Band termination in $^{120-122}$Te : Comparative study of Shell model and cranked Nilsson Strutinsky (CNS) approach

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Introduction

The spectroscopy analysis of $^{120-122}$Te containing two protons outside the Z = 50 proton shell-closure reveals phonon-vibrational collective behavior at low spin followed by rotational structures at high spins [1, 2]. Pairing independent CNS explains band termination in ^{120}Te at 16^+ and 22^+ whereas in ^{122}Te at 16^+ and 24^+ with $\pi[(0g_{7/2})^2] \otimes \nu[(g_{7/2}d_{5/2})^{14}(d_{3/2}s_{1/2})^n(h_{11/2})^4]$ configuration, where 'n' is 0 or 2 for ^{120}Te and ^{122}Te respectively.

The motivation of the present work is to understand the band termination phenomenon in context of the spherical shell model calculations A ≈ 120 and compare the results with that of CNS formalism to signify pairing interaction.

Calculations

The shell model calculations are done with unnormalized two-body effective interactions based on G-matrix formalism derived from BonnA [3] free *NN* potentials for both type of nucleons. Windows version of NuShellX [4] was used. The valence space consists of $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$, $0h_{11/2}$ with nucleons single-particle energies obtained from [5]. Neutrons excitations are prohibited from fully occupied $0g_{7/2}$ and $1d_{5/2}$ orbitals. The details of CNS calculations have been presented in [1].

Results and Discussion

The most dominant configurations as calculated using BonnA potential are given in Table I. The observed excitation energy between 0^+ to 22^+ (branch "a") in ^{120}Te shows minima at $16\hbar$ and $22\hbar$ indicating terminating structure. Shell model calculation agrees well up to $6\hbar$ where phonon vibrational states prevail. The agreement between calculated and observed results are poor outside the termination regime. Thus, for branch "a" maximum contribution comes from $\pi[(0g_{7/2})^2] \otimes \nu[(g_{7/2}d_{5/2})^{14}(h_{11/2})^4]$. The branch "c" which terminates at 21^- state can be possibly explained by $\pi[(g_{7/2})^2] \otimes \nu[(g_{7/2}d_{5/2})^{14}(d_{3/2})^1(h_{11/2})^3$ as par shell model treatment.

In case ^{122}Te, shell model concludes that the positive parity band including two branches can be defined by $\pi[(g_{7/2}d_{5/2})^2] \otimes \nu[(g_{7/2}d_{5/2})^{14}, (d_{3/2}s_{1/2})^2, (h_{11/2})^4$ with I_{max} = $24\hbar$ [Table I]. Corresponding CNS results for both the nuclei are displayed in Fig. 1.

From the results we conclude that the shell model results predict fully aligned terminating states successfully which are in agreement with CNS in pairing independent regime.

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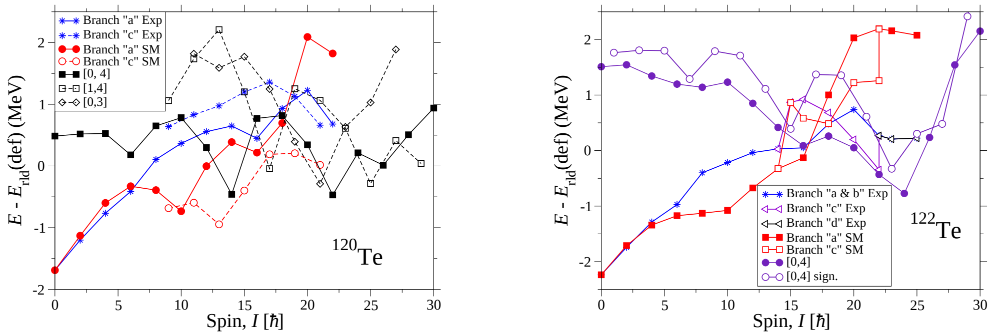

FIG. 1: Excitation energies relative to a rotating-liquid drop energy, for observed and calculated states in ^{120}Te and ^{122}Te. "Exp" and "SM" stand for experimental and shell-model calculations respectively. CNS configurations [1] are given in format $[p_1, n_1]$ where p_1, n_1 are the number of protons and neutrons in $h_{11/2}$ orbital respectively. "sign." written after the CNS configuration signifies that it is generated with distribution of nucleons in different signature orbitals.

TABLE I: Wave function components of various spin states in ^{120}Te and ^{122}Te.

Nucleus	J_i^p	Neutron wave function	Proton wave function	Amplitude^2
^{120}Te	0^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^2(0h_{11/2})^2$	$(0g_{7/2})^2$	34.54
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^2$	$(0g_{7/2})^2$	16.75
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	16.51
	6^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^2(0h_{11/2})^2$	$(0g_{7/2})^2$	30.26
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^2$	$(0g_{7/2})^2$	15.00
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	10.65
	16^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	87.65
	22^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2}1d_{5/2})^2$	55.75
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	43.50
	21^-	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^1(2s_{1/2})^0(0h_{11/2})^3$	$(0g_{7/2})^2$	80.42
^{122}Te	0^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2})^2$	22.62
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	20.75
	6^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2})^2$	18.91
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	20.46
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2}2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2})^2$	24.74
	15^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2}2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2}1d_{5/2})^2$	50.53
	16^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^0(2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2})^2$	24.1
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2})^2$	21.87
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2}2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2})^2$	25.75
	24^+	$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2}2s_{1/2})^2(0h_{11/2})^4$	$(0g_{7/2}1d_{5/2})^2$	50.86
		$(0g_{7/2})^8(1d_{5/2})^6(1d_{3/2})^2(2s_{1/2})^0(0h_{11/2})^4$	$(0g_{7/2}1d_{5/2})^2$	38.13