Study of electromagnetic properties of even-even medium-mass tellurium isotopes

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INTRODUCTION

The investigation of nuclear structure of nuclei around doubly magic tin isotopes has been the subject of interest in the previous two decades. The even-even tellurium (Te) isotopes are two protons away from the atomic number (Z)=50 closed shell and at low spins, most of the medium mass Te isotopes were observed to manifest vibration like level scheme but deformed rotational bands were also observed in some of the medium mass Te isotopes. The measured lifetimes and B(E2) transition probabilities [1-3] of yrast states of these isotopes show anomalous values as compared to the values normally expected for vibrational nature of yrast states. In the present work, an attempt has been made to study the yrast spectra, B(E2) transition probabilities and g-factors of medium mass Te isotopes by employing projected shell model. The computed properties are compared with the available experimental data.

THEORETICAL FRAMEWORK

The detailed description of the PSM is found in refs. [4,5]. In the present study, three major harmonic oscillator shells with N=2,3,4 for protons and N=3,4,5 for neutrons are taken. The Hamiltonian that has been used in the present calculation contains the single particle energies, monopole pairing between like particles, quadrupole – quadrupole and quadrupole pairing interactions

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

The monopole pairing interaction constant G_M is adjusted via G_1 and G_2 and is taken as

$$G_M^{\nu} = \left[G_1 - G_2 \frac{N-Z}{A}\right] A^{-1}(\text{MeV})$$

$$G_M^{\pi} = G_1 A^{-1}(\text{MeV})$$

The value of constants G_1 and G_2 used here are 19.60 MeV and 15.70 MeV. The quadrupole pairing strength G_Q is proportional to G_M and the proportionality constant is taken in the range 0.18-0.22 in these Te isotopes. The quadrupole deformation parameter (ϵ_2) is taken to be -0.147 in the present calculations for all the Te isotopes as these isotopes are predicted to have oblate ground state in previous study [6]

RESULTS

Figure 1. Comparison of calculated and available experimental yrast energy states of $^{114\text{-}122}$Te isotopes

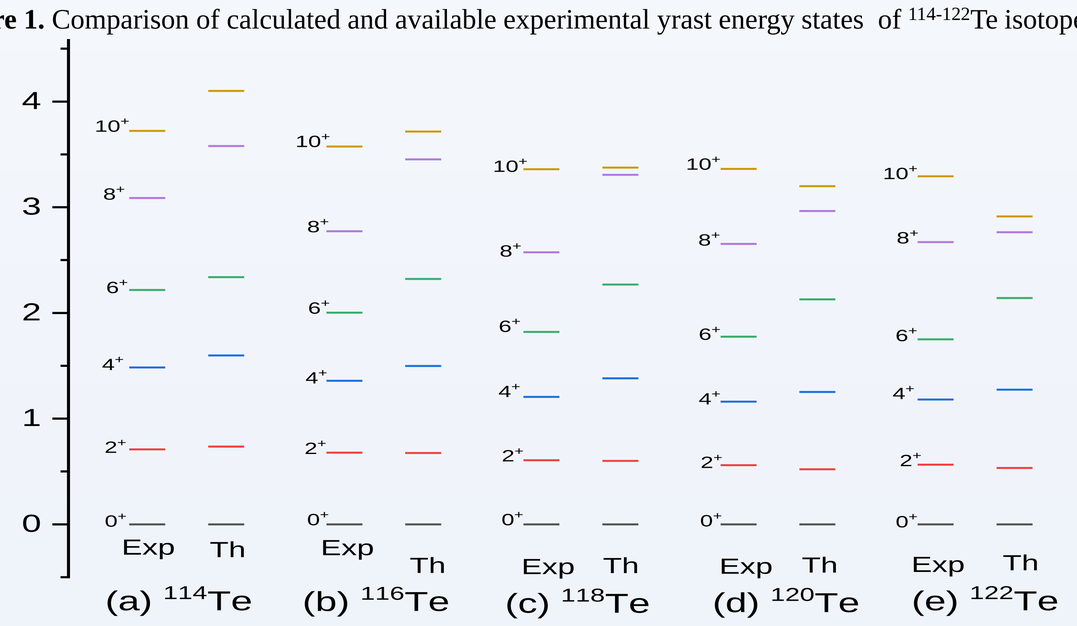


Table 1. The quasiparticle configurations and weight factors of yrast energy states of $^{114\text{-}122}$Te isotopes

