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Research Article

Monopole Correction Effects on even nuclei near ^{132}Sn region[#]

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Abstract: Nowadays, the role of three-nucleon forces in the description of nuclear structure properties is a main topic in the field of microscopic many-nucleon calculations. Our work have been focused on the study of the spectroscopic properties of the even-even isobars around ^{132}Sn region. Based on the Schrödinger equation, the calculations are carried out by means of OXBASH nuclear structure code in taking into account the three-body forces interaction. After some modifications, a new interaction is derived from kh5082 empirical interaction. The energies of the low-lying states of these isobars have been determined. The obtained results have compared with available experimental data.

1. Introduction

The neutron-rich nuclei with few-valence nucleons above the doubly closed ^{132}Sn core are interesting to extract empirical NN interaction and to test the theoretical description of the nuclear structure shell model in this mass region. These nuclei are of a great interest for modeling r-process, and comprehension the element abundances in the universe. The study of their structure properties aims to gathering new data on decay of Sn isotopes beyond the magic ^{132}Sn nucleus. These data are important inputs for astrophysical r-process model calculations. Therefore, they give an opportunity to develop our knowledge about the NN interaction. A lot of studies have been performed in this region, by modelling using the mean field or the shell model [1-4].

The even-N neutron-rich *Sn* isotopesare the classical "waiting point" nuclei in the A=130 solar system abundance peak under typical r-process conditions. With respect to the r-process, N=86 isotope is an important waiting-point nucleus for moderate neutron densities to drive the r-process flow beyond A≃130 peak. For such systems, the consideration of the three-body monopole effects is presently a relevant issue in nuclear structure calculations in order to reproduce their experimental studies.

The aim of the present study is devoted to determine excitation energies for the even-even nuclei with two, four and six valence nucleons around ^{132}Sn mass region. Basing on three body effects, we carry out some modifications on the kh5082 original interaction [5] and new interaction named khm is constructed.

2. Calculations

The two body realistic interactions derived from the N-N force fail to reproduce some nuclear properties of some isotopic chains [2]. A. Poves and A. Zuker [6] shown that it is required to consider the monopole interactions between the core and the valence particles.

$$H = H_m + H_M \quad (1)$$

where H_M and H_m denote respectively the multipole and the monopole Hamiltonians. The diagonal form of H_m is given by Eq. 2 if the model space contains only one or two neighbouring oscillator shells.

$$H_m = E_0 + \sum_i \varepsilon_i n_i + \sum_{i \le j} V_{ij} \frac{n_i(n_j - \delta_{ij})}{1+\delta_{ij}} \quad (2)$$

where ε_i correspond the single particle energies (SPEs) and n_i, n_j are the valence nucleon numbersin the i and j shells, respectively.

The centroid V_{ij}, expressed as the sum over all allowed values (JT) of the two-body matrix elements, is defined by:

$$V_{ij} = \frac{\sum_{JT} (2J+1)(2T+1) V_{ij}^{JT}}{\sum (2J+1)(2T+1)} \quad (3)$$

The diagonal two-bodymatrix element (TBME) $\langle i, j | V | i, j \rangle_{JT}$ represents the antisymmetric state of spin and isospin angular momenta (JT) of coupling of two nucleons in i and j orbitals. It can be determined in the neutron-neutron and proton-proton pairs cases by using the binding energies of nuclei taken from ref. [7].

Large basis calculations are carried out by means of Oxbash nuclear structure code [8], in the framework of the shell model in jj56pn model space. Basing on three body effects [7], we have realized some modifications on the empirical kh5082 interaction [5]. The TBME of this original interaction are modified taking in consideration the monopole effect for even-even nuclei in the ^{132}Sn region.The nn (V^{nn}) and pp (V^{pp}) monopole terms values obtained by Eq. 3 were found equal to 395 keV and 291 keV, respectively. Therefore, the n-n tbme $\langle ff | V | ff \rangle^{T=0}_{J=0^+ to 6^+}$ and p-p tbme $\langle gg | V | gg \rangle^{T=1}_{J=0^+ to 6^+}$ are modified. Then, we have multiplied the obtained elements by the renormalization factors taken from [9-12]. Here g and f refer to $\pi g_{7/2}$ and $\nu f_{7/2}$ respectively. New interaction named khm is constructed. The new experimental values of proton and neutron SPEs are taken from ref. [13].

