Structural and Decay Properties of Even-Even Trans-Lead Nuclei Using HFBRAD (V1.00)

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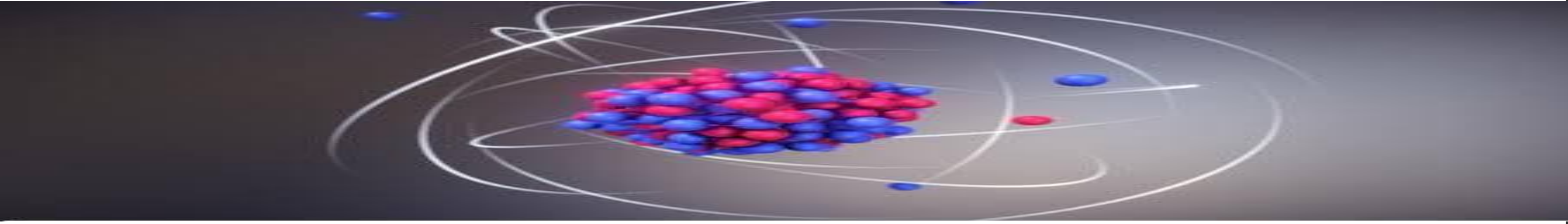


Aim of The Work

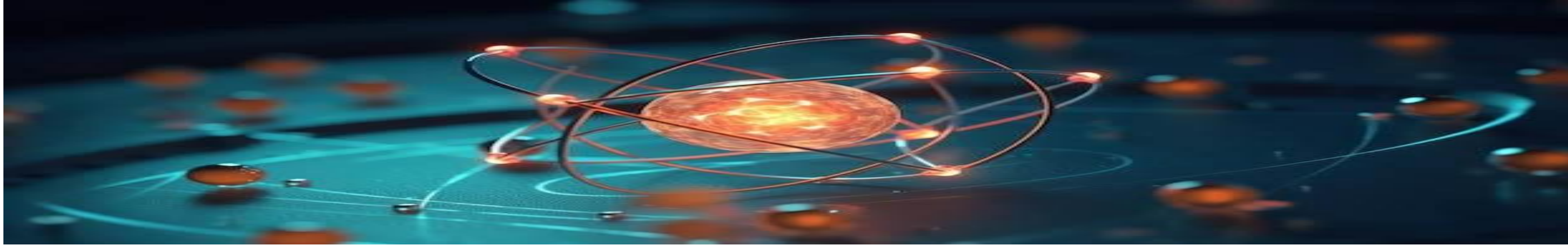
- Investigation of ground state properties such as binding energy per nucleon BE/A, Rc and two-neutron separation energies S2n for even-even trans - lead nuclei like 188-218Po, 210- 230Th and 210-230Th using Skyrme HFB method in the spherical basis with the SIII, SKM*, SLy4 ,SKP and SLy5 Skyrme force parameters.

- Check the Validation of the HFB model in structural properties calculations.

Introduction

Many of approaches have been developed in nuclear structure theory to study ground state properties of even-even and odd nuclei. Among them there are ab-initio calculations based on N-N interaction for the lightest nuclei, large -scale shell model for medium mass, and non-relativistic and relativistic mean field theories are mostly used for heavier nuclei. Hartree-Fock (HF) or Hartree-Fock+Bardeen–Cooper–Schrieffer (HF+BCS) method are the most used ones for heavier nuclei.

Hartree-Fock extends along a single-particle picture that does not include the pairing correlations but BCS model is the simplest mean field approach in which the pairing correlations are added to the mean field via a corresponding potential term.

