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# Study of Nuclear Structure for N=50 Isotones at Z=28 Shell Closure

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## Abstract

The influence of filling the pfg proton shells on low-lying states structure for neutron-rich N=50 isotones have been studied for the nuclei $^{80}$Zn, $^{82}$Ge, $^{84}$Se and $^{86}$Kr. The shell model calcula-tions have been performed in the model space jj45pn, using the effective interaction jj45pnb. Energies of low-lying states, reduced transition probabilities B(E2; $J_{i\rightarrow}J_f$), the quadrupole moment Q and the deformation parameter are evaluated for studied nuclei, We compare the gotten results with available experimental data.

**Keywords:** NushellX@MSU Shell Model Code, Realistic Interaction, Doubly Magic $^{78}$Ni Core, Deformation Parameter, Transition Probabilities

## 1. INTRODUCTION

Due to the huge progress in experimental techniques, it became possible to explore more exotic nuclei, especially those with large N/Z ratio, and which lies at the drip-lines. From these nuclei, neutron rich nickel $^{78}$Ni and its neighbouring present a challenge for both experimental and theoretical investigations. For this region, several works were evaluated since the last decade [1-5], nowadays, different international groups work independently at ISOLDE facility (CERN), in the RIBF in Tokyo, and in Technische Universitat Dresden, Germany. These research groups have recently confirmed the doubly magicity of $^{78}$Ni, also insight our knowledge about nuclei in this region.

For this purpose we are interested about the structure of the N=50 isotones near this doubly magic core in term of shell model theory; in order to know the influence of populating the pfg proton shells on the nuclei of this part of nuclear chart.

Therefore this paper is aimed to study the influence of populating the pfg proton shells on the structure of $^{80}$Zn, $^{82}$Ge, $^{84}$Se and $^{86}$Kr nuclei lie in this mass region.

## 2. EFFECTIVE INTERACTION AND SINGLE PARTICLE ENERGIES

The aim of microscopic nuclear structure calculations is to derive different properties of finite nuclei from the underlying Hamiltonian describing the interaction between nucleons. These nucleons occupy selected orbits which define the model space.

Calculations were performed with the model space comprised of ($1f_{5/2}$, $2p_{3/2}$, $2p_{1/2}$ and $1g_{9/2}$) orbits for protons using the NuShellX@MSU shell model code considering the $^{78}$Ni as an inert core; employing an effective interaction which is an extension of the renormalized G-matrix interaction based on the Bonn-C NN potential named jj45pnb [6].

On the basis of the new interpretations proposed in ref.[5], the study of experimental spectra of $^{79}$Cu highlights the possibility of $1f_{5/2}$ is the ground state and $2p_{3/2}$ is the first excited one, contrary to what postulated for the proton and neutron rich $^{57-73}$Cu isotopes [7,1]. This is due to the island of inversion existed at N=40-50. This study permits to know the proton single particle energies which are displayed in Table.1 in units of keV.

Table 1. Single particle energies for protons in $^{78}$Ni region

| Orbit | $1f_{5/2}$ | $2p_{3/2}$ | $2p_{1/2}$ | $1g_{9/2}$ |
|---|---|---|---|---|
| Energies(keV) | -15.022 | -14.366 | -13.511 | -12.762 |

## 3. RESULTS AND DISCUSSION

In this section we will study some nuclear properties of the N=50 isotones, especially those of even A. First, we present the excitation energies of 2+ and 4+ states, the calculation shows rather good agreement especially with the experiment for the $^{80}$Zn. Structure of the wave function for low spin states is presented in Fig.1..

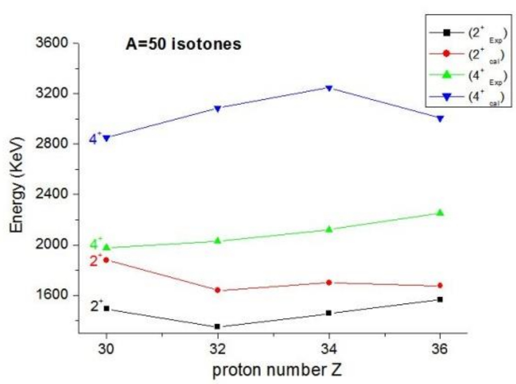


Figure 1. Experimental excitation energies of N=50 isotones compared with the experimental values [8-9].

Main configuration of proton orbits for the first three states in N=50 isotones obtained with the jj45pnb interaction are shown on Table.2.

