Ground state properties of Z = 118

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Introduction

In the late 1960s, about two decades after the introduction of the nuclear shell model [1,2], an "island of stability" of SHEs far from the known nuclei was predicted. Recent experimental evidence for the existence of isotopes of elements up to Z = 118 [3] has confirmed this concept, but the exact location and extension of this island are still unknown [4-6]. The progress in experiment has a great advantage for further theoretical investigations of nuclear structure in the superheavy mass region of the nuclear chart.
Several theoretical investigations have been carried out using the microscopic - macroscopic (MicMac) method and the self consistent mean field in both the relativistic and non relativistic formalisms. The Skyrme Hartree-Fock calculation with the SkI4 force gives Z = 114, N = 184 as the next shell closures and the microscopic relativistic mean-field (RMF) formalism [7] predicts probable shell closures at Z = 120 and N = 184. Recently, a lot of activity for super heavy nuclei appeared in the literature with experimental confirmation of Z=118 [3] encouraged us to study the ground state properties of this super heavy element, which may be a direction towards the further conformation of "Island of Stability" beyond the doubly closed shell spherical magic nucleus ^{208}Pb.

Theoretical Framework

The Relativistic Mean Field theory [8-10] is now established to be one of the most successful approach for the accurate description of nuclear properties. It starts with a Lagrangian describing the Dirac spinor nucleons interacting via exchange of mesons and the photon and is given by:

$$L = \bar{\psi}(i\partial - M)\psi + \frac{1}{2}\partial_\mu\sigma\partial^\mu\sigma - U(\sigma) - \frac{1}{4}\Omega_{\mu\nu}\Omega^{\mu\nu}$$

$$+\frac{1}{2}m_\omega^2\omega_\mu\omega^\mu - \frac{1}{4}R_{\mu\nu}R^{\mu\nu} + \frac{1}{2}m_\rho^2\rho_\mu\rho^\mu - \frac{1}{4}F_{\mu\nu}F^{\mu\nu}$$

$$-g_\sigma\bar{\psi}\sigma\psi - g_\omega\bar{\psi}\omega\psi - g_\rho\bar{\psi}\rho\tau\psi - e\bar{\psi}A\psi$$

Calculations and Results

We study the ground state properties, like binding (BE), two-neutron separation (S_{2n}) and the differential variation of two neutron separation (dS_{2n}) energies. The neutron radii (r_n), proton radii (r_p) and other bulk properties are also calculated by using the RMF formalism for the isotope Z=118. The predicted results are compared with the Finite Range Droplet Model (FRDM) [11] and shown in Figures 1, 2 and 3.

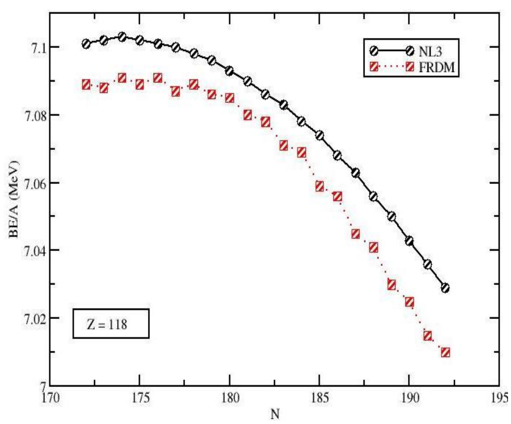

Fig. 1 The binding energy per particle (BE/A) for the $^{290-310}$118 isotopes verses parent neutron number (N), obtained in the RMF (NL3) formalism and compared with the FRDM results [11].

From the Fig.1, it shows that the BE/A increases with increase of neutron number and reaches a peak value at N ~ 174 (A =292, Z =118) and then decreases gradually towards higher mass region. This means that ^{290}118 is the most stable element from the binding energy point of view. The similar results are also obtained from FRDM [11] data.

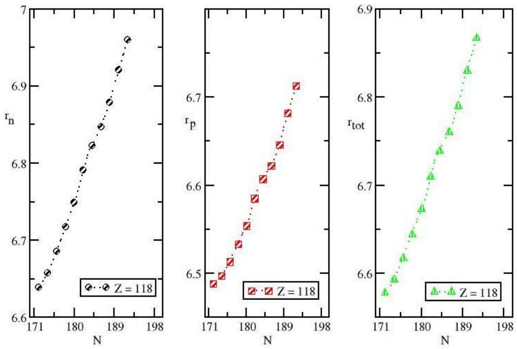

Fig. 2 The radii of neurton (r_n),proton (r_p) and total radii (r_{tot}) for $^{290-310}$118 nuclei.

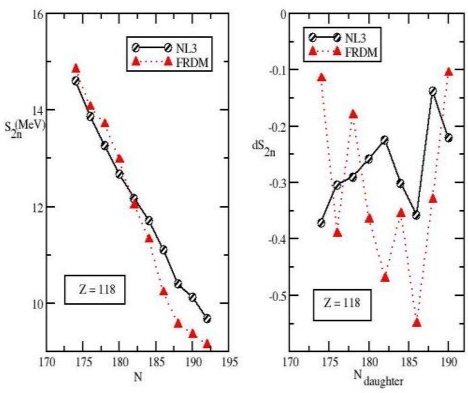

Fig. 3 The two neutron separation energy S_{2n} and dS_{2n} verses daughter neutron number for the $^{290-310}$118 isotopes and are compared with the FRDM results [11].

Fig.2 clearly shows that the neutron radius increases with increase of neutron number, following $A^{1/3}$ law ('A' being the mass number). There is no data or other calculations available for comparisons.

In Fig.3 the evolution of S_{2n}, as a function of neutron number shows the well-known regularities. The differential variations of the S_{2n} along the isotopic chains symbolized in the present work by dS_{2n} also shown in the figure. We notice that, dS_{2n} shows clearly a drop at N=186. This shows that the major shell closure at N=186 may be there and the same has been compared with the FRDM result which gives nearly similar behavior with our calculated results.

Conclusion

Here, we have studied the ground state properties for super heavy element Z=118 and its isotopes using RMF formalism. From the calculated binding energy, we have also estimated the two-neutron separation energy and dS_{2n} which shows that the possible major shell closure at N=186. From the binding energy analysis, we found that the most stable isotope in the series of ^{292}118, is at N=172.

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