Ground State Properties of Es Isotopes

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Introduction

Significant technical progress concerning the availability of intense heavy-ion beams and highly-efficient and sophisticated detection devices has made nuclear structure investigations possible in the region of medium and super-heavy region. Nuclei are finite many-body systems regulated by the laws of quantum mechanics and interactions of neutrons and protons. Deeper understanding of nuclear structure would open wider variety of applications. The shell structure of nuclei has substantial effects on nuclear mass, nuclear decay, and nuclear reactions. We have investigated the ground state properties of the isotopes of Einsteinium (Es) element using the axially deformed Relativistic Mean-Field (RMF) theory with NL3 and NLSH force parameters. This has been used successfully to describe the ground state properties of nuclei in the line of stability, distorted and exotic nuclei.

Einsteinium has 16 isotopes whose half-lives are known, with mass numbers 241 to 256. Einsteinium has no naturally occurring isotopes. Its longest lived isotopes are ^{252}Es, with a half-life of 471.7 days, ^{254}Es with a half-life of 257.7 days and ^{255}Es with a half-life of 39.8 days. This results also indicated the need to explore unstable nuclei to obtain more universal idea in nuclear shell structure.

Theoretical formalism

The relativistic mean field Lagrangian density for many body system is taken as [1,2]

$$
\begin{aligned}
L = \bar{\psi_i}(i\gamma^\mu\delta_\mu - M)\psi_i + \frac{1}{2}\delta^\mu\sigma\delta_{mu}\sigma - \frac{1}{2}m_\sigma^2\sigma^2 \quad (1)\\
-\frac{1}{3}g_2\sigma^3 - \frac{1}{4}g_3\sigma^4 - g_s\bar{\psi_i}\psi_i\sigma - \frac{1}{4}\Omega^{\mu\nu}\Omega_{\mu\nu}\\
+\frac{1}{2}m_\omega^2 V^\mu V_\mu + \frac{1}{4}c_3(V_\mu V^\mu)^2 - g_\omega\bar{\psi_i}\gamma^\mu\psi_i V_\mu\\
-\frac{1}{4}\vec{B}^{\mu\nu}.\vec{B}_{\mu\nu} + \frac{1}{2}m_\rho^2\vec{R}^\mu.\vec{R_\mu} - g_\rho\bar{\psi_i}\gamma^\mu\vec{\tau}\psi_i.\vec{R^\mu}\\
-\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - e\bar{\psi_i}\gamma^\mu\frac{(1-\tau_{3i})}{2}\psi_i A_\mu
\end{aligned}
$$

All the quantities have their usual meaning. From the above Lagrangian, we obtain the field equations for the baryons and mesons. These equations are solved by expanding the upper and lower components of the Dirac spinors and the boson fields in an axially deformed Harmonic oscillator basis, with an initial deformation β_0 . WE use the well known NL3 and NLSH parameter set. This set reproduces the properties of not only the stable nuclei but also well predicts for those far from the β- stability line.

Results & Discussion

In this paper we study the structural properties of Es Isotopes $^{240\text{-}258}$Es by relativistic mean field |(RMF) theory. We have calculated the B.E of all the Es isotopes both using NL3 and NLSH parameters. The variation of B.E with neutron number is shown in figure -1. The grapes are smooth straight line without any peculiar character for both the parameters.

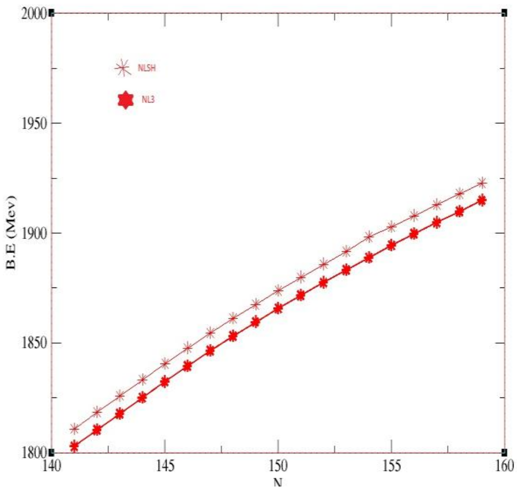

Figure-1

The plot between the neutron numbers and the binding energies of NL3 (Red line with bold star) and NLSH (Red line with thin star)

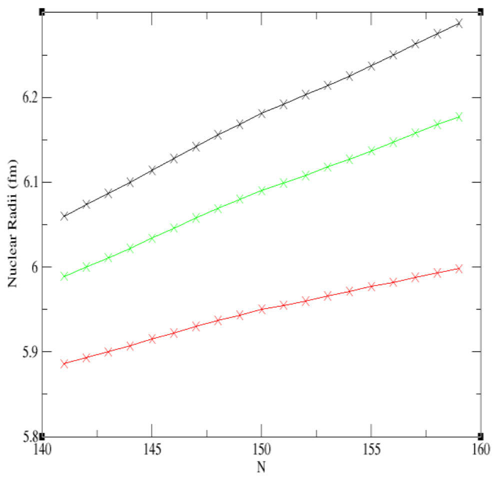

Figure-2

The plot between the neutron numbers and the nuclear redii in RMF formalism r_n (Black line with star), r_p (Red line with star) and r_m (Green line with star)

The nuclear redii for proton (r_p) neutron (r_n) and matter (r_m) is shown in figure -2. The figure shows that the redii increases smoothly without any special character. The radii show the expected monotonic nature.

Conclusion

We have studied the ground state properties like B.E nuclear redii for different isotopes $^{240-258}$Es with the both NL3 & NLSH parameters by using RMF formalism. The binding energy shows an increase with increasing mass number. From the B.E data we calculate the neutron separation energy (S_n and S_{2n}) which will be presented at the conference along with its differentiations which shows the shell structure of the Es nuclei.

References

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