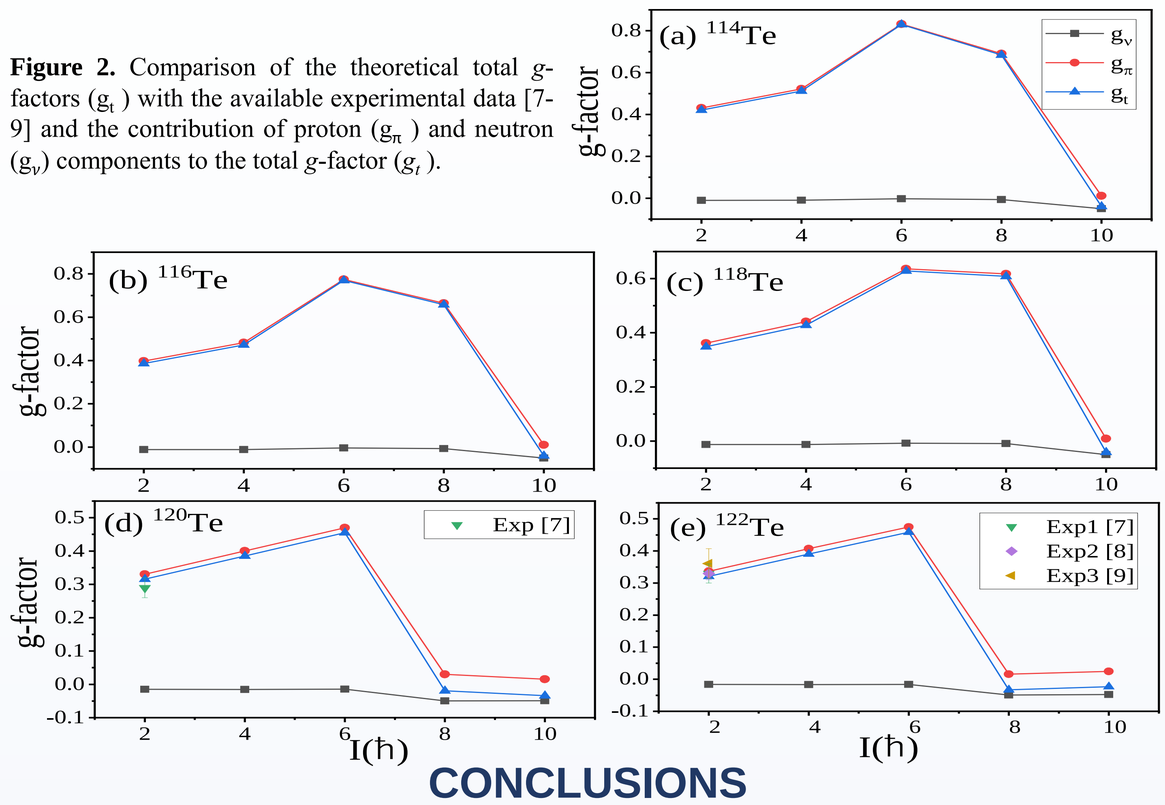
Spin	Configuration	weight factor	Configuration	weight factor	Configuration	Weight factor	Configuration	weight factor	Configuration	weight factor
	^{114}Te		^{116}Te		^{118}Te		^{120}Te		^{122}Te	
0	0-qp	0.997	0-qp	0.998	0-qp	0.998	0-qp	0.998	0-qp	0.989
2	0-qp	0.922	0-qp	0.939	0-qp	0.951	0-qp	0.957	0-qp	0.939
4	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.707 0.212	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.725 0.180	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.765 0.158	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.801 0.130	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.727 0.161
6	2-qp($\pi g_{7/2}$)^2 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.560 0.231	2-qp($\pi g_{7/2}$)^2 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 0-qp	0.433 0.286 0.110	2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 0-qp 2-qp($\pi g_{7/2}$)^2	0.361 0.266 0.223	0-qp 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$)	0.489 0.327	2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 0-qp 2-qp($\pi g_{7/2}$)^2	0.364 0.361 0.111
8	2-qp($\pi g_{7/2}$)^2 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 2-qp($\pi\, d_{5/2}, \pi g_{7/2}$)	0.392 0.267 0.211	2-qp($\pi g_{7/2}$)^2 2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 2-qp($\pi\, d_{5/2}, \pi g_{7/2}$)	0.370 0.313 0.173	2-qp($\pi g_{7/2}, \pi\, d_{5/2}$) 2-qp($\pi g_{7/2}$)^2 2-qp($\pi\, d_{5/2}, \pi g_{7/2}$)	0.375 0.319 0.124	2-qp($\nu h_{11/2}$)^2	0.761	2-qp($\nu h_{11/2}$)^2	0.485
10	2-qp($\nu h_{11/2}$)^2	0.983	2-qp($\nu h_{11/2}$)^2	0.970	2-qp($\nu h_{11/2}$)^2	0.846	2-qp($\nu h_{11/2}$)^2	0.825	2-qp($\nu h_{11/2}$)^2	0.639

RESULTS (Continued)

Table 2. . Comparison of experimental [1-3] and theoretical B(E2) values (in units of e^2b^2). The theoretical values are given in red color.

