Large-scale configuration-interaction calculations in Sn-isotopes

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The formation of complex nuclei form their basic constituents as well as the explanation for the collective phenomena from individual motions have been the fundamental questions for the nuclear physics community. The properties of low-lying states of these nuclei in the vicinity of closed shells are important pillars in the understanding of nuclear structure. The variation of nuclear structure with the changing valence nucleons offers an ideal laboratory to understand the developments of nuclear many-body systems and test recent descriptions of single-particle energies (SPEs) and residual interaction between valence nucleons. Several models have been proposed to understand these problems in a systematic form. During the last decade, both qualitative and quantitative advancement in shell-model studies has resulted in remarkable achievements in better understanding of nuclear structure [1]. The advancement in the present-day computing facilities has enabled us to take these calculations beyond the mass 100 region with the basis dimension size up to $2*10^{10}$.

In this work we have made an attempt to present systematic calculations on the spectroscopy and electromagnetic transition properties in even-A Sn isotopes by using configuration-interaction large-scale shell model code BIGSTICK [2, 3]. We have used ^{100}Sn as a core for all the studied isotopes with the same valence space (i.e. $1d_{5/2}$, $2s_{1/2}$, $1d_{3/2}$, $0g_{7/2}$, $0h_{11/2}$, or 'sdgh') for both protons (Z) and neutrons (N) between 50 and 82. These calculations have been performed by means of globally optimized monopole effective interaction for the sdgh-shell [4]. These interactions and the single particle energies for the sdg-shell were derived from the realistic CD-Bonn nucleon-nucleon potential by fitting to the binding energies of 157 low-lying states in $^{102\text{-}132}$Sn.

As for these mid-shell nuclei, huge inequality between protons and neutrons Slater determinants was observed, the protons were activated mainly in $0g_{7/2}$ and $1d_{5/2}$, whereas the neutrons were activated in $1d_{3/2}$, $2s_{1/2}$ & $0h_{11/2}$ orbits. The default interaction file format for two body interaction is derived from OXBASH/NuShell which can be in isospin-conserving formalism or in explicit proton-neutron format.

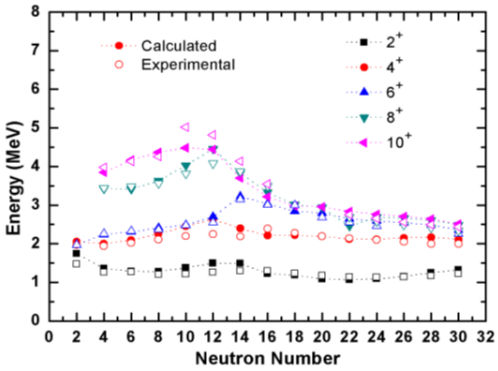

Fig. 1 Experimental and calculated excitation energies of the low-lying positive parity yrast states in $^{102\text{-}130}$Sn isotopes.

As shown in Fig. 1, the calculated excitation energies up to state 10^+ matches nicely with the experimental values [5]. A maximum deviation of 270 keV for 2^+ state was observed for ^{102}Sn, nevertheless, the average deviation was observed to nearly 100 keV which correspond to a maximum of 11% deviation for 2^+ state for ^{102}Sn, however, for rest of the isotopes, this discrepancy was calculated to be less than 7%. Further, as shown in Fig. 2, we have plotted the E4/E2 ratio with respect to the mass number of

studied isotopes showing an overall good agreement with the experimental data.

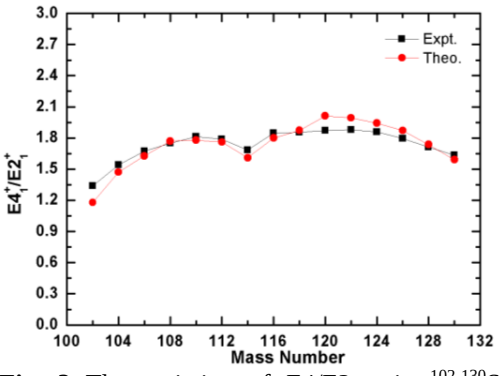

Fig. 2 The variation of E4/E2 ratio $^{102\text{-}130}$Sn isotopes.

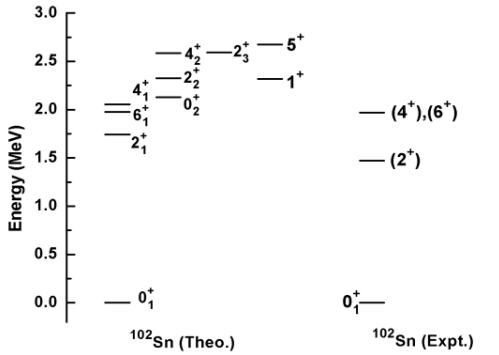

Fig. 3 Low-level energy scheme for first 10 excited states nucleus with available experimental levels [nndc].

Till date, only a few states have been assigned experimentally in ^{102}Sn nucleus. In Fig. 3 we have presented a low-level energy scheme for ^{102}Sn nucleus calculated with bigstick, which shows reasonably good agreement with the experimental levels. In the bigstick calculations, we have considered only the positive parity states.

To calculate the transition probabilities the given sample input for the 'dens' program was used. Dens is a nuclear density and electromagnetic form factor program which is a part of Oxbash package developed by B.A. Brown [6]. We used ^{100}Sn as a core with valence space up to $1h_{11/2}$ orbital corresponding to shell-closure at 82. For the good isospin in the interaction file, the one-body density matrices will be coupled to good isospin. But if the interaction file breaks the isospin, the density matrices will be in proton-neutron format. Since there is no valence protons, the BE2 values were not affected by the proton effective charge, therefore, in the figure, we have only presented the values for different neutron effective charges. The BE2 values are found to underestimate the experimental BE2s for proton rich isotopes whereas matches with reasonably good agreement for above mid-shell isotopes (118-130) for neutron effective charge equal to 0.9e. May be due to the truncation, the BE2s for mid-shell nuclei show enhancement over the experimentally determined values [5].

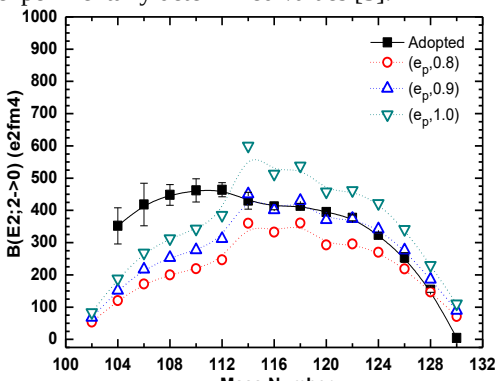

Fig. 4 The calculated and adopted B(E2;2→0) values (in e^2fm^4) for $^{102\text{-}130}$Sn-isotopes.

The results obtained using BIGSTICK code for the low-level excitation states and transition probabilities for the studied even-A tin isotopes has been presented and will be discussed in details during the conference.

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