Shell Model Calculations for ^{132}Te

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Introduction

Recently, ^{132}Te has been studied experimentally using INGA facility at TIFR, Mumbai [1]. Using time-stamped data, lifetime of 10^+ state has been remeasured and two new levels above the 10^+ isomer have been identified in ^{132}Te [1]. In this work, we present the results of our investigation on the structure of ^{132}Te in the framework of nuclear shell model. Excitation energies, level lifetimes, magnetic and electric quadrupole moments of a few excited states have been calculated. The results are compared with corresponding experimental data, wherever available. A systematic study of neighbouring Te isotopes have also been carried out to understand the structure of isomeric levels in these isotopes.

Shell Model Calculation

In order to understand the microscopic origin of the excited states in ^{132}Te, LBSM calculations have been carried out using the code OXBASH [2]. The valence space consists of ($1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, $3s_{1/2}$, $1h_{11/2}$) orbitals for both protons and neutrons, respectively, above the ^{100}Sn inert core. The $sn100pn$ interaction based on $sn132g$ interaction [3] has been used for the calculation. The number of valence particles (proton + neutron) in ^{132}Te is 32, amongst them, only 2 are valence protons and the rest 30 are valence neutrons. The maximum number of neutrons that can be accommodated in this valence space is 32. Hence, most of the neutron orbitals are completely filled up, effectively having only two neutron holes. Therefore, no truncation was needed for the present calculation.

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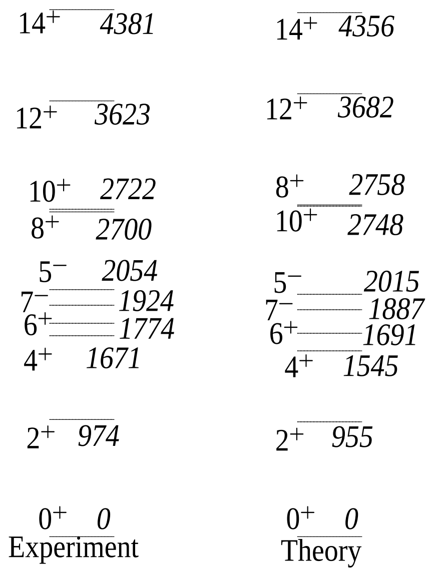

FIG. 1: Comparison between the experimental and theoretical level scheme of ^{132}Te.

Results and Discussion

We have used full valence space for both proton and neutron orbitals to reproduce the experimental level scheme. All the positive and negative parity states including the observed new levels [1] are reproduced quite reliably with this full space calculation (Fig. 1). However, for 8^+ and 10^+ states, the positions are interchanged in theoretical results.

The reduced transition probabilities (B(E2)) for a few transitions have been calculated using the effective charges e_p=1.47 and e_n=0.64 [4]. The lifetimes (τ_m) of the corresponding levels are then calculated from theoretical B(E2) values after considering

TABLE I: Comparison of experimental [5] and theoretical lifetimes for different levels in ^{132}Te.

E_x	J_i^π	E_γ	Branching	α_k	$B(E2)_{Theo}$	Mean Life (τ_m)		μ (nm)		Q_t
MeV		MeV	(%)	[6]	e^2fm^4	Theo.	Expt.	Expt.	Theo.	efm^2
0.974	2^+	0.974	100	0	258.6	3.53 ps	2.64(26) ps	0.70(10)	0.956	19.61
1.671	4^+	0.697	100	0.003	244.5	19.8 ps			3.114	2.76
1.774	6^+	0.103	100	1.52	109.3	244.3 ns	209(12)ns	5.08(15)	4.970	-50.59
2.700	8^+	0.926	100	0	0.03	19.6 ns			-2.546	18.17
2.722	10^+	0.022	6.9	681	30.0	0.52 μs	5.34(13) μs		-3.289	52.70
3.623	12^+	0.901	100	0	87.0	15.5 ps			-0.372	30.23
4.381	14^+	0.758	100	0	0.08	38.3 ps			1.670	-7.54

corrections for branching ratios [5] as well as internal conversion coefficients (α_k) obtained from BrIcc Conversion Coefficient Calculator [6]. Results show good agreement with the experimental lifetimes values except for the isomeric 10^+ state at 2722 keV (Table-I), providing evidences in favour of the reliability of the calculated wave functions. The experimental branching ratio of the 10^+ state for the decay out transitions (22 and 798 keV [5]) are not available. Therefore, the branching (Br = 6.9%) of 22 keV ($10^+ \rightarrow 8^+$) transition has been estimated from shell model calculation. Similarly, the internal conversion coefficient of 22 keV transition (α_k=681) was calculated from BrIcc [6]. The effective charge for calculating the B(E3) for the 798 keV transition has been kept the same as that for other E2 transitions. These uncertainties in the calculations may have resulted in the mismatch of the theoretical lifetime with the experimental data for 2722 keV (10^+) level.

In the present work, we have also calculated (Table-I) the quadrupole moments (Q_t) and magnetic moments (μ) of the excited states. The effective charges used for quadrupole moments are same as that for B(E2) values. The magnetic moment calculations have been carried out for the free values of g-factors as well as for the effective g-factors g_l^p=1.0, g_l^n=0, g_s^p=2.5 and g_s^n=-3.826 [4]. The results obtained from LBSM calculations have been compared with the experimental values [3], wherever available. It has been found that our calculated results have good agreement with the experimental values for effective g-factors (Table-I). The contributions from protons and neutrons to the magnetic moment (μ) have also been calculated.

The theoretical calculations within LBSM have successfully interpreted the experimental data for ^{132}Te. However, there has been a interchange between the positions of the 8^+ and 10^+ levels in theory compared to experiment. This observation warrants some special attention in both experimental and theoreticals endeavours in future.

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