Description of collective and non-collective states in ^{120}Te

Somnath Nag[1],* Purnima Singh[1], A. K. Singh[1], and I. Ragnarsson[2]
[1]Department of Physics & Meteorology,
Indian Institute of Technology Kharagpur, IN-721302, India and
[2]Department of Mathematical Physics, Lund Institute of Technology, Box 118, S-221-Lund, Sweden

Introduction

Nuclei in A ≈ 120 with vibrational collective properties at low spin [1] and high-spin deformed bands [2] have been successfully described theoretically [2] using cranked Nilsson-Strutinsky (CNS) [3, 4] formalism. Experimental results for ^{120}Te have been discussed in [5]. Parity has been tentatively set to be negative above the 18^+ state. In the present work observed results have been compared using CNS calculations. In this model the configurations are labeled by the number of particles in the different high-j orbitals outside a closed core. Different orbitals are identified and particles in high-j intruder shells and in the other j-shells can be distinguished. The formalism produces nice agreement in absence of pairing correlations; making it compatible in high-spin region where pairing is quenched.

Calculations

In the calculations, parameters derived for A = 110 region has been applied [3]. Observed energies have been calculated with respect to a standard rotating drop energy. Lublin-Strasbourg drop (LSD) [6] with diffuse surface has been considered in order to calculate the rotational energy. An absolute energy scale based on mass excess has also been applied so that different nuclei can be compared. The calculation minimizes the energy with respect to the deformation parameters $(\epsilon_2, \epsilon_4, \gamma)$. For ^{120}Te, ^{114}Sn with Z = 50 and N = 64 has been chosen as the core. The configurations have been labelled as $[p_0(p_1)p_2, n_0n_1n_2; n_3]$ where p_1 is number of proton holes in $g_{9/2}$, p_0 and p_2 are the numbers of protons in $(g_{7/2}, d_{5/2})$ and $h_{11/2}$ respectively whereas the number of neutron holes in $(g_{7/2}, d_{5/2})$ have been marked as n_0, the number of neutrons occupying $h_{11/2}$, $(h_{9/2}, f_{7/2})$ and $i_{13/2}$ as n_1, n_2 and n_3 respectively.

*Electronic address: somnanag@phy.iitkgp.ernet.in

Results and Conclusions

Experimental and calculated E-E$_{rld}$ vs spin have been shown in upper and lower panel of Fig. 1 respectively. The observed states between 0^+ to 18^+ can been described by coupling $\pi[g_{7/2}, d_{5/2}]^2$ to $\nu[h_{11/2}]^{0,2,4}$ (Fig. 1 [2(0)0, 040;0]) $I_{max} = 6\hbar$, $14\hbar$, $22\hbar$ respectively. Excitation of one proton from "gd" shell to $h_{11/2}$ with two paired up neutrons in $h_{11/2}$ may explain the negative parity states between $9\hbar$ to $17\hbar$ (see Fig. 1 [1(0)1, 040;0]). The configuration $(\pi[(g_{7/2}, d_{5/2})^2] \otimes \nu[d_{3/2}, h^3_{11/2}])$ (see Fig. 1 [2(0)0, 030;0]) which becomes yrast at $I = 21\hbar$. Two separate branches; branch "a" lying between $23\hbar$ and $25\hbar$ and branch "b" lying between $22\hbar$ and $25\hbar$ have been observed experimentally which feed to the state with $I = 21\hbar$. The yrast branch "a" may have a possible configuration $\pi[(g_{7/2}, d_{5/2}), h_{11/2}] \otimes \nu[(h_{11/2})^4]$ (ref. Fig. 1 [1(0)1, 040;0]). On the other hand $(\pi[(g_{9/2})^{-2}, (g_{7/2}, d_{5/2})^2, (h_{11/2})^2] \otimes \nu[d_{3/2}, h^3_{11/2}])$ with two protons excited across Z = 50 core may possibly explain the branch "b".

Five high spin deformed bands have been observed in ^{120}Te [5]. Yrast band has been tentatively connected to the low spin states through 795 keV transition at $25\hbar$ of branch "a"; though parity has not been fixed yet. $(\pi[g^{-2}_{9/2}(g_{7/2}, d_{5/2})^2, h^2_{11/2}] \otimes \nu[(g_{7/2}, d_{5/2})^{-2}, h^6_{11/2}])$ (ref. Fig. 1 [2(2)2, 260;0]) and $(\pi[g^{-2}_{9/2}(g_{7/2}, d_{5/2})^2, h^2_{11/2}] \otimes$

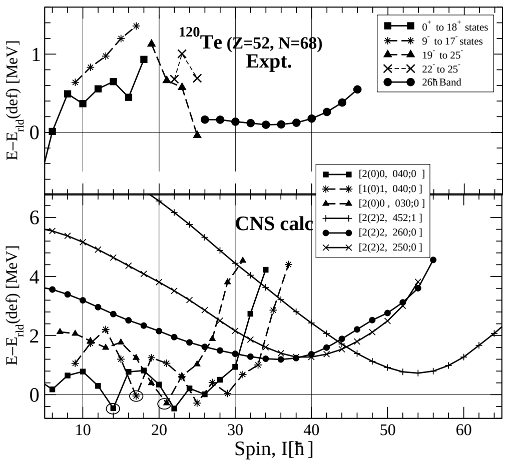

FIG. 1: Excitation energies relative to a rotating-liquid drop energy, for observed (upper panel) and calculated (lower panel) valence-space states for ^{120}Te.

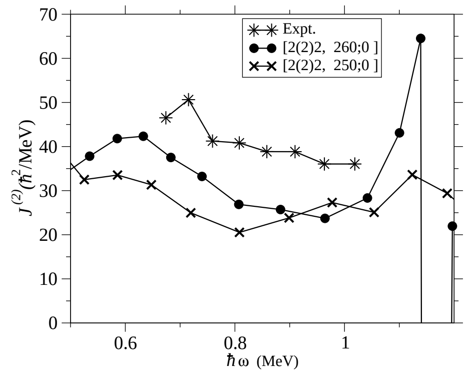

FIG. 2: Comparison of experimentally observed and calculated dynamic moment of inertia $\mathcal{J}^2$ vs spin for yrast high-spin deformed band in ^{120}Te.

$\nu[(g_{7/2}, d_{5/2})^{-2}, d_{3/2}, h^5_{11/2}]$) (see Fig. 1 [2(2)2, 250;0]) may be the two probable configurations for the yrast band. Former one is a positive parity configuration whereas latter one produces negative parity states. Both the configurations produce results comparable to observed ones. Configurations involving $i_{13/2}$ ([2(2)2, 452;1]) produces very different results as shown in Fig. 1; hence, can be ruled out. Calculated dynamic moment moment of inertia for the above configurations have been compared with the experimental values in Fig. 2; which shows a nice agreement. Both the configurations are associated with $\epsilon_2 \approx 0.28$.

In conclusion the observed phenomena at low and high spin have been successfully described using CNS. Even though CNS results are relevant at high spin region; results agree well at moderate spins too. At low spin; instead of the observed collective phenomenon single particle features have been predicted by CNS. This may be because pairing has not been considered here. Calculated and observed excitation energy for highly deformed band differs by an amount of 1.5 MeV which may be due to non vanishing of pairing at higher spin.

Acknowledgments

Authors acknowledge CSIR-India and DST-India for financial support.

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