Study of subshell gap around *N* = 70 for neutron-rich nuclei

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Introduction

The study and search for new regions of shell closure for nuclei away from stability is a topic of current interest both experimentally and theoretically. There have been few studies predicting a weak spherical subshell gap of ^{110}Zr (*N* = 70), for example Ref. [1]. This is supported by a recent study indicating that the spherical *N* = 70 shell gap may not have a large effect at *N* = 68 for Zr isotopes [2]. It would be, therefore, interesting to know whether there is a subshell closure at *N* = 70 in the neutron rich region and also for the very neutron-rich nuclei, ^{110}Zr.

Systematic studies from measurements of nuclear masses have provided vital indications of shell closures. Ozawa *et al.* [3] have reported a new magic number at *N* = 16 near the neutron drip line by surveying the neutron separation energies and the interaction cross sections for these nuclei. In this short communication, we carry out an investigation of the neutron number dependence of one neutron separation energies in the *N* = 70 region, similar to that of Ref. [3]. It is of interest to know if there is a subshell closure at N = 70 and what is the strength if it exists.

Earlier, we have carried out elastic scattering calculations for 50 MeV proton scattering from chain of Zr isotopes [4]. These investigations were carried out by analyzing the microscopically generated *p*-nucleus optical potentials in the framework of first order Brueckner theory employing Urbana V14, soft-core inter-nucleon interaction along with the relativistic mean field (RMF) densities both for protons and neutrons. These calculations showed that there is a small increase in the reaction cross section as well as the magnitudes of the first maximum of the analyzing power for ^{110}Zr [4]. One can check this prediction as well for ^{110}Zr in the present work where analysis is carried out by studying the neutron number dependence of neutron separation energies as reported in this abstract.

Results and Discussions

Since there is no experimental information available for ^{110}Zr, we have taken the values of one neutron separation energies, S_n from Ref. [5]. The one neutron separation energies, S_n [5] as a function of neutron number, *N* for Sr, Zr and Mo isotopes are plotted in Fig. 1. Fig. 1 shows that there is a change of slope in S_n at *N* = 70 but it is not large enough. This is consistent with the findings of Ref. [2] where it is indicated that the spherical *N* = 70 shell gap (*Z* = 40) may not have a large effect at *N* = 68 for Zr isotopes. Our results are also in agreement with that of Ref. [1] that the predicted spherical *N* = 70 shell gap may be weak. The small change in slope of S_n for chain of Zr isotopes observed in Fig. 1 is consistent with the prediction of a small increase in cross section and analyzing power of Ref. [4]. It must be noted here that systematic investigations are required to reach a definite conclusion.

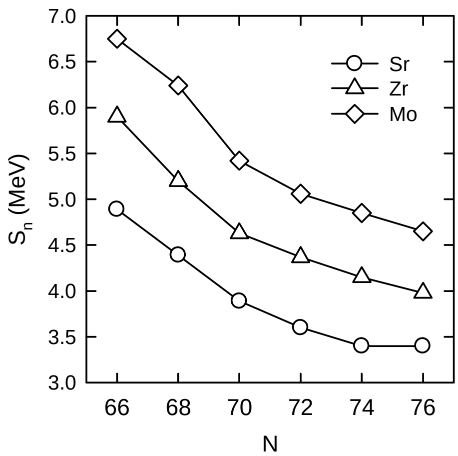

Fig. 1 The single neutron separation energies, S_n [5] as a function of neutron number, *N* for Sr, Zr and Mo isotopes. The S_n values have been taken from Ref. [5]. The solid lines are to guide the eye.

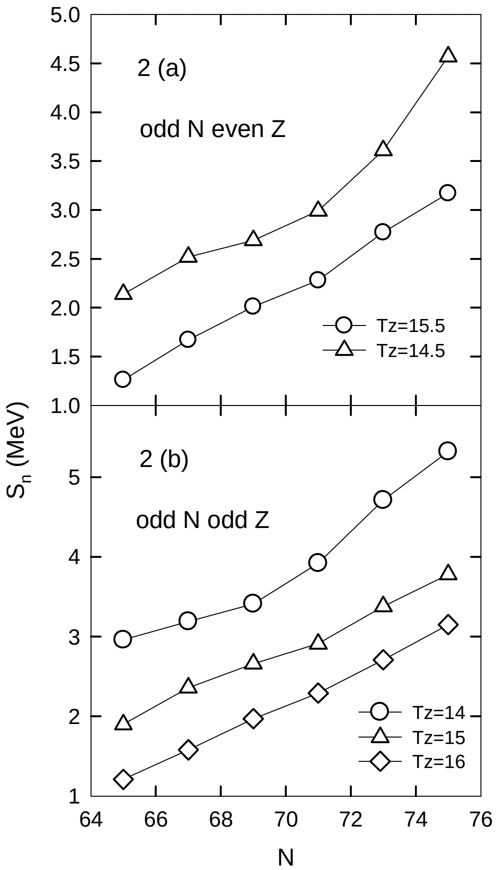

Fig. 2 One neutron separation energies, S_n [5] as a function of neutron number, *N* for nuclei with (a) odd *N* even *Z* (b) odd *N* odd *Z*, for different T_z values. The S_n values have been taken from Ref. [5]. The solid lines are to guide the eye.

The plot of single neutron separation energies, S_n [5] as a function of neutron number, *N* for nuclei with odd *N* even *Z* and odd *N* odd *Z* are given in Fig. 2 (a) and 2 (b), respectively. The neutron number dependence of S_n is shown in Fig. 2 (a) and 2 (b) for different T_z values. Fig. 2 indicates a hint of a change of slope at *N* = 70 for the different T_z values.

There is a small break in the S_n values but much less pronounced as that observed for light nuclei by Ozawa *et al.* [2]. This small change obtained in S_n for *N* = 70 and *Z* = 40 is in agreement with a possible weak subshell closure reported in Ref. [1, 2].

Summary

In summary, we have investigated the subshell gap in the *N* = 70 region. It is found that there is a small change in the slope of S_n with the increase of neutron number in this region. This is in accordance with the results of Ref. [2] that suggests the spherical *N* = 70 shell gap (*Z* = 40) may not have a large effect at *N* = 68 for Zr isotopes. Our results are also in agreement with that of Ref. [1] that the predicted spherical *N* = 70 shell gap may be weak. Also the small change in slope of S_n for chain of Zr isotopes observed in Fig. 1 is consistent with the prediction of a small increase in the cross section and the first maximum of the analyzing power for 50 MeV proton scattering from chain of Zr isotopes [4]. Calculations are underway to have more insight about the subshell nature of ^{110}Zr and also the *N* = 70 subshell gap.

Experimental information about the very neutron-rich ^{110}Zr is not yet available. Further calculations and measurements in the *N* = 70 region are required to ascertain the extent of the subshell gap at *N* = 70.

References

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