Chiral partner bands in ^{98}Tc

R.K. Sinha[1],* A. Dhal[1,2], D. Negi[2], D. Choudhury[3], G. Mahanto[2], M. Patial[3], N. Gupta[3], S. Kumar[4], S. Agarwal[5], R.P. Singh[2], S. Muralithar[2], N. Madhavan[2], S.S. Ghugre[6], J.B. Gupta[7], A.K. Sinha[6], A.K. Jain[3], I.M. Govil[8], R.K. Bhowmik[8], S.C. Pancholi[2],† and L. Chaturvedi[8]

[1]*Department of Physics, Banaras Hindu University, Varanasi-221 005, INDIA*
[2]*Inter University Accelerator Centre, New Delhi-110 067, INDIA*
[3]*Department of Physics, IIT Roorkee, Roorkee-247 667, INDIA*
[4]*Department of Physics & Astrophysics, Delhi University, Delhi-110007, INDIA*
[5]*Babu Banarasi Das College of Engineering, Lucknow - 226016, INDIA*
[6]*UGC-DAE CSR, Kolkata Centre, Kolkata-700 098, INDIA*
[7]*Ramjas College, Delhi University, Delhi-110 007, INDIA and*
[8]*Guru Ghasidas University, Bilaspur, Chhatisgarh-495 009, INDIA*

Introduction

Candidate chiral doublet bands are based on unique parity high-j particle-hole nucleon configurations. In the mass A $\sim$ 100 region, such bands have been found in several of the odd-odd and odd-A Rh, Tc and Ag nuclei [1, 2]. For a deeper understanding of the phenomenon of chirality, it is important to map out the A $\sim$ 100 region to search for signatures of this phenomenon. The aim of the present experiment is to look for possible chiral candidate doublet bands in ^{98}Tc. TRS calculations for the negative parity band based on the $\pi g_{9/2}^{-1} \otimes \nu h_{11/2}$ configuration in ^{98}Tc shows minima at $\beta_2 \sim 0.2$ and $\gamma \sim$ -29^0-27^0 depicting triaxial shape for the nucleus.

Preliminary results of the present investigations were reported earlier in [3, 4].

Experimental Details

High spin states in the odd-odd ^{98}Tc nucleus were populated using the ^{94}Zr(^{7}Li, 3n)^{98}Tc reaction at an incident beam energy of 32 MeV. The ^{7}Li beam was delivered by the 15-UD Pelletron accelerator at Inter University Accelerator Centre (IUAC), New Delhi. The de-exciting γ-rays were detected utilizing the Indian National Gamma Array (INGA) [5] which at the time of the experiment comprised of 15 Compton suppressed Clover detectors. The Clover detectors were arranged in five rings *viz.* 32^0, 57^0, 90^0, 123^0 and 148^0 with respect to the beam direction. The total coverage of Ge crystals is about 25% of 4π corresponding to a total photopeak efficiency of $\sim$ 5%. The distance between the target and the detector is $\sim$24 cm. The isotopically enriched ^{94}Zr self supporting target was $\sim$ 4.4 mg/cm^2 thick. The data were collected in the list mode using the CAMAC-based MULTICRATE synchronization mode coupled with PC-LINUX environment. The energy and timing information from the clover detectors were processed using the indigenously developed (at IUAC) Clover modules and ADC's. A total of about 850 million two or higher fold coincidences were recorded.

Data analysis and results

The data were analyzed off-line using the analysis programs INGASORT and CANDLE. The coincidence events were sorted into the conventional $\gamma - \gamma$ symmetric as well as asymmetric matrices. The 4k $\times$ 4k matrices had an energy dispersion of 0.5 keV/channel. From the analysis of our experimental data, the obtained level scheme of ^{98}Tc has been extended up to J$^\pi$ = 19$^-$ and excitation energy of E$_x$ $\sim$ 6 MeV. A fully developed candidate chiral partner band and a number of

*Electronic address: rishi_india@rediffmail.com
†Formerly at:Department of Physics & Astrophysics, Delhi University, Delhi-110 007, INDIA

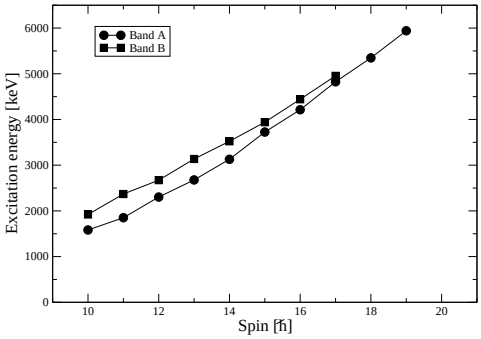

FIG. 1: Variation of excitation energy with spin, for both of the partner bands in ^{98}Tc.

gamma transitions connecting it to the yrast band have been found for the first time. Decay pattern similar to ^{98}Tc is also observed in odd-odd Rh and other nuclei [6]. Earlier investigations on this nucleus were done in [7]. During the course of the data analysis of the present work, we noticed the recent investigations on ^{98}Tc reported in [8]. In principle, our work confirms their level scheme but in contrast, in [8], only a few levels in the partner band and some interconnecting transitions to the yrast band were observed.

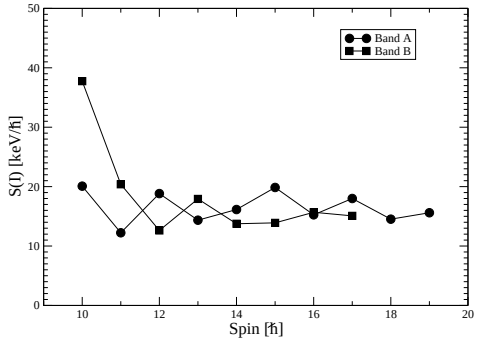

FIG. 2: Variation of the staggering parameter S(I) for both of the partner bands in ^{98}Tc.

The excitation energy *vs.* spin plot for the doublet structure in ^{98}Tc is shown in Fig. 1. With increasing spin the energy degeneracy is achieved which is an indication of stable chiral geometry. Beyond the spin value $12\hbar$ the staggering parameter S(I) = [E(I) - E(I-1)]/2I, for both the partner bands shows relatively smooth variation as a function of spin (see Fig. 2). A stringent test of chirality can only be from the B(M1) and B(E2) strengths for the doublet bands. Lifetime measurements are however required