A Search for shell closure in isotopic series of Z=124&126

Abdul Quddus[1],* Tasleem Ahmad Siddiqui[1], Shakeb Ahmad[1,2], and S. K. Patra[3,4]
[1] *Department of physics, Aligarh Muslim University, Aligarh - 202002 India*
[2] *Physics Section, Women's College, Aligarh Muslim University, Aligarh- 202002, India*
[3] *Institute of Physics, Sahcivalaya Marg Bhubaneswar-751 005, India and*
[4] *Homi Bhaba National Institute, Training School Complex, Anushakti Nagar, Mumbai 400 085, India*

Introduction

The region of superheavy nuclei (SHN) is characterized by large number of proton i.e, $Z \geq 100$. The possibility of existence of SHN was first built by Myers and Swiatecki [1] in the middle of 1960s. The synthesis of SHN is a challenging issue for experimentalists due to extremely small cross section observed during production of Z=112 at GSI. Despite these difficulties the nuclei with Z=114-118 have been synthesized at Dubna [2] using hot fusion reaction.
According to the liquid drop model, the SHN should decay through instant fission due to large electric charge. The reason for the SHN being stable despite having so many protons is puzzle for theorists and experimentalists. The quantum shell effects may be reason for stability of SHN. To quantify the shell effects the Strutinsky shell correction scheme is found to be very useful. The level density of single particle energy for superheavy nuclei are found to be large which leads to consensus among theorists for magic gap. In this work, we searched for neutron shell closure in isotopes of Z=124 and Z=126 using Strutinsky shell correction scheme (SSC) [3]. The ground state properties have been obtained using Covariant Energy Density Functionals (CEDFs) with DD-ME2 [4] and DD-PC1 [5] interactions. We have restricted our calculation for even-even nuclei due to lack of faithful configuration assignments of experimentally known odd mass SHN in GS to be confronted with theory.

*Electronic address: `abdulqudduscphy@gmail.com`

Results and Discussions

In Strutinsky averaging method, the magnitude of energy (δE_{shell}) due to shell effect is given by the difference total single-particle energy E and the smoothed sum of single-particle energy $\bar{E}$.

$$\delta E_{shell} = E - \bar{E} = \sum_{i=1}^{N(z)} e_i - 2\int_{-\infty}^{\bar{\lambda}} e\bar{g}(e)de.$$

Where the terms $N(Z)$, e_i, and $\bar{\lambda}$ are particle number, single particle energy, and smoothed Fermi level, respectively. Smoothed level density is represented by $\bar{g}(e)$. The shell closure is indicated at particular point with large negative shell correction to the energy.
The calculated results for neutron, proton and total shell correction energy from Strutinsky averaging method of both the isotopic series (Z=124 and Z=126) are presented in Fig. 1 and Fig. 2, respectively. The shell correction with both the force parameter corresponding to neutron and proton distribution are shown in the upper panels of each graph. The total shell correction is represented in the bottom panels. It is clear from the figures that results from both the interaction have almost same trend except at very few points. One can observe that total shell correction energy has more variation at the beginning as compared to the end of the isotopic series i.e, after N=200 in both of the figures. Due to very less fluctuation of proton shell correction, the minima of total shell correction is coincide with minima of neutron shell correction. Therefore, the minima of total shell correction are correspond to neutron shell closure. The distinct minima are clearly observed at N=168, 174, and 178 in Fig. 1 for both the interac-

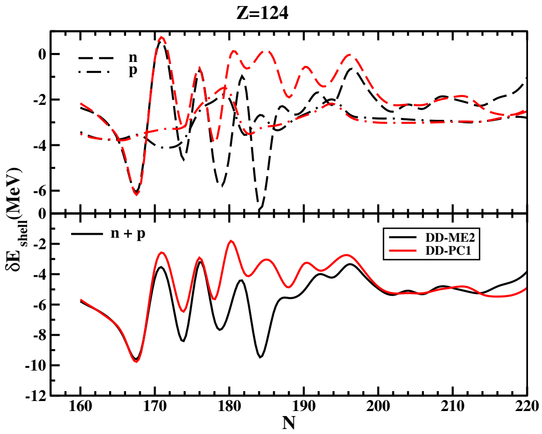

FIG. 1: (Color online) Neutron, proton, and total shell correction to the energy of the isotopic series of Z=124 at their ground state.

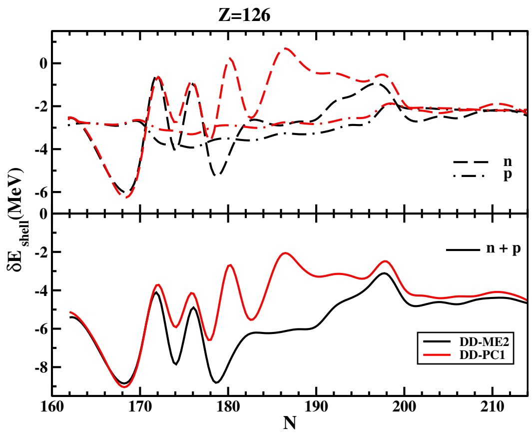

FIG. 2: (Color online) Same as Fig. 1 but for Z=126.

tion while DD-ME2 calculates one extra minimum at N=184. The nucleus with N=168 is found to be highly oblate ($\beta_2 = -0.45$) in our structural investigation while nucleus corresponding to N=174 and 178 are found as less oblately deformed ($\beta_2 \approx -0.20$). So, these number can be reported as deformed neutron magic number of isotopic series for Z=124. We also got sharp down fall in S_{2n} at these numbers which strengthen our findings. An extra sharp minimum observed for DD-ME2 other than DD-PC1 at N=184. Therefore, we can conclude that there is model dependency at N=184 for neutron shell closure.

Fig. 2 represents results for isotopic series of Z=126. The behavior of curves from both the force parameters follows more or less same trend. Here, we got three points common for minima i.e, N=168, 174, and 178 from both the graphs. These three nuclei are also predicted as deformed nuclei by the both relativistic interactions. So, we can conclude these three (N=168, 174, 178) as deformed neutron magic for the whole region which have been studied here. An extra peak of total shell correction is observed around N=182 only by DD-PC1. But, reporting N=182 as neutron magic is difficult that we do not found any signature of extra stability for this nucleus.

conclusion

The main aim of present work is to locate the neutron shell closure in superheavy region using Strutinsky shell correction scheme. The deformed neutron magic are found at N=168, 174, and 178 for both the isotopic series. The results at N=184 for Z=124 series, and N=182 for Z=126 series have got some matter discussion for reporting as magic shell gap because of lack of support from other stability test. The almost constant behavior of neutron and proton shell correction curves after the N=200 suggests that increment in neutron beyond this will leave no effect on shell correction.

References

[1] W.D. Myers, W.J. Swiatecki, Nucl. Phys. **81** (1966) 1.

[2] Y. T. Oganessian et al., Phys. Rev. Lett. **104**, 142502 (2010); 108, 022502 (2012); Y. T. Oganessian, Acta Phys. Pol. B **43**, 167 (2012).

[3] V. M. Strutinsky, Nucl. Phys. A**122**, 1 (1968)

[4] G. A. Lalazissis, T. Niksic, D. Vretenar, and P. Ring, Phys. Rev. C **71**, 024312 (2005)

[5] X. Roca-Maza, X. Vinas, M. Centelles, P. Ring, and P. Schuck, Phys. Rev. C **84**, 0354309 (2011).