Shell-model studies of nuclei around A $\simeq$ 130

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Introduction

Scarcity of experimental results close to drip lines for medium-heavy to heavy nuclei has provoked theoreticians to study and explain the existing experimental data of a few proton (neutron) -rich nuclei and predict structure of other similar nuclei to encourage more experimental efforts. These studies are also important to understand the evolution of nuclear interaction at extremes of isospin. Nuclei in the region ^{100}Sn to ^{132}Sn is very interesting as one can follow the changes of nuclear interaction as one moves from proton rich nuclei (N$\simeq$Z; N/Z$\simeq$1) near ^{100}Sn to neutron - rich ones near ^{132}Sn (N-Z$\simeq$32; N/Z$\simeq$1.64)). However it is found that systematic study with data (energy, transition probability and moment) for several isotopic and isotonic chains are inadequate. Several new experimental [1] and theoretical studies [2] are being attempted presently to understand this region better.

We have initiated a study of this mass region over the range of neutron numbers from 50 to 82 [3]. Primarily the excitation spectra and transition probabilities for the same set of nuclei have been calculated with shell model code OXBASH [4] using different effective interactions successful in heavier and lighter isotopes to understand them better. We also intended to suggest necessary additions and alternations in effective single particle energies as well as two body matrix elements to make them more suitable for a particular set of isotopes. The aim of the present endeavour is to continue this systematic study of this region further to fix effective charges and spin g-factors for transition probabilities and magnetic moments for neutron-rich nuclei close to A $\simeq$130.

Theoretical Calculations

The calculation has been started with $sn100pn$ interaction [5]. This a realistic interaction proposed by Brown et al. [5] for neutron rich nuclei below ^{132}Sn with ^{100}Sn as the core. The two body matrix elements are based on CD Bonn interaction. This interaction,$sn100pn$ has been proven remarkably successful for nuclei close to ^{132}Sn. The SPEs (single particle energy) are well tuned for A$\simeq$ 130 region, but fails to explain some issues near ^{100}Sn region. More recently, Qi et al. [6] explained the origin of the spin inversion between ^{101}Sn and ^{103}Sn by a new monopole optimized effective interaction named as *Bonnnew*. This interaction has been proposed in isospin formalism. This has been applied primarily for isotopes of Sn and other nuclei near A$\simeq$100. However, there have been attempts [6] to use this interaction for isotopes of Sn near A$\simeq$132 also. In the isospin formalism, proton and neutron single particle energies are the same and usually applied when protons and neutrons occupy similar orbitals. However, to apply this interaction for nuclei where proton and neutron numbers are around Z=50-56 and N=74-82, it is important that n-p formalism is utilised. Neutron and proton single particle energies (SPE) and two body matrix elements (TBME) can be tuned independently for interactions represented in this formalism. The *Bonnnew* interaction therefore has been converted to proton neutron formalism [3] and used for the present work .

For the model space, the neutron and proton orbitals between the shell closures N = Z = 50 and 82, comprising of $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, $3s_{1/2}$, and $1h_{11/2}$ with ^{100}Sn core have

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been chosen. In the earlier work [3], the neutron and proton single particle energies and the NN, PP and PN tbmes were tested for each interaction by comparing the calculated values with relevant experimental data.

By calculating excitation energy only, one cannot test any interaction. In the earlier work, the testing of wavefunctions in terms of comparing calculated and measured transition probabilities was initiated. Currently, efforts are being taken to compare calculated and experimental transition probabilities, quadrupole moments and magnetic moments [7].

To calculate this, effective charge of neutron is taken to be 0.64e and the calculated B(E2; $10^+ \rightarrow 8^+$)s for $^{124-130}Sn$ isotopes have been compared with data (Fig. 1) to fix the effective charge of neutron. Similar efforts will be taken to test the proton effective charges also. Similarly, for moment calculation, only free g factor is considered. Results are compared with data to get the most suitable quenching factor.

Results and Discussion

The Fig. 1 demonstrates an interesting difference between the predictions by two interactions. The sudden drop in the calculated B(E2)s with *sn*100*pn* and saturation of these values for experimental data in $^{128,130}Sn$ need special attention. However, the *Bonnnew* interaction reproduces this experimental trend better. The effective charges for two interaction therefore also show two completely different trends for $^{128,130}Sn$. While *sn*100*pn* results need decrease of effective neutron charge from $\simeq$ 0.8 to $\simeq$ 0.5 from N=80 to N=78, for *Bonnnew* results it is almost similar. This trend of B(E2)s in these two neutron-rich isotopes of *Sn*, which contradicts the estimation from seniority rules [8] has been already discussed by earlier workers [2, 8]. The relevant tbmes of two interactions are being compared and will help us in understanding the structure of these nuclei better. It is expected that these studies will lead to better understanding of the nuclear properties of nuclei in this region. It is also envisaged that present study

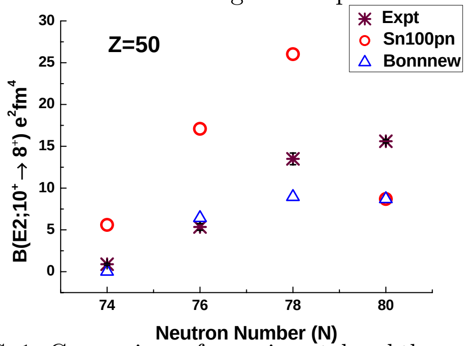

FIG. 1: Comparison of experimental and theoretical B(E2; $10^+ \rightarrow 8^+$)s for $^{124-130}Sn$ isotopes with neutron numbers 74-80, respectively.

will be able to provide the experimentalists useful information to plan new experiments for resolving several ambiguities in the theoretical predictions.

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