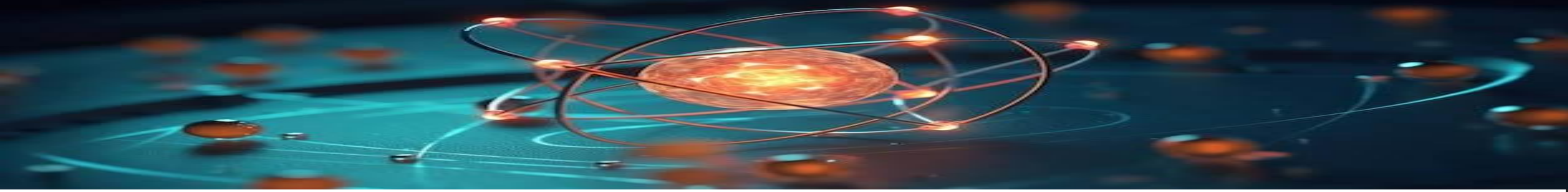


Hartree Fock Bogoliubov Method

In nuclei far from the shell closure, the role of the pairing correlations is particularly essential for description of open shell nuclei and has been derived for even-even, odd-odd and even-odd nuclei. In HF+BCS approach, the production of the single particle states and the evaluation of their pairing correlations are treated in two different types of calculations, the two processes are unified in the Hartree–Fock–Bogoliubov (HFB) theory .

In this work, binding energies are investigated in the framework of the self-consistent HFB approximation based on finite range and density-dependent Skyrme interactions with different parameterizations. In this method, binding energies of even–even nuclei can be evaluated self-consistently. The total energy E of a nucleus is the sum of kinetic, Skyrme, pairing and Coulomb terms:

$$\begin{aligned} E &= K + E_{Skyrme} + E_{Pair} + E_{Coul} \\ &= \int d^3r \left[k(r) + \varepsilon_{Skyrme}(r) + \varepsilon_{Pair}(r) + \varepsilon_{Coul}(r) \right] \end{aligned}$$



The nucleon densities in the spherical representation can be evaluated as:

$$\rho_q(r) = \sum_{i \in q} N_i \psi_i(r)^2$$

The effective Skyrme forces used in this approximation are expressed in density-dependent form as:

$$V_{12} = t_0(1 + x_0 P_\sigma)\delta(r_i - r_j) + \frac{1}{2} t_1(1 + x_1 P_\sigma)\left\{\delta(r_i - r_j) K^2 + K'^2 \delta(r_i - r_j)\right\}$$
$$+ t_2(1 + x_2 P_\sigma) K'.\delta(r_i - r_j) K + i W_\theta(\sigma_i - \sigma_j).K' \times \delta(r_i - r_j) K$$
$$+ \frac{1}{6} t_3(1 + x_3 P_\sigma)\delta(r_i - r_j)\rho^\alpha\left(\frac{r_i + r_j}{2}\right)$$

The root mean square radii of proton and neutron (r_p, r_n)can be calculated , where q= r, n:

$$\langle r_q^2 \rangle = \int_0^{R_{box}} r^2 \rho_q(r)\, d^3 r$$

The effective mass due to dependence of ε on kinetic densities can be calculated by using:

$$M_q = \frac{\hbar^2}{2m_q^*} = \frac{\hbar^2}{2m} + \frac{t_1}{4}\left[\left(1+\frac{x_1}{2}\right)\rho - \left(x_1+\frac{1}{2}\right)\rho_q\right] + \frac{1}{4}t_2\left[\left(1+\frac{x_2}{2}\right)\rho + \left(x_1+\frac{1}{2}\right)\rho_q\right]$$

And The abnormal effective mass :

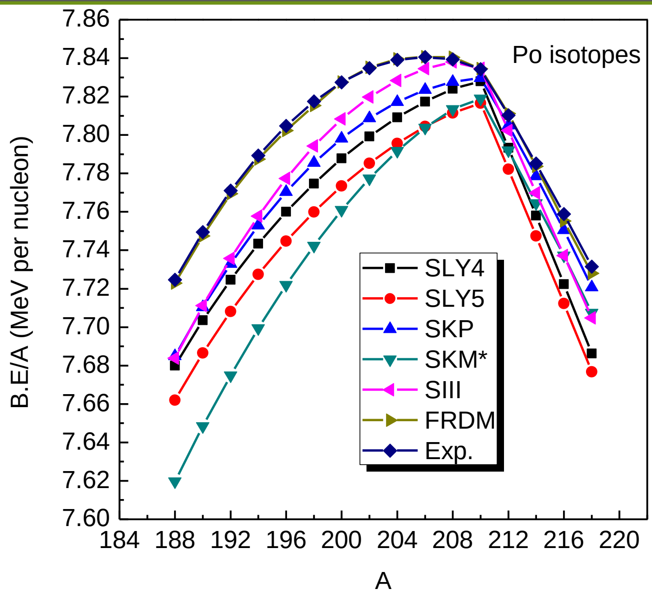
$$\tilde{M}_q = \frac{1}{4}t_1'(1-x_1')\tilde{\rho}_q$$