Transition	^{114}Te	^{116}Te	^{118}Te	^{120}Te	^{122}Te
$2^+ \rightarrow 0^+$	0.112(9) **0.097**	 **0.105**	0.113($^{+0.021}_{-0.017}$) **0.111**	0.133(3) **0.118**	0.132(0.001) **0.120**
$4^+ \rightarrow 2^+$	0.095(9) **0.150**	 **0.161**	0.237($^{+0.065}_{-0.038}$) **0.171**	0.211(35) **0.179**	0.198(0.007) **0.178**
$6^+ \rightarrow 4^+$	0.141(26) **0.038**	 **0.063**	0.275($^{+0.048}_{-0.034}$) **0.125**	0.316(70) **0.186**	 **0.178**
$8^+ \rightarrow 6^+$	0.082(29) **0.087**	 **0.104**	0.282($^{+0.092}_{-0.069}$) **0.129**	 **0.014**	 **0.0005**
$10^+ \rightarrow 8^+$	 **0**	 **0**	0.313($^{+0.076}_{-0.069}$) **0.000025**	 **0.001**	 **0.002**

Figure 2. Comparison of the theoretical total *g*-factors (g_t) with the available experimental data [7-9] and the contribution of proton (g_π) and neutron (g_ν) components to the total *g*-factor (g_t).



CONCLUSIONS

- Figure 1 shows that the systematics of 2^+ and 4^+ states with N is reproduced well by the present calculations. The computed yrast states up to I=6^+ are show good agreement with the experimentally measured ones for all the Te isotopes. The configuration of yrast states at each spin with their weight factors are given in table 1. The 6^+ yrast states of $^{114\text{-}120}$Te and 8^+ yrast states of $^{114\text{-}118}$Te show the major contribution from the 2-qp proton bands arising from the 3/2, 7/2 components of proton $g_{7/2}$ subshell and 5/2 component of proton $d_{5/2}$ subshell.
- The structure of yrast states further changes at spin 8^+ from 2-qp proton to 2-qp neutron bands in $^{114\text{-}118}$Te. The I=10^+, 8^+ yrast states in $^{114\text{-}118}$Te, ^{120,122}Te, respectively, arise from 2-qp neutron $h_{11/2}$ bands.
- As seen from table 2, the observed systematics of B(E2) values with N is also reproduced well in all the considered Te isotopes. The theoretical B(E2) values show a drop at spin I=6^+ in ^{114,116}Te due to the alteration in the constitution yrast bands. Further, the theoretical B(E2) value collapses around spins I=8^+-10^+ in all the considered Te isotopes due to alteration in the composition of yrast bands to neutron $h_{11/2}$ bands.
- The experimental data is available only for g-factors of 2^+ states of ^{120,122}Te isotopes reproduced by the results presented in figure 2.
- The 8^+ states of $^{114\text{-}118}$Te are envisaged to be of $(\pi g_{7/2})^2$ nature and in ^{120,122}Te these states are found to be of $(\nu h_{11/2})^2$ nature. However, the 10^+ states of $^{114\text{-}118}$Te are envisaged to be of $(\nu h_{11/2})^2$ nature.

REFERENCES

[1] O. Moller *et al.*, Phys. Rev.C**71** 064324 (2005).

[2] A .A. Pasternak *et al.*, Eur. Phys. J. A**13** 435 (2002).

[3] M Saxena M *et al.*, Phys. Rev. C**90** 024316 (2014).

[4] Y. Sun and K. Hara , Comp. Phys. Commun. 104, 245 (1997).

[5] K. Hara and Y. Sun, Int. J. Mod. Phys. E4, 637 (1995).

[6] S. Sharma *et al.*, Nucl. Phys. A**988** 9 (2019).

[7] N.K.B. Shu *et al.*, Phys. Rev. C**24** 954 (1981).

[8] J.S. Dunham *et al.*, Phys. Rev. C**37** 2881 (1988).

[9] A.E. Stuchbery *et al.*, Phys. Rev. C**76** 034306 (2007).

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