Single-neutron and Two-neutron Separation energies in Odd-A nuclides of Ar and Ca

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Introduction

The study of nuclear structure properties of the nuclides is always a challenging task in nuclear physics as the nuclear chart is not fully explored experimentally. Complexity of many body problem makes the task even more difficult. Theoretical models can serve better this purpose. The models available to study nuclei are best suited for the even-even system of nuclei only [1, 2]. Here in this work, we have made an attempt to study the Odd-A (A is mass number of respective nuclei) nuclides and we have selected Odd-A Ar and Ca isotopes for our purpose as a lot of crucial experimental information [5] is availabe for these nuclides. We present our theoretical results of single-neutron separation energies S_n and two-neutron separation energies S_{2n} for isotopes these nuclides. The theoretically computed results with DD-PC1 [3] and DD-PCX [4] parameterization of Relativistic-Hartree-Bogoliubov Nuclear Density Functional are reasonably reproducing the recently available experimental [5] extractions.

Theoretical Framework

This work has been done by using Relativistic-Hartee-Bogoliubov (RHB) Theory [6, 7] with DD-PC1 [3] and DD-PCX [4] parameterizations. A brief discussion of this models is given below.

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1. DD-PC Model

In RMF phenemenology, Lagrangian density of point coupling models including the isoscalar-scalar $(\overline{\psi}\psi)^2$, isoscalar-vector $(\overline{\psi}\gamma_\mu\psi)(\overline{\psi}\gamma^\mu\psi)$, and isovector-vector $(\overline{\psi}\vec{\tau}\gamma_\mu\psi).(\overline{\psi}\vec{\tau}\gamma^\mu\psi)$ four-fermion contact interactions in the isospace-space can be written as [3],

$$\begin{aligned}\mathcal{L} = \overline{\psi}(i\gamma.\partial - m)\psi - \frac{1}{2}\alpha_S(\rho)(\overline{\psi}\psi)(\overline{\psi}\psi) \\ -\frac{1}{2}\alpha_V(\rho)(\overline{\psi}\gamma^\mu\psi)(\overline{\psi}\gamma_\mu\psi) \\ -\frac{1}{2}\alpha_{TV}(\rho)(\overline{\psi}\vec{\tau}\gamma^\mu\psi)(\overline{\psi}\vec{\tau}\gamma_\mu\psi) \\ -\frac{1}{2}\delta_S(\partial_\nu\overline{\psi}\psi)(\partial^\nu\overline{\psi}\psi) - e\overline{\psi}\gamma.A\frac{1-\tau_3}{2}\psi. \quad (1)\end{aligned}$$

Result and Discussion

The quantity $S_n(\mathrm{Z}, N)$ known as single-neutron separation energy is defined as

$$S_n(Z, A) = B(Z, N) - B(Z, N-1) \quad (2)$$

where $B(Z, N)$ represents the binding energy of the nuclei with atomic number Z and neutron number N. Whereas the two-neutron separation energy is defined as the energy required to remove two neutrons from a nucleus. It is calculated by using the formula,

$$S_{2n}(Z, N) = B(Z, N) - B(Z, N-2) \quad (3)$$

We have calculated theoretically the results of S_n(Z,N) and S_{2n}(Z,N) for Odd-A isotopes of Ar and Ca with the help of binding energies B(Z,N) and B(Z,N-2). Comparison of theoretical results with the experimental data [5] is also done in our studies. These results along with the experimental data are shown in Figures 1 and 2. Figure 1, presents results of

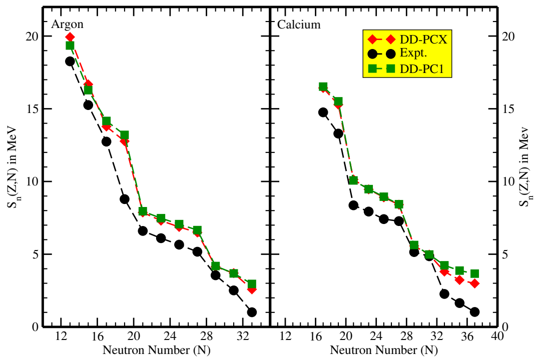

FIG. 1: (color online) The variation in experimental [5] and theoretical single-neutron separation energy $S_n(Z, N)$ in units of MeV, plotted as a function of neutron number N, for the exotic nuclei of Argon (left panel) and Calcium (right panel).

single-neutron separation energies and Figure 2 presents our theoretical estimates of two-neutron separation energies for the Odd-A nuclides of Ar and Ca. All our theoretical estimates with DD-PC1 and DD-PCX parameterizations are in good agreement with the experimental data [5] reflecting the efficiency of RHB model with respective parameterizations used in the work. These results also show that the separation energies depend on the type of effective interactions used in the theoretical calculations.

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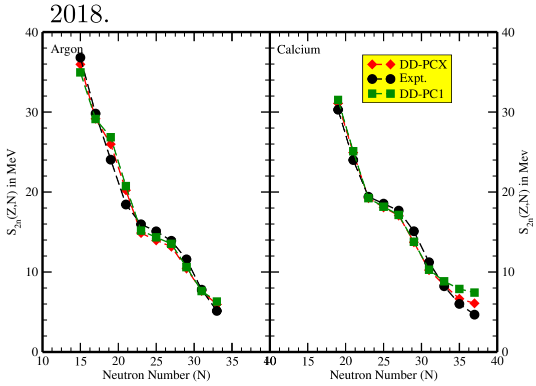

FIG. 2: (color online) The variation in experimental [5] and theoretical single-neutron separation energy $S_{2n}(Z, N)$ in units of MeV, plotted as a function of neutron number N, for the exotic nuclei of Argon (left panel) and Calcium (right panel).

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