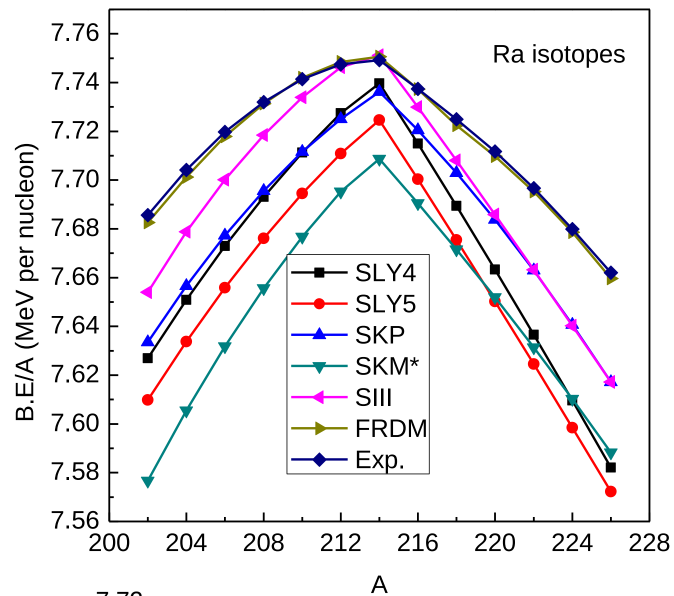
The form factors of spin o-orbit fields and its pairing have the following expressions:

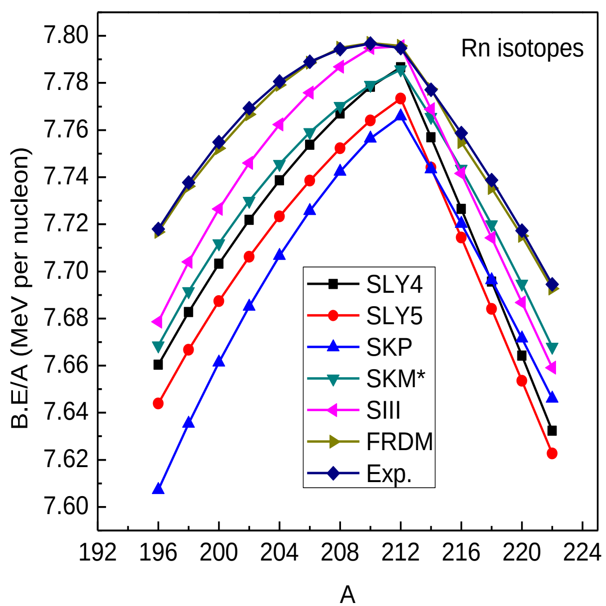
$$B_q = -\frac{1}{8}(t_1x_1 + t_2x_2)J + \frac{1}{8}(t_1 - t_2)J_q + W_0\nabla\left(\rho + \rho_q\right)$$

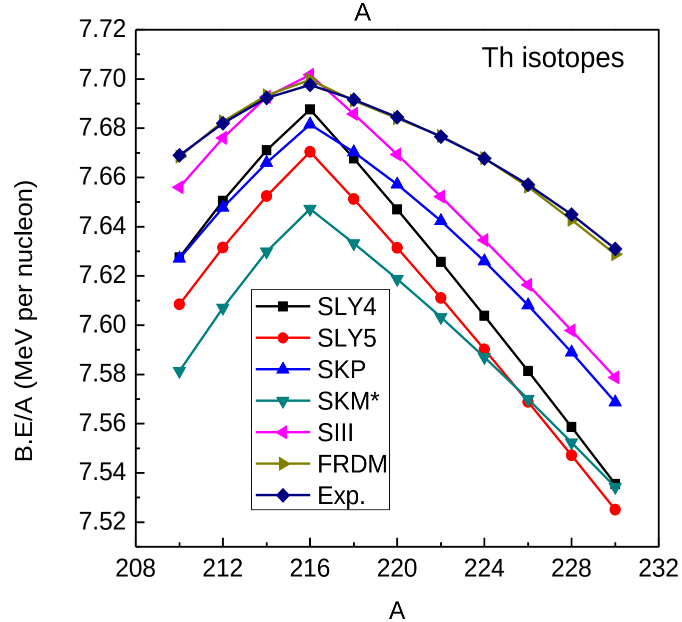
$$\tilde{B}_q = \left[\frac{1}{2}t_2'(1+x_2') + W_0'\right]\tilde{J}_q$$

