# Neutron separation energies of Ca, Sn and Pb isotopes using different mass models

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## Introduction

Many microscopic theories have been devoted for calculating nuclear masses, binding energies, nucleon separation energies and other global properties. Nucleon separation energy plays an important role in predicting new shell closures in the proton and neutron drip line nuclei. The one and two nucleon separation energies are fundamental properties of the atomic nucleus. The systematic study of proton and neutron separation energies are essential to investigate nuclear structure toward drip lines [1]. In literature it is understood that the energy spend in removing two fermions from a system of identical fermions shows system stability [2]. If the pairing dominates in fermion-fermion interaction, then energy required to separate two fermions for even number of particles will be much higher than odd number. These characteristics can be observed from the study of two neutron separation energy $S_{2n}$. It is known that in neutron-rich nuclei, odd magic numbers disappear and new ones appear. It is also very useful to plot $S_{2n}$ and study the kinks as evidence for magicity [3]. In this work we present an investigation of $S_{2n}$ which is quite a sensitive quantity to test any microscopic model [4]. Two popular models are Relativistic Mean Field (RMF) and Infinite Nuclear Matter (INM) model. The objective of the present study is to undertake a systematic analysis of two neutron separation energy using these models in comparison with experiment.

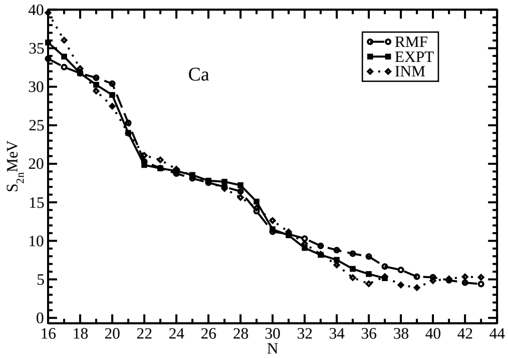


FIG. 1: Two neutron separation energy for $^{20}Ca$ as a function of N for fixed Z using different mass models and experimental result.

The INM model of atomic nuclei was prepared in 1999 [5] using known mass data of Audi-Wapstra published in 1993 [6]. During the last few decades, RMF theory is very successful in describing many nuclear phenomena for both stable and unstable nuclei. RMF theory can reproduce the accurate nuclear saturation properties in nuclear matter and account automatically the spin orbit interaction. The use of RMF formalism for finite nuclei as well as the infinite nuclear matter are well documented and details can be found in [7].

Two neutron separation energy is the required energy to remove two neutrons from a nucleus with Z protons and N neutrons. It is calculated by using the expression:

$$S_{2n} = BE(N, Z) - BE(N - 2, Z) \qquad (1)$$

It is a big challenge for nuclear many body theories to explain shell closure, new magicity in terms of proton and neutron separation energies [3]. To discuss the usefulness of dif-

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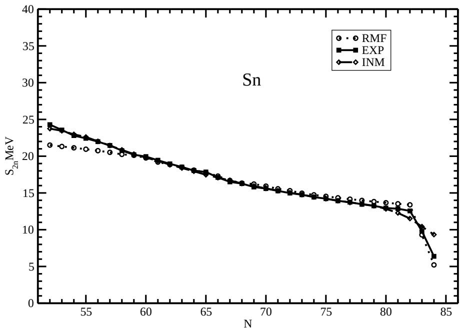


FIG. 2: Same as figure 1 but for $^{50}Sn$.

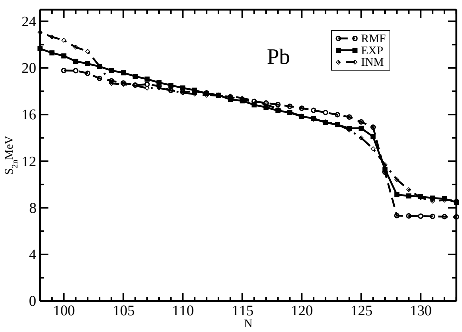


FIG. 3: Same as figure 1 but for $^{82}Pb$.

ferent models we plot $S_{2n}$ as a function of N for a particular Z using different isotopes of Ca, Sn and Pb. We shall find here that these new plots give useful information regarding the advantage of different models. The evolution of nuclear collectivity is observed in terms of smooth variation of $S_{2n}$ as a function of N or Z. It also shows the position of neutron subshell closures if the proton spherical subshell closures will not influence the two neutron separation energies.

## Summary and Conclusion

In this work, the results of self-consistent RMF calculations for two neutron separation energies have been performed for Ca, Sn and Pb isotopes using RMF theory for NL3 parameter set. Our calculations using RMF theory and predictions of INM model are in excellent agreement with the experimental results [8] for $S_{2n}$. The two neutron separation energies and their variation with proton and neutron number disclose nuclear structure information and it gives a check for various nuclear structure models. In this regard a further study like $S_{2p}$, $S_{1p}$, $S_{1n}$ are in progress.

## References

[1] C. A. Radha, V. Ramasubramanian and E. J. J. Samuel, *Elect. J. of Theo. Phys.* **8**, 327 (2011).
[2] S. Anghel, G. C. Danil, and N. C. Zamfir, *Rom. Journ. Phys.* **54**, 301 (2009).
[3] A. Abbas, *Mod. Phys. Lett. A* **20**, 2553 (2005).
[4] S. Zhang, Jie Meng and S. Zhou, *Science in China(Series G)* **46**, 632 (2003).
[5] R. C. Nayak and L. Satpathy, *At. Data and Nucl. Data Tables* **72**, 213 (1999).
[6] G. Audi and A. H. Wapstra, *Nucl. Phys. A* **565**, 1 (1993).
[7] S. K. Patra and C. R. Praharaj, *Phys. Rev. C* **44**, 2552 (1991); Y. K. Gambhir, P. Ring, and A. Thimet, *Ann. Phys.* (N.Y.) **198**, 132 (1990).
[8] G. Audi, O. Bersillon, J. Blachot and A. H. Wapstra, *Nucl. Phys. A* **729**, 3 (2003).