Table 2. Main configuration of proton orbits occupation and their percentages

| Nucleus | Main Configuration | Percentage |
|---|---|---|
| $^{80}Zn$ | $(1f_{5/2})^2$ | 35%-76% |
| $^{82}Ge$ | $(1f_{5/2})^2\ (2p_{3/2})^2$ | 17%-36% |
| $^{84}Se$ | $(1f_{5/2})^2\ (2p_{3/2})^2\ (1g_{9/2})^2$ | 20%-23% |
| $^{86}Kr$ | $(1f_{5/2})^4\ (2p_{3/2})^2\ (1g_{9/2})^2$ | 31%-39% |

The second part of this work is to determine some spectroscopic properties for studied nuclei, since experimental data about this region are not well known, especially for the quadrupole moment Q, we realize a fit in order to reproduce the available experimental data, which allowed us to get the best value of proton effective charge ($e_\pi$=1.95e). Results are summarized on Fig.2. We present only our calculated results for Q. Deformation parameter b values show that these nuclei are deformed, where Q values change of sign for $4^+$ level from positive to negative value when the number of protons increased systematically with isotones. This leads to a change of shape for this level. But the Q value for $2^+$ stay constant and less than 0 meaning it has oblate form.
It was found that, reduced transition probabilities B(E2: $2^+_1 \rightarrow 4^+_1$) are almost constant, but B(E2: $0^+_1 \rightarrow 2^+_1$) have linear behavior when Z increase.

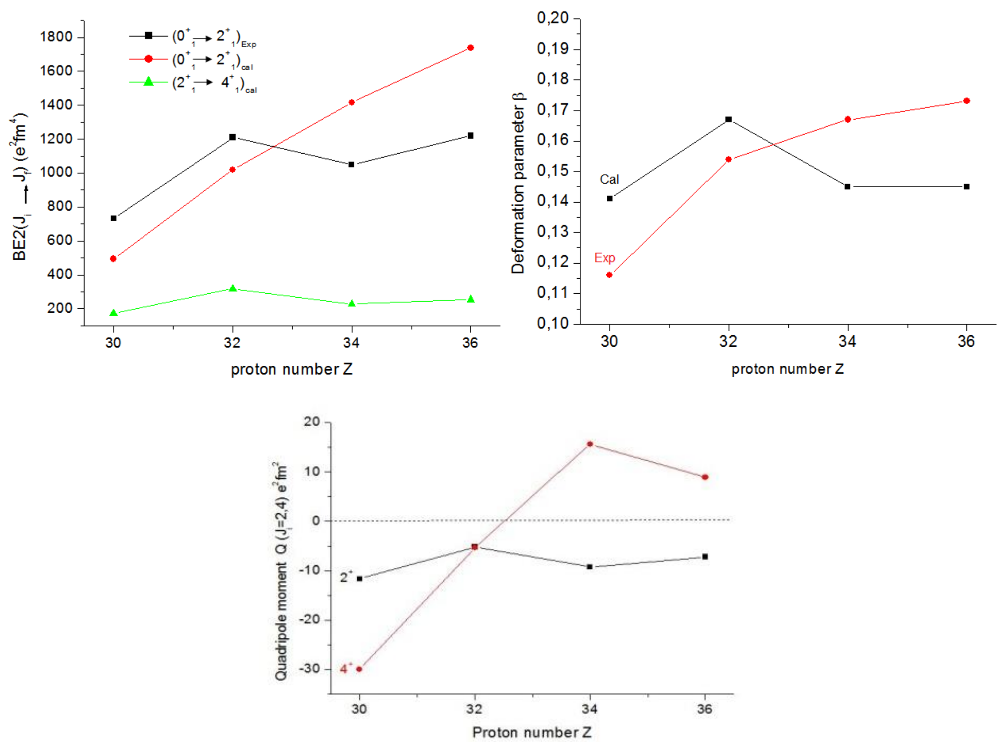


Figure 2. Calculated B(E2: $0^+_1 \rightarrow 2^+_1$), B(E2: $2^+_1 \rightarrow 4^+_1$) and β values compared with the available experimental data [8] ( upper part). Calculated Q values (lower part); for N=50 isotones.

## 4. CONCLUSION

Our results are in rather good agreement with the available experimental data. The values of deformation parameter $\beta$ show that this region is a region of deformation. On the other hand, Q values for $4^+$ level change sign from positive to negative value when the number of protons increased systematically with isotones. This proves the existence of changing shape and symmetry. We conclude that populating the pfg proton shells with more protons lead to a change of shape.

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