Study of Yrast Spectra, Yrast Energy Splitting and Backbanding for ^{130}Te,^{130}I,^{130}Xe within the framework of Projected Shell Model

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Introduction

The new technology developments are helping up in setting various $\beta\beta$ decay experiments across the world to estimate half-life of many $\beta\beta$ decay candidates. The experimental achievements of $\beta\beta$ decay processes may help in establishing the properties of neutrinos. Theoretically, various mean field approximations are being used to estimate the (Nuclear Matrix Element) of $\beta\beta$ decay processes. The accuratly obtained NMEs should be helpful for extraction of half-life of $\beta\beta$ decay processes and neutrino mass from experimental data. Therefore accurate information of nuclear structure properties of $\beta\beta$ candidates is very important in extracting half-life and $\langle m_\nu \rangle$ from experimental data.
The Projected Shell Model[1] is being used by so many theoretical teams to explain nuclear structure properties. In the present paper, we intend to employ PSM to estimate NMEs of various $\beta\beta$ decay candidates, so we are discussing nuclear structure properties such as yrast spectrum, yrast energy splitting and backbanding of ^{130}Te,^{130}I,^{130}Xe respectively.

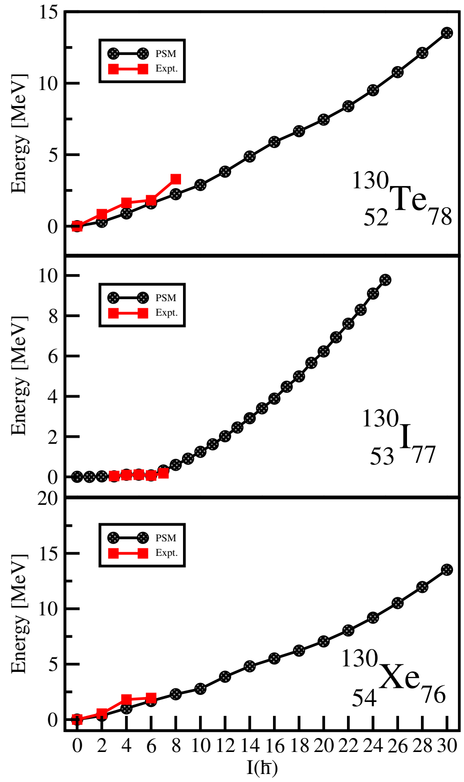

FIG. 1: Comparison of PSM and Expt data[2] for yrast bands of ^{130}Te,^{130}I,^{130}Xe.

Theoretical Framework

In PSM[1] calculations, the Shell Model truncation is first achieved within the quasiparticle (qp) states with respect to the deformed Nilsson+BCS vacuum $|\phi\rangle$, then rotational symmetry are restored for these states by standard projection techniques to form a spherical basis in the laboratory frame. Finally the shell model Hamiltonian is diagonalized in the basis. The set of multi-qp states relevant to the present study (even-even) and (odd-odd) system is

$$|\phi_k\rangle = \left\{ a^\dagger_{\nu 1} a^\dagger_{\nu 2}|0\rangle,\ a^\dagger_{\pi 1} a^\dagger_{\pi 2}|0\rangle, a^\dagger_{\nu 1} a^\dagger_{\nu 2} a^\dagger_{\pi 1} a^\dagger_{\pi 2}|0\rangle \right\} \tag{1}$$

$$|\phi_k\rangle = a^\dagger_\nu a^\dagger_\pi |0\rangle \tag{2}$$

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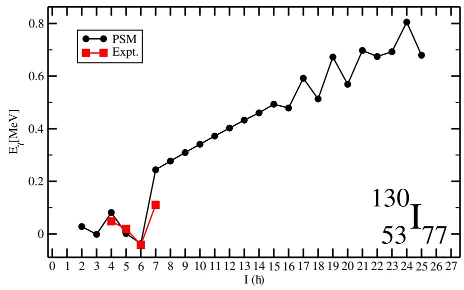

FIG. 2: Comparison of PSM and Experimental data[2] for Yrast energy splitting between [Eγ][2] and I($\hbar$) for ^{130}I.

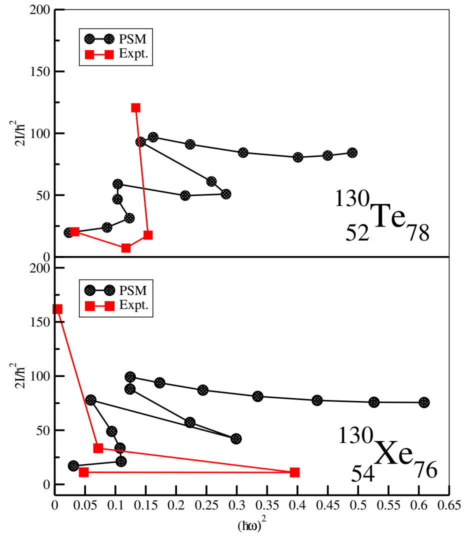

FIG. 3: Comparison of PSM and Experimental data[2] for Backbanding between $2I/\hbar^2$ and $(\hbar\omega)^2$ for ^{130}Te and ^{130}Xe.

where $\nu's(\pi's)$ denote the neutron (proton) Nilsson quantum numbers which run over properly selected (low-lying) quasi-particle states.
In PSM calculations, we use Hamiltonian of separable forces

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi \sum_\mu \hat{Q}^\dagger_\mu \hat{Q}_\mu - G_M \hat{P}^\dagger \hat{P} - G_Q \sum_\mu \hat{P}^\dagger_\mu \hat{P}_\mu \quad (3)$$

Where $\hat{H}_0$ is the spherical single particle hamiltonian. The second term in the Hamiltonian is the quadrupole-quadrupole (Q-Q) interaction and the last two terms are monopole and quadrupole pairing interactions respectively. The coupling constants for the monopole pairing force G_M is taken as[1]

$$G_M = \left(G_1 \mp G_2 \frac{N-Z}{A}\right)\frac{1}{A}\ (MeV) \quad (4)$$

where -(+) sign for neutron (proton) and G_1, G_2 coupling constants are taken as 20.70, 12.12 for ^{130}I[3] and 20.12, 12.12 for ^{130}Te and ^{130}Xe. The ratio of G_Q/G_M is taken as 0.16 for ^{130}I[3] and 0.18 for ^{130}Te and ^{130}Xe.

Results and Discussion

1. Yrast Spectra

In fig.1 we present the Comparison of PSM results with experimental data for yrast spectra obtained for ^{130}Te, ^{130}I, ^{130}Xe. The (ϵ_2) and (ϵ_4) used for ^{130}Te ,^{130}I, ^{130}Xe calculations are 0.240, 0.299, 0.212 and 0.001.

2. Yrast energy splitting

In fig.2 we present the Comparison of PSM results with experimental data for energy splitting for ^{130}I.

3. Backbanding Phenomena

In fig.3 we present the Comparison of PSM results with experimental data for moment of inertia (2I) as a function of square of rotational frequency $\hbar\omega^2$ for even-even ^{130}Te (upper panel), ^{130}Xe (lower panel). The effect of backbanding is attributes to deformation.

Acknowledgments

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