Collectivity and nuclear structure of ^{120,122,124}Te

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Introduction

In recent years the region in the vicinity of tin isotopes has been intensively investigated both from experimental and theoretical perspectives. In particular, the excitation energies and the reduced transition probabilities across the Z=50 chain has been examined in detail. In tellurium nuclei with two protons outside the major shell, the partial level schemes are dominated by the $1g_{7/2}$ orbit leading to 6^+ isomers in the vicinity of N=82 shell closure. For the mid-shell nuclei ^{120,122,124}Te one observes the expected transition to vibrational-like structure with equal energy spacing between the phonon states. This observation is quite in contrast to the measured quadrupole moments Q_2^+ for the doubly even Te isotopes. These quadrupole moments can reach 60% of the one predicted by the symmetric rigid rotor. These sizable quadrupole moments motivated us to measure the reduced transition probabilities connecting the higher lying states which also yield information on the nuclear structure of ^{120,122,124}Te. In this paper we report the theoretical interpretation of the high precision results obtained from the experiment.

Three consecutive Coulomb excitation experiments were performed to measure the reduced transition probabilities in ^{120,122,124}Te. The experiment was carried out at IUAC, New Delhi, stable targets of ^{120,122,124}Te were bombarded with a ^{58}Ni beam. All targets were of nearly equal thickness ~ 0.15(5) mg/cm^2 evaporated onto a thin carbon backing of 25-30 $\mu g/cm^2$. The details can be found in Ref [1].

Interpretation of Experimental Results

A precise Doppler correction was performed event by event for the measured γ-rays for target and projectile excitation. The particle identification was performed on the basis of the kinematics of the colliding partner.The excitation strength of the 2^+ state in the different isotopes were determined for distant collisions, with the first excited 2^+ state in ^{58}Ni used for normalization. The double ratio $[I_\gamma(^{120}\mathrm{Te})/I_\gamma(^{58}\mathrm{Ni})]/[I_\gamma(^{122}\mathrm{Te})/I_\gamma(^{58}\mathrm{Ni})]$ of the γ-ray yields were determined. This γ-ray ratio allowed a precise measurement of the B(E2↑) of ^{120}Te. For ^{120}Te $B(E2;\ 0^+_{g.s.} \rightarrow 2^+)$ value of 0.666(20) e^2b^2 was extracted which yields a collectivity of 40 single particle units.

The experimental $B(E2;\ 0^+_{g.s.} \rightarrow 2^+)$ value were also compared with Large Scale Shell Model (LSSM) calculations and good agreement was found (see Fig. 1). Two calculations were included here with two different sets of single particle energies ϵ_{sp}. In the first set, the values for ϵ_{sp} are identical to the values used to reproduce the behavior of Sn isotopes [2]. The model space $1d_{5/2}$, $0g_{7/2}$, $1d_{3/2}$, $2s_{1/2}$ and $0h_{11/2}$ was used for neutron configuration. In the second set, the new result from Ref. [3] was taken into account where single particle energies ϵ_{sp} $(g_{7/2})$ = 0 and

ϵ_{sp} ($d_{5/2}$) = 172 keV were used to generate the excitation energy and other property of Te nuclei.

The larger collectivity $B(E2;\ 0^+_{g.s.} \rightarrow 2^+)$ observed in Te isotopes relative to the ones in Sn isotopes (12 s.p.u. for ^{118}Sn) results from the two extra protons present in Te above the Z = 50 shell closure. A comparison has been made for Tellurium and Cadmium isotopic chain in order to investigate the difference between two proton and two proton-hole configurations by plotting $B(E2;\ 0^+_{g.s.} \rightarrow 2^+)$ values for tellurium and cadmium versus the neutron number. Both distributions had the same dependence on the neutron number (see Fig. 2).

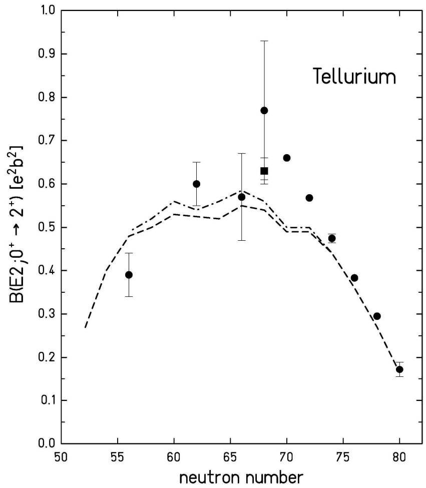

Fig. 1 Reduced transition probabilities B(E2↑) for tellurium isotopes with the present, more precise experimental result for ^{120}Te (full square symbol). The dashed curve corresponds to single-particle energies according to Ref. [4]. For the dash-dotted curve the $d_{5/2}$, $g_{7/2}$ orbitals were inverted.

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The B(E2) ratios normalized to $B(E2;\ 0^+_{g.s.} \rightarrow 2^+)$ were also determined for the higher lying states to probe the nuclear structure of ^{120,122,124}Te nuclei. The B(E2) ratios were also theoretically calculated under the vibrator model, rotational model and the asymmetric rotor model. It was observed that the asymmetric model with γ parameter equal to 27° is more appropriate to explain the experimentally determined B(E2) ratios.

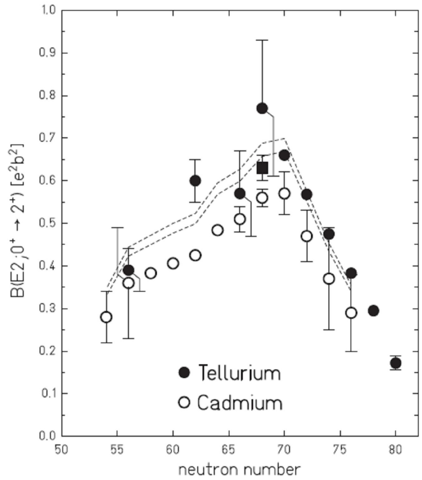

Fig. 2 Reduced transition probabilities B(E2↑) for Te and Cd isotopic chains versus the neutron number. The dashed curves are calculated from the experimental Cd data, scaled by a factor of $(52/48)^2$ in order to obtain the corresponding B(E2↑) values in Te isotopes.

In addition, IBA-2 calculations were also performed to interpret the results. The performed calculations could explain the energy spectra as well as the measured E2 transition probabilities and found it close to the O(6) limit. These nuclei thus, show an unusual rotational behaviour and all the experimental results can be quite well described by a soft triaxial rotor.

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