Large scale shell model calculation for $^{120-130}$Sn

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Introduction

In semimagic nuclei $^{120-130}$Sn isotopes, filling of neutrons in $sdg_{7/2}h_{11/2}$ subshells provide the platform to study proton shell closure properties, collectivity and many body effects [1]. The degree of rigidity of nuclear spherical shape and effect of E2 core polarization is reflected in the excitation energy of the lowest 2^+ state and in the associated B(E2; $0^+ \rightarrow 2^+$) values. In recent years ample experimental data has been aquired in this regard and this motivated us to look into this mass region theoretically without applying any type of truncation on occupation of orbitals and tally the same with previous calculations which were mainly done with particle/hole formalism with respect to the nearest shell closure.

Effective interaction and shell model calculations

The m-scheme based shell model calculation has been done with closed-core of ^{100}Sn using Oslo shell model code. The model space consists of single particle orbits $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$ from the N = 4 oscillator shell and the intruder $0h_{11/2}$ orbital from the N = 5 oscillator shell for neutrons. Hence the dimensionality n of the basis states increses with decreasing number of valence particles and for our calculation it peaks up to 10^6. The neutron single particle energies are chosen as $\epsilon_{0g_{7/2}}$-$\epsilon_{1d_{5/2}}$=0.2 MeV, $\epsilon_{0h_{11/2}}$-$\epsilon_{1d_{5/2}}$=3.2MeV, $\epsilon_{2s_{1/2}}$-$\epsilon_{1d_{5/2}}$=2.80 MeV and $\epsilon_{1d_{3/2}}$-$\epsilon_{1d_{5/2}}$=1.50MeV, respectively. The isospin based residual two-body interaction used here is obtained starting with a normalized G-matrix derived by perturbative many-body techniques[2].

Results and Discussion

Comparison of the observed [3] and calculated levels of $^{120-130}$ Sn is shown in Fig. 1. In calculation, the low-lying yrast states 4^+_1,6^+_1, 8^+_1 and 10^+_1 are well reproduced. Moreover, calculation also produces the next higher levels of each spin state as have been observed in [4]. The calculation agrees well with the fairly stable observed [3] energy of first excited 2^+ states ($\approx$ 1 MeV) in Sn isotopes of this mass region which reveals dominant contribution from one kind of nucleon outside doubly magic closure and is a cause of weak quadrupole deformation [5]. For B(E2; $0^+ \rightarrow 2^+$) calculations, neutron effective charge is taken as 0.8e and 0.9e respectively. The effective neutron charges also agree with that suggested by A. Banu et al. [6] according to whom the range of effective neutron charges should lie around (1 - 1.5)e to compensate for the unavailability of proton excitations from within the closed core. For nuclei lying between two shell closures B(E2) values should follow a parabolic nature attaining maximum at around mid-shell [7]. Our results show nice agreement for A $\leq$ 124 with e_{eff} = 0.8e and underestimate for others whereas for A $\geq$ 126 e_{eff} = 0.9e produces results much close to the experimental ones. Surprisingly, the calculation could not produce expected B(E2) in case of ^{128}Sn. The underlying cause is still under consideration, see [Fig. 2]. The role of particle hole excitation and hence rotational structures could not be studied due to limitation of model space.

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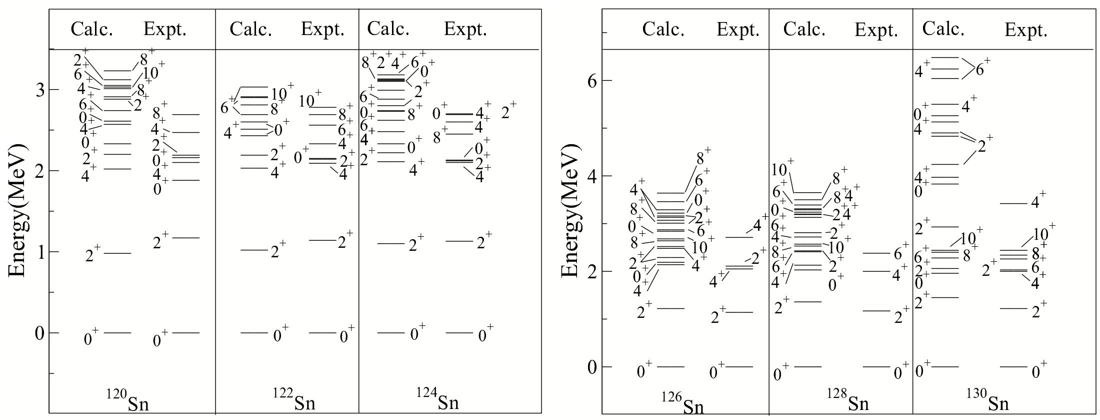

FIG. 1: Comparison of experimental and calculated level schemes of $^{120-130}$Sn using renormalized G-matrix.

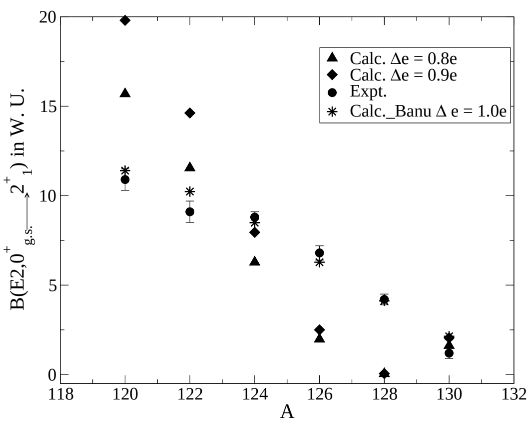

FIG. 2: Comparison of experimental, calculated B(E2, $0^+ \rightarrow 2^+_1$) in present as well as A. Banu et al.'s work [6] (in W. U.) for Sn isotopes.

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