Study of valence space excitations in ^{122}Te

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Introduction

The β stable $^{122}_{52}$Te with two protons outside Z = 50 proton shell closure is a good candidate to study the shape coexistence phenomenon in A $\approx$ 120 region. A small number of available valence particles tend to drive the nucleus towards deformation. An optimal stage is reached through progressive alignment of neutrons and protons which results in gradual shape change from prolate deformation at low spin to oblate shape at higher spin via intermediate states of triaxiality. The orbitals lying in proximity to Fermi surface play the dominant role. Terminating states are produced by Coriolis interaction leading to gradual alignment of limited number of available nucleons along the rotational axis leaving the nucleus in an oblate shape with $\epsilon_2 \approx$ 0.15 and $\gamma = +60°$. This phenomenon is referred as smooth band termination where a gradual decrease in dynamic moment of inertia value with increasing rotational frequency is observed [1]. Total Routhian surface (TRS) and cranked Nilsson-Strutinsky (CNS) calculations have been used to explain the phenomenon of band termination in this mass region [2]. In the present work we report on the valence-space structure which leads to fully aligned configurations in ^{122}Te. Moreover, observed results have been compared to the CNS calculations.

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Experimental Details

Excited states in ^{122}Te were populated using the reaction ^{116}Cd(^{11}B, p3n)^{122}Te with beam energy 65 MeV. The ^{11}B beam with 1.5nA current was provided by 14UD pelletron accelerator at TIFR-Mumbai. Self supporting target with a thickness of 15mg/cm^2 was used for the reaction. A total of 3.1×10^9 events with Ge fold $\geq$ 2 were obtained using 15 clover Ge detectors in INGA [3, 4] in 3 days of beam-time. Some of the other reaction channels populated in the experiment are 3n, 4n, 5n, 6n, p3n, p4n, α3n, α4n and α5n corresponding to ^{124}I,^{123}I, ^{122}I, ^{121}I, ^{123}Te, ^{120}Sb, ^{119}Sb and ^{118}Sn residual nuclei, respectively. Radware software [5] has been used for offline analysis of the data. The intensity ratio : $R_\theta = \frac{I(\gamma1^{23°},\gamma2^{all})}{I(\gamma1^{90°},\gamma2^{all})}$ distinguishes between stretched dipole and quadrupole transitions whose values come out to be 0.75 and 1.4, respectively. The use of clover detectors facilitate linear polarization measurement studies. Assymetric parameter is defined as $\Delta_{assym} = \frac{aN_\perp - N_\parallel}{aN_\perp + N_\parallel}$ where $N_\perp$ and $N_\parallel$ are the number of scattered photons in direction perpendicular and parallel to the direction of reaction plane respectively. The correction factor a is expressed as a function of γ energy with a relation $a(E_\gamma) = a_0 + a_1E_\gamma$. Deduced values of a_0 and a_1 are 1.013 and -1.9358×10^{-5} respectively. Δ_{assym} is positive and negative for electric and magnetic transitions respectively.

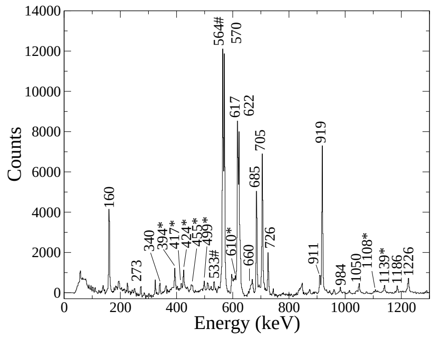

FIG. 1: Summed triple-gated γ ray coincidence spectra for ^{122}Te. The newly placed γ-transitions are displayed with "$*''$. The doublets are shown with "$\#''$ symbol.

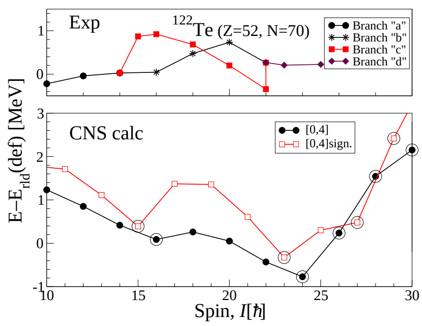

FIG. 2: Excitation energies, relative to a rotating liquid drop energy for observed (upper panel) and calculated [7] (lower panel) in ^{122}Te. CNS configurations are given as $[p_1, n_1]$ where p_1, n_1 are the proton and neutron numbers in $h_{11/2}$ orbital respectively. "sign." refers to different signature.

Results and Discussion

Low lying states were reported upto spin $15\hbar$ and excitation energy 6.64 MeV [2, 6]. The present work confirms the previous placements and spin assignments of the γ rays. Furthermore, the level scheme has been extended to excitation energy 9.836 MeV. Two new parallel cascades branch "b" and "c" are placed between 8.27 MeV state and 4.68-MeV $I^\pi = 14^+$ state. Branch "b" consisting of four E2 transitions feeds branch "a" via 726 keV transition. Branch "c" containing a M1 and three E2 transitions decay on the top of branch "a" through 1186 keV dipole transition. Branch "d" containing two γ-rays of 455 and 1108-keV feed on the top of level at 8.27 MeV. In Fig.1 summed triple gated coincidence gamma spectrum are displayed. Polarization measurement confirms the previous parity assignments of low-lying states. Based on polarization measurement 1186 keV γ-ray was found to be magnetic in nature. Thus, positive parity has been assigned to branch "c". The excited states up to $6\hbar$ are phonon vibrational states coupled to Sn core. The states above $6\hbar$ may be described by $\pi[(g_{7/2}, d_{5/2})^2] \otimes \nu[(d_{3/2}s_{1/2})^2, h^4_{11/2})]$ with $I_{max} = 24\hbar$. CNS calculation [7] predicts the states 16^+ and 24^+ as terminating states which is evident from Fig. 2. No other positive parity even spin configuration was found to lie at lower excitation energy, which could have been a probable configuration for branch "c". CNS calculation considers $g_{7/2}d_{5/2}s_{1/2}d_{3/2}$ as one entity, hence it cannot distinguish between different nucleon permutations over these orbitals. Previously observed three negative parity bands have also been confirmed in this work, which may have odd number of neutrons in $h_{11/2}$ orbital.

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