Rotational behavior of Tellurium isotopes

K.M. Muhammed Rafic[1], A. Muhila Suba Janani[1], N.Boomadevi[2], T. R. Rajasekaran[1*]
[1]*Department of Physics, Manonmaniam Sundaranar University, Tirunelveli - 627012, TamilNadu, INDIA*
[2]*Department of Physics, Vyasa Arts & Science Women's College, Subramaniapuram, Tirunelveli – 627758, TamilNadu, INDIA*
*email: trrpub1959@gmail.com

1. Introduction

Structure studies of Tellurium nuclei with two protons outside the major shell (Z = 50) has become essential in describing their energy spectrum obtained experimentally [1]. The statistical theory of hot rotating nuclei [2] is used to predict the shape transition from thermodynamical properties. The following parameters such as nuclear level density parameter, entropy, rotational energy, excitation energy, moment of inertia, level density, single nucleon separation energy can be studied on the basis of statistical theory.

In this present work, the thermal and rotational properties were studied for the isotopes of ^{120}Te and ^{124}Te. The STHRN was able to reproduce moment of inertia at high spin states which shows a good comparison with the experimental data for the even – even isotopes of Tellurium nucleus.

2. *The Statistical Theory of Hot Rotating Nuclei (STHRN)*

The grand canonical partition function for the hot rotating nuclei is given by [3],

$$lnQ = \sum_i ln\left[1 + \exp(\alpha_N + \lambda m_i^N - \beta\epsilon_i^N)\right] + \sum_i ln\left[1 + \exp(\alpha_Z + \lambda m_i^Z - \beta\epsilon_i^Z)\right]$$

where, the lagrangian multipliers α_Z, α_N and λ conserve the number of protons, neutrons, and total angular momentum of the system. Rotational energy E_{rot} and rotational frequency ω_{rot} is expressed as,

$$E_{rot} = E(M,T) - E(0,T), \quad \omega_{rot} = \frac{\partial E_{rot}}{\partial M} .$$

Kinematical (j) moment of inertia is calculated from rotational energy as,

$$j = \hbar^2 M \left(\frac{\partial E_{rot}}{\partial M}\right)^{-1}$$

3. Results and discussions

The present work involves the calculations of kinematic moment of inertia and rotational frequency based on the STHRN method for the Tellurium isotopes for A = 120, 124.

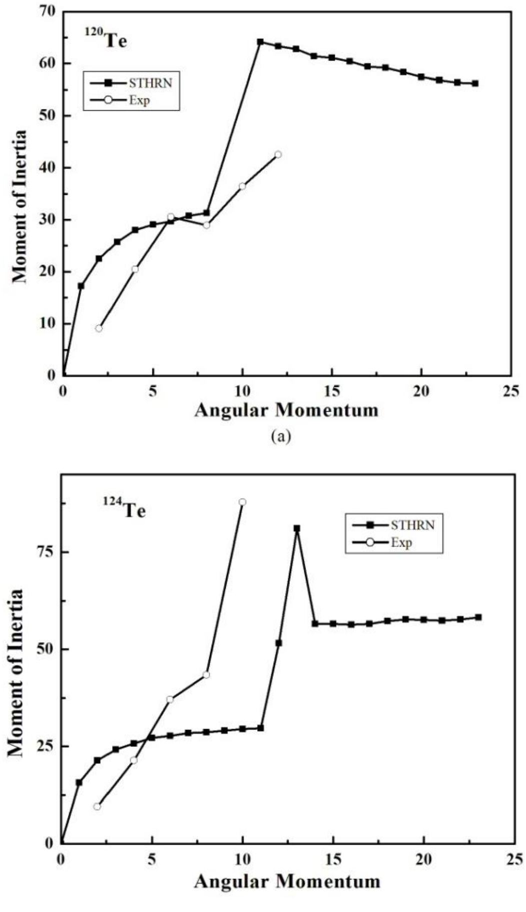

Fig.1 Moment of Inertia (ħ^2/MeV) as function of Angular momentum for (a) ^{120}Te and (b) ^{124}Te

From Fig. 1(a) and (b), the kinematic moment of inertia as a function of angular momentum is shown for ^{120}Te and ^{124}Te. At low and high angular momentum, the calculated moment of inertia is compared with the experimental values. The kinematical moment of inertia changes sharply at M = 10ħ for ^{120}Te and at M = 14ħ for ^{124}Te.

