International Journal of Nuclear and Radiation Science and Technology (IJNuRaSaT)
Vol. 1-No.1 (2016) pp. 12-14
http://ulakbim.dergipark.gov.tr/ijnurasat

Research Article

Nuclear Structure Properties of the N=81 Odd-Odd Isotones in ^{132}Sn mass region

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(Received date: 4 November 2015 , Accepted date: 20 February 2016)

Presented in "2nd International Conference on Computational and Experimental Science and Engineering (ICCESEN-2015)"

Keywords
Nuclear structure
Particle-hole nuclei
Oxbash code
N=81 isotones

Abstract: Study of nuclear shell evolution, from the proton to the neutron drip-lines, is of great theoretical interest. In the framework of studying and understanding the role of these effects, shell model calculations have been realized for interpreting and developing the two body matrix elements of N-N interaction. In this context and in order to reproduce the nuclear properties of odd-odd N=81 isotones in the ^{132}Sn mass region; we have performed these calculations using available experimental single particle and single hole energies, by means of Oxbash nuclear structure code. The two-body matrix elements (TBME) of the using effective interactions were deduced from a realistic interaction for ^{100}Sn mass region, and using single particle or single hole energies from ^{132}Sn mass region.

1 Particle-hole system structure

The study of nuclear structure near drip lines provide excellent opportunities to develop theoretical spectroscopic models, in order to improve the existing description of nuclear interaction. In this context, the odd-odd nuclei with single hole nearby ^{132}Sn doubly magic core offer important information on the *p-n* part of the nuclear force [1].

As the creation of a hole state with quantum numbers *n, l, j* and *m* is equivalent to the annihilation of a particle state with the quantum numbers *n, l, j* and *-m*, the single-hole configuration can be described in terms of single-particle one [1].

For the operator $b^{+}(jm)$ creating a single hole [1]:

$$b^{+}(jm)\equiv a(\bar{j}\bar{m})=(-1)^{j+m}a(j-m) \qquad (1)$$

Thus, the single hole state can be obtained using this operator. The matrix elements for hole states and those for the single particle are, then, related by

$$\left\langle j_2^{-1}m_2\middle|F\middle|j_1^{-1}m_1\right\rangle=-\left\langle \bar{j}_1\bar{m}_1\middle|F\middle|\bar{j}_2\bar{m}_2\right\rangle+\left\langle\hat{0}\middle|F\middle|\hat{0}\right\rangle\delta\big((n_1l_1)j_1m_1,(n_2l_2)j_2m_2\big) \qquad (2)$$

Here, F is an arbitrary single particle operator.

2 Results and discussion

In this work, we focused our calculation on the study of N=81 isotones in ^{132}Sn mass region. In this context, the calculations of some nuclear properties for these nuclei are developed in the framework of the nuclear shell model by means of Oxbash nuclear structure code [2].

- The ^{136}Cs is one of these nuclei, with five proton particles and one neutron hole in addition to the tin core, and decays by Beta minus decay with a half-life of 13.16 day. Its ground state has $J^{\pi}=5^{+}$, and the first excited state has $J^{\pi}=8^{-}$.
- The ^{134}I nucleus has three particle proton and a hole neutron in addition to the tin core. The energy levels are recently identified from the spontaneous fission of ^{252}Cf [3].
- The ^{132}Sb nucleus has a particle proton and a hole neutron in addition to the tin core. The 4^{+}, 3^{+}, 5^{+}, and 2^{+} states have the configuration $(\pi 1g_{7/2})^{1}$ $(\nu 2d_{3/2})^{-1}$, and the 8^{-} state has the $(\pi 1g_{7/2})^{1}$ $(\nu 2h_{11/2})^{-1}$ configuration [4].

The Fig.1 shows the experimental spectra of these nuclei taken from nndc.bnl.gov.