Binding Energy per nucleon

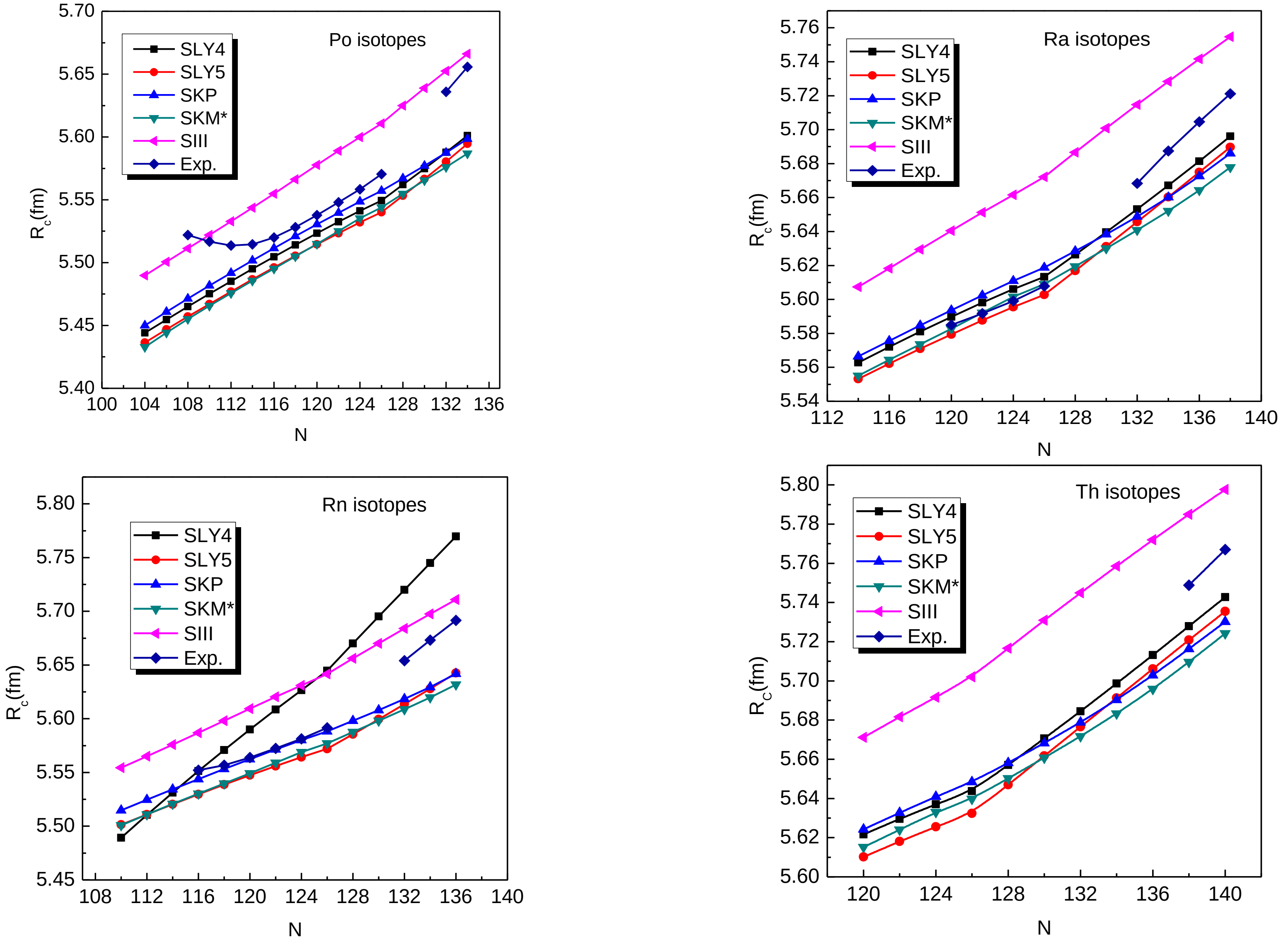




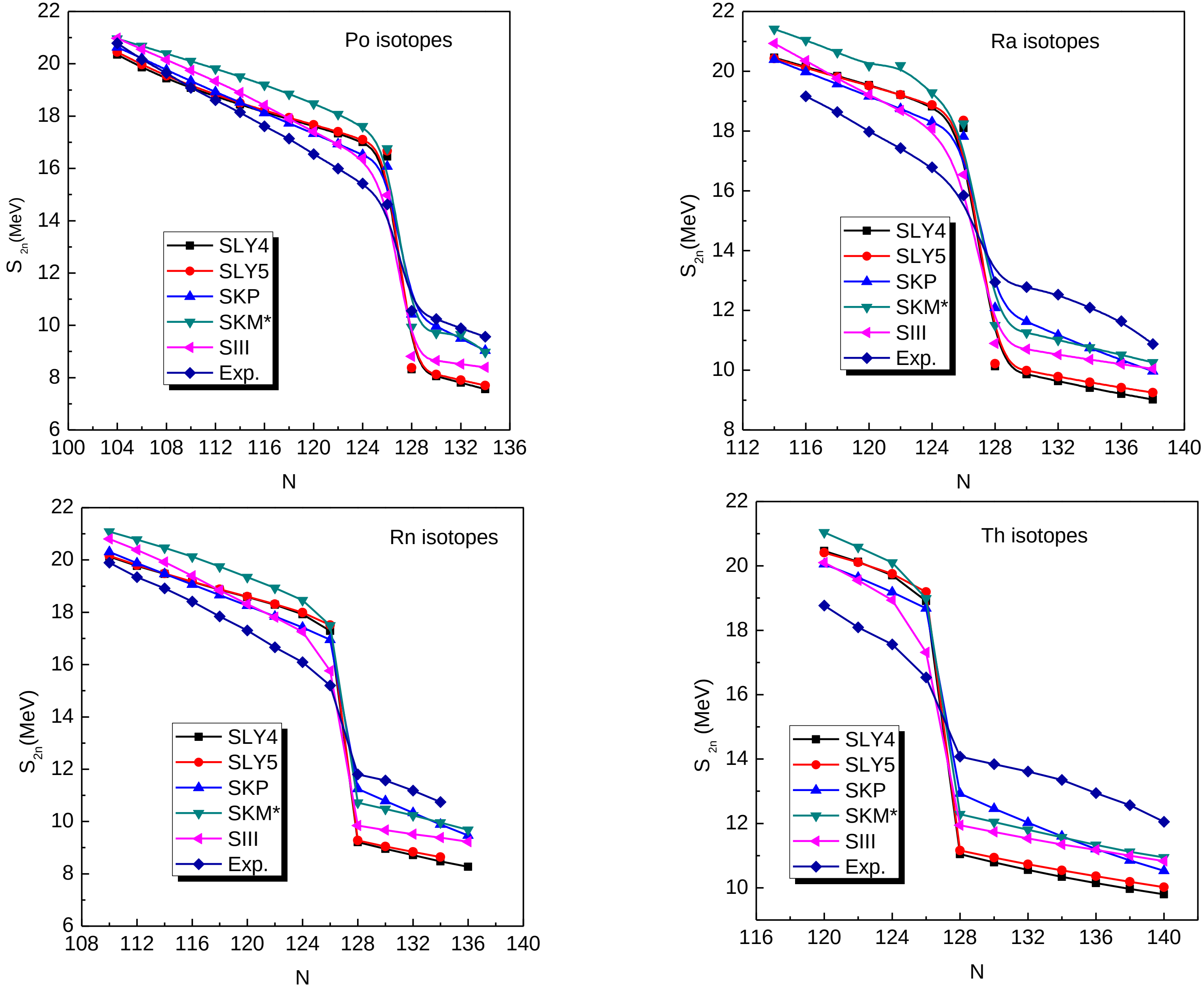




Charge Radius (Rc)



Two Neutron Seperation Energy (S_{2n})



Conclusion

- The used model is capable to describe the BE/A, RMS and S_{2n} values by selecting suitable Skyrme force parametrizations. Furthermore, when comparing the calculated results with the experimental data, the calculated results are in a good agreement with experimental ones and other theoretical model FRDM.

Thank you