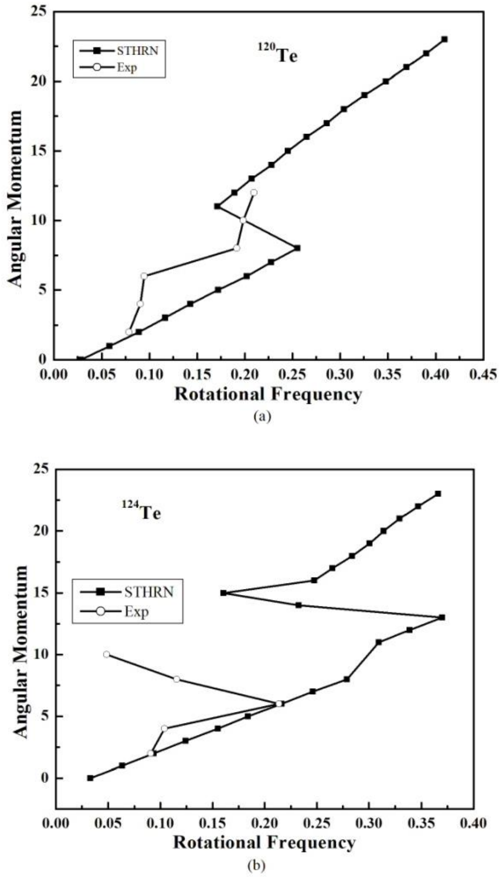

Fig. 2 Angular Momentum (ħ) as function of rotational frequency (ωħ/MeV) for (a) ^{120}Te and (b) ^{124}Te.

Table 1: Comparison of Moment of inertia and Rotational frequency as a function of angular momentum [5] for the isotopes ^{120}Te.

^{120}Te						
M (ħ)	Moment of Inertia (ħ^2/MeV)			Rotational Frequency (ωħ/MeV)		
	STHRN	Exp	IBM-1	STHRN	Exp	IBM-1
2	22.505	9.04	10.707	0.058	0.078	0.078
4	28.030	20.4	22.701	0.117	0.090	0.095
6	29.699	30.5	32.699	0.172	0.095	0.113
8	31.312	28.9	41.147	0.228	0.192	0.133
10	64.182	36.4	48.392	0.171	0.199	0.154
12	63.340	42.5	54.658	0.208	0.209	0.178

In Fig. 2(a) and (b), the angular momentum as a function of rotational frequency is plotted for ^{120}Te and ^{124}Te and the results are compared with available experimental values [3]. The rotational frequency calculated from STHRN method gives very good comparison with the experimental data.

The deviation in rotational frequency for certain states corresponds to shape a change which is called as band crossing. For ^{120}Te and ^{124}Te a single band crossing, around M ≈ 10ħ and 12ħ is observed respectively.

4. Summary and Conclusion

Depending upon the thermodynamic parameters such as rotational frequency, kinematic moment of inertia, transition behavior has been studied for Tellurium isotopes. The moment of inertia and rotational frequency describes the spin distribution of nuclear levels. The calculated results are in very good agreement with the experimental data and it overcomes the linear pattern obtained by IBM-1 model [5] From the results obtained, STHRN method is found to be the most suitable method to study the even – even isotopes of Tellurium nucleus at high spin states compared to Shell model and IBM – 1 model. However, the deviations in rotational frequency and moment of inertia corresponds to shape changes due to band crossing. And it can be overthrown by the inclusion of pairing interactions in STHRN method.

Acknowledgment

One of the authors (A. Muhila Suba Janani) is grateful to the University Grants Commission (UGC), Government of India for the award of research fellowship under the UGC – SAP – Basic Science Research Program.

References:

1. M. Saxena et.al., Phys. Rev. C **90** (2014) 024316.
2. T.R. Rajasekaran, G. Kanthimathi, Eur. Phys. J. A **35** (2008) 57-68.
3. I. Hossain et.al., Armenian Journal of Physics **8** (2015) 7-16.
4. Y. K. Gupta, Bency John, D.C. Biswas, B.K. Nayak, A. Saxena, and R. K. Choudhery, Phys. Rev. C **78** (2008) 054609.
5. Saad.N.Abood and Laith A.Najim, Advances in Applied Science Research 4 (2013)444–451.