The Fig. 1 shows the calculated spectra using kh5082 [5] and khm interactions in comparison with the experimental data for N=82, 84,86 and 88 isotones.

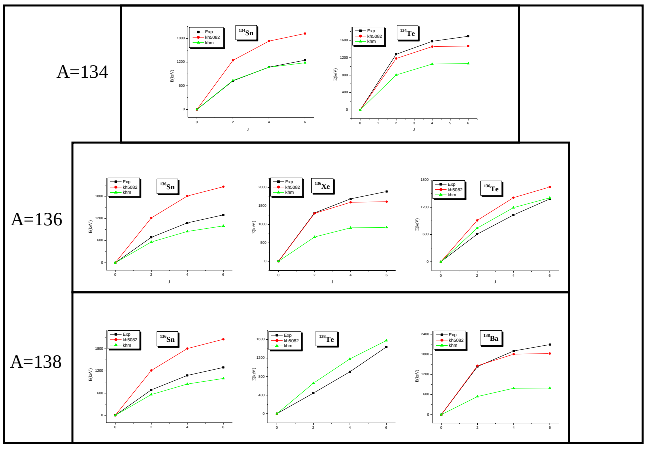

***Figure 1**. Calculated energies by means of kh5082 and khm interactions in comparison with the experimental ones for ^{134}Sn, ^{134}Te, ^{136}Sn, ^{136}Te, ^{136}Xe, ^{138}Sn, ^{138}Te and ^{138}Ba.*

We first discuss our results for the two A=134 isobars. These nuclei, with two valence protons and two neutrons, allow a direct study of the main features of the proton-proton and neutron-neutron interactions in the presence of the same closed core [14]. This is particularly interesting because of the large difference between proton and neutron experimental energy gaps. More precisely, while the first 2^+ state in ^{134}Te lies at 1279 keV, the excitation energy of this state in Sn drops to 726 keV. We note that all states reported in Fig. 1 have a weak configuration mixing. More accurately, the ground state as well as the three excited states are dominated by the $(\pi g_{7/2})^2$ configuration in $^{134,136,138}Te$ and by the $(\nu f_{7/2})^2$ configuration in $^{134,136,138}Sn$. This emphasizes to only focus our attention on the TBMEs involving these two configurations.

On the basis of these results, we can show two very important ideas :The first exposes the contribution of the three body effects on the neutron-neutron and proton-proton interactions in the shell model calculations. As it is clear, the V^{nn} monopole effect on $^{134-136-138}Sn$ isotopes is more interesting than the V^{pp} one on N=82 isotones (^{134}Te, ^{136}Xe and ^{138}Ba nuclei).

The original kh5082 interaction represents the proton-proton interaction better than the modified khm one, as we can see in ^{134}Te, ^{136}Xe and ^{138}Ba nuclei. The consideration of the two corrections V^{nn} and V^{pp} in the modified khm interaction gave the closest values to the experimental data as shown on the ^{136}Te nucleus.

The second idea shows the influence of the ^{132}Sn inert core on the calculations of energy spectra of the nuclei with valence protons i.e. the effect of the interaction of neutrons located in the N =82-126 shells on the valence protons in the Z = 50-82 shells [15].

3. Conclusion

in this work we are interested by studying and understanding of the monopole effect role on the shell model calculations for the even-even nuclei near the neutron-rich tin region. the calculation are carried out in the framework of the shell model, by means of oxbash nuclear structure code. basing on kh5082 interaction, some modifications are released using the monopole correction and a new interaction khm is introduced. the new experimental values of speswere used. the monopole term v^{nn} is more interesting than the v^{pp} one. the original kh5082 interaction represents the proton-proton interaction better than the modified khm one, as in the case of ^{134}te, ^{136}xe and ^{138}ba nuclei unlike the neutron-neutron interaction as in the case of ^{134}sn, ^{136}sn and ^{138}sn nuclei. the consideration of the two corrections v^{nn} and v^{pp} in the modified khm interaction gave the closest values to the experimental data.the three body effects in even-even nuclei in addition to the kh5082 interaction, can ameliorate the calculation results of excitation energies in even-even nuclei.

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