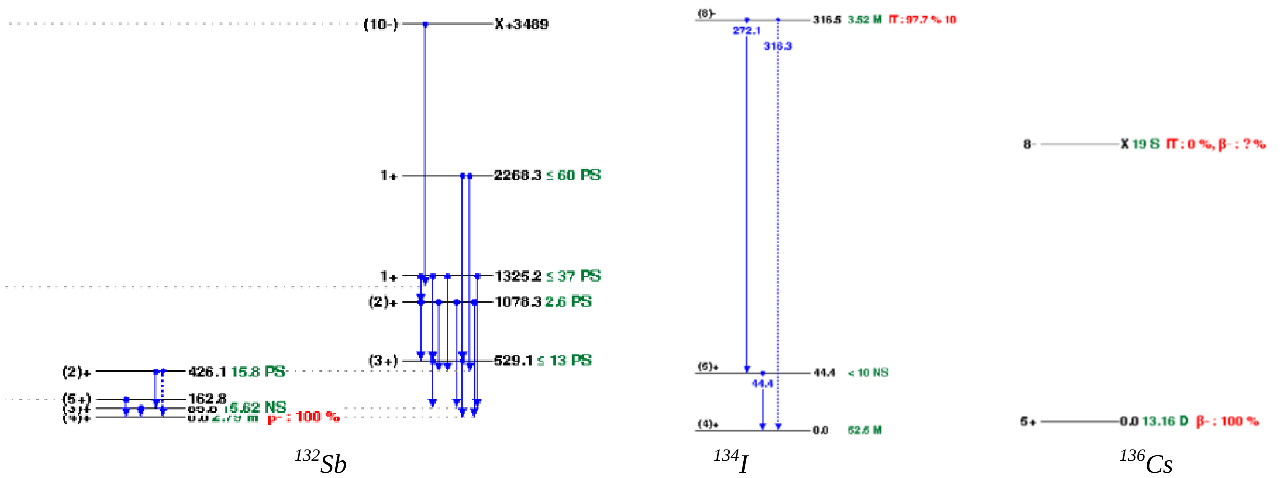

Figure 1. *Experimental spectra of N=81 odd-odd isotones in ^{132}Sn mass region with Z=51, 53 and 55, respectively [5].*

In this work, we carry out some modifications on the *CD-Bonn* interaction [6], basing on the consideration of pairing hole effect with the use of the recent experimental single particle and single hole energies (SPE , SHE) [3, 6, 7].

The calculations of some nuclear properties for *N=81* isotones with Z=51, 53 and 55 are developed in the framework of the nuclear shell model by means of Oxbash nuclear structure code, and a new interaction named *snh* is introduced.

$$\langle j_1 j_2 |V| j_2 j_4 \rangle_{snh} = \left\{ \langle j_1 j_2 |V| j_2 j_4 \rangle_{CD-Bonn} + pairing\,effect \right\} \quad (3)$$

Pairing correlations of the extra pair formed when creating 2h1p configuration can be expected using neutron hole pairing energy, which can be calculated by [8]

$$\Delta(h) = 2S_p(Z,N) - S_{2p}(Z,N) \qquad (4)$$

Z and N denote respectively the closed shell proton and neutron numbers. This energy difference reduces to the pairing energy for the extra hole-pair (particle-pair), for single hole (or single-particle) nucleus.

The space model is composed of $\{0g_{7/2}, 1d_{5/2}, 1d_{3/2}, 2s_{1/2}$, and $0h_{11/2}\}^{Z-50}$ orbitals for particle protons and $\{0g_{7/2}, 1d_{5/2}, 1d_{3/2}, 2s_{1/2}$, and $0h_{11/2}\}^{N-50}$ orbitals for hole neutrons. The *SPE* and *SHE* are respectively taken from the experimental spectra of *^{133}Sb* and *^{131}Sn* [3, 6, 7, 9]. The obtained results are presented in Fig.2 in comparison with the experimental data.

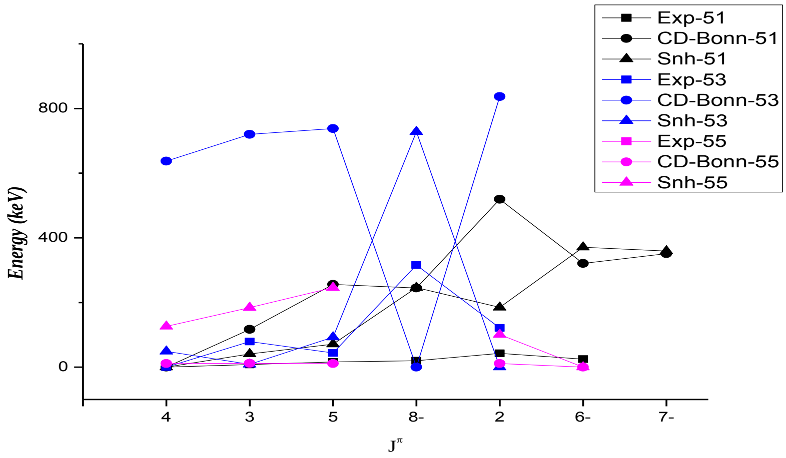

***Figure.1**. Calculated energetic spectra using CD-Bonn [6] and snh interactions for N=81 isotones, with Z=51, 53 and 55, in comparison with the experimental ones.*

Our new interaction reproduce the experimental ground state and the energetic sequence of ^{132}Sb however, it cannot reproduce the experimental ground and the first excited states of ^{134}I and^{136}Cs. It is the same case for CD-Bonn [6] that gives, respectively, 4^+, 8^-, and 5^+, 8^- as the ground and the first excited states for the two isotones.

3 Conclusion

This study is based on the nuclear properties calculations, for odd-odd N=81 isotones, with particles-hole configuration of there valence spaces. The calculations are carried out in the framework of the shell model, by means of OXBASH nuclear structure code. Using the original interactions of the code, we carry out some modifications based on the neutron hole pairing interaction to get snh interaction. Our new interaction cannot reproduce the experimental energetic spectra of the studying nuclei. It is the same case for the original interaction.

Acknowledgement

Authors thanks to ICCESEN-2015 for the organization and the supports providing during this conference.
Special thanks are owed to B. A. Brown for his help in providing us the OXBASH code (Windows Version).

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