has to be extracted indirectly from observables that are related to it. The slope parameter is the quantity which relates the neutron pressure of finite nuclei to symmetry energy at saturation. The collective behavior of symmetry energy and neutron pressure is reffered as effective surface properties. We have covered isotopic series of Z=124 for systematic studies of effective surface properties.

Results and Discussion

The densities for Z=124 isotopic series are calculated with in CEDFs with DD-ME2 [3] and DD-PC1 [4] parameters. To investigate the surface properties, the calculated densities of isotopes are served as input to the CDFM [5]. The effective symmetry energy S_0, its corresponding pressure p_0, and the symmetry energy curvature K_0 of finite nuclei are calculated by CDFM using relation as follows:

$$S_0 = \int_0^\infty |f(x)|^2 \, S_0^{NM}(\rho(x)),$$

$$p_0 = \int_0^\infty |f(x)|^2 \, P_0^{NM}(\rho(x)),$$

$$k_0 = \int_0^\infty |f(x)|^2 \, \Delta k_0^{NM}(\rho(x)).$$

where $|f(x)|^2$ is the weight function which depend on the densities of nuclei ($|f(x)|^2 = -\frac{1}{\rho_D}\frac{d\rho}{d\alpha}$). S_0^{NM}, P^{NM}, and k_0^{NM} are the symmetry energy, pressure, and symmetry energy curvature of the finite nuclear matter which have been taken from Brueckner energy density functionals [6]. Fig. 1 shows the behavior of calculated symmetry energy and quadrupole deformation (β_2) for the isotopes. Both the force parameter give almost the same results except at N=184. The sharp down fall for symmetry energy and shape transition from highly oblate ($\beta_2 = -0.45$) to relatively low oblate ($\beta_2 = -0.20$) is noticed at N=168 which has been reported as deformed magic number [7]. The minimim symmetry energy is found at N=184 for DD-ME2 interaction which is exactly spherical with DD-ME2 seen in the figure. The DD-PC1 calculates finite obalate shape at N=184. There is another abrupt change is observed at N=194, where symmetry energy increased by ≈2 MeV and quadrupole deformation chnges from low oblate region to highly oblate. As the deformation is constant after N=196, there is no

*Electronic address: tasleemahmad038@gmail.com

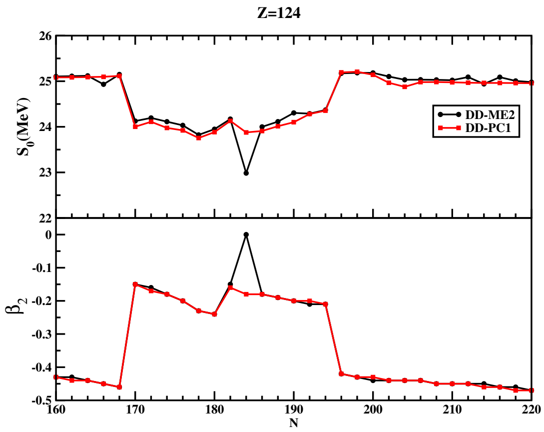

FIG. 1: The symmetry energy (S) and quadrupole deformation (β_2) for isotopic series of Z=124 corresponding to DD-ME2 and DD-PC1.

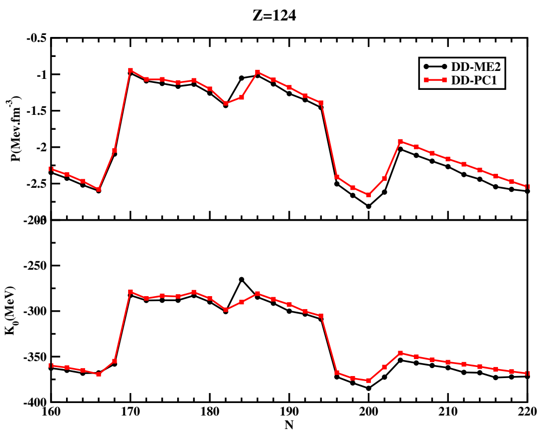

FIG. 2: Neutron pressure and symmetry energy curvature for isotopic series of Z=124 corresponding to DD-ME2 and DD-PC1.

noticable variation seen for symmetry energy. The behavior of symmetry energy has relation with the development of quadrupole deformation as a function of mass number. A larger value of symmetry energy is calculated for highly deformed isotope as compared to less deformed nuclei. The trajectory of neutron pressure (p_0) and symmetry energy curvature (k_0) with neutron number is shown in Fig. 2. Both force parameter give nearly the same behavior for p_0 and k_0. Here, also we get two sharp changes similar to previous one at N=168 and 194 which is observed as transition point for shape. At N=184, the DD-ME2 calculates different result from DD-PC1 due to spherical magicity predicted only by DD-ME2 in our structural calculation [7]. We have noticed a gradual decrease from N=196 to 200. After N=200 a incrememt is observed upto 204 for both neutron pressure and symmetry energy curvature. As earlier studies mentioned the decrease in S_0, p_0, and k_0 is due to open shell nuclei. Hence the study will also help for searching shell closure in superheavy region. The region after N=204 has got constant decrement up to the end for both p_0, and k_0. From the study of all four physical quantity, we can say that shape of nuclei has major role in the study surface property. It can be concluded that surface properties are useful for determining the shell closure of nuclei.

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