Proceedings of the DAE Symp. on Nucl. Phys. 66 (2022)

Correlations among the surface properties of finite nuclei within the Coherent Density Fluctuation Model

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1. Introduction

In many branches of nuclear and astro-nuclear physics, the investigation of nuclear symmetry energy and its isospin dependency is of utmost importance. The correlation between various structural properties of finite nuclei and nuclear matter is firstly deduced by Brown *et. al.* [1]. In this work it has been explained the correlation between neutron skin thickness and compressibility. Later on the extensive correlation among different properties are carried out by Centelles *et. al.* [2] and B. K. Agrawal *et. al.* [3] and collaborators. In this present study, the surface properties of finite nuclei are studied for various parameter sets under the coherent density fluctuation model with the help of newly derived effective field theory motivated relativistic mean field (E-RMF) energy density functional. It is very interesting to observe the correlations among the surface properties like symmetry energy (S^A), neutron pressure (P^A), slope parameter (L^A_{sym}), compressibility (K^A) and curvature parameter (K^A_{sym}).

2. Theoritical formalism

E-RMF based densities are used as the input in the framework of coherent density fluctuation model, to produce the weight function $|F(x)|^2$, which is nothing but a bridge in between nuclear matter in $x-$space and finite nuclei in $r-$space using local density approximation. Details can be found in Refs. [4, 5]. In nuclear matter [4]:

$$S^{NM} = 41.7\,\rho_0^{2/3}(x) + \sum_{i=3}^{14} a_i\,\rho_0^{i/3}(x), \quad (1)$$

$$L^{NM}_{sym} = 83.4\,\rho_0^{2/3}(x) + \sum_{i=3}^{14} i\,a_i\,\rho_0^{i/3}(x) \quad (2)$$

In finite nuclei:

$$S^A = \int_0^\infty dx\,|F(x)|^2\,S^{NM}(\rho(x)), \quad (3)$$

$$L^A_{sym} = \int_0^\infty dx\,|F(x)|^2\,L^{NM}_{sym}(\rho(x)). \quad (4)$$

The weight function $|F(x)|^2$ for a given density ρ (r) is defined as

$$|F(x)|^2 = -\left(\frac{1}{\rho_0(x)}\frac{d\rho(r)}{dr}\right)_{r=x}, \quad (5)$$

with $\int_0^\infty dx|F(x)|^2 = 1$ [6, 7].

3. Results and discussion

In our present work, E-RMF energy density functionals are constructed for the considered latest RMF parameter sets like G1, G2, IOPB, FSUGold, FSUGarnet and density dependant DDME-2, which are further used in coherent density fluctuation model to determine various surface properties like symmetry energy, neutron pressure, slope parameter, compressibility and curvature parameter. To deal with the best outcome we have considered the 7

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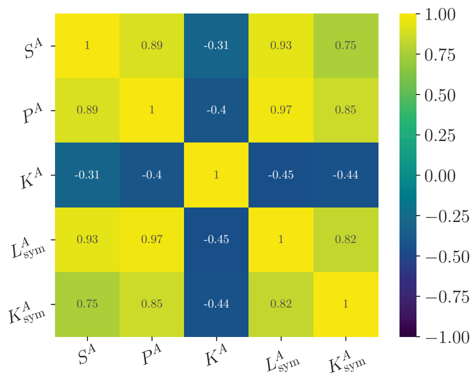

FIG. 1: The Pearson correlation plot for symmetry energy (S^A), neutron pressure (P^A), compressibility (K^A), slope parameter (L^A_{sym}) and curvature parameter (K^A_{sym}).

known doubly-closed spherical nuclei for this study, which are also used for construction of a new parameter set [8]. To find the correlation between the determined properties, Pearson correlation formula is used. The Fig. 1 justifies the correlation between the above considered quantities along with their respective Pearson co-efficients. In Fig. 1 the strong correlation are noticed among two pairs such as S^A & L^A_{sym} and L^A_{sym} & P^A to be 93% and 97% respectively. Also in case of nuclear matter, such correlations can be observed in Ref. [9]. But here, for the first time, we intend to see such correlation in case of finite nuclei. By observing the correlation, we try to enumerate the relation between S^A & L^A_{sym} and also the deviation with the fitted data is found to be 0.019 i.e $\sim 1.9\%$. Similar case is also studied for L^A_{sym} & P^A, where the deviation is 0.001 i.e $\sim 0.1\%$. The approximate relations are as follows;

$$L^A_{sym} = 10.334 * S^A - 265.75, \quad (6)$$

$$L^A_{sym} = 15.7 * P^A + 6.9206. \quad (7)$$

4. Summary

By using various E-RMF energy density functionals, we determined the so-called surface properties like symmetry energy, neutron pressure, slope parameter, compressibility and curvature parameter and investigated correlations between them. By using the relation Eq. 6 and Eq. 7, L^A_{sym} can be obtained from both S^A & P^A respectively and vice-versa. The deviations are 0.019 & 0.001 respectively. More investigations regarding the relations among the quantities are under process, will be communicated soon.

Acknowledgments

One of the authors (JAP) is thankful to the Institute of Physics, Bhubaneswar, and SERB partly reinforces this work, Department of Science and Technology, Govt. of India, Project No. CRG/2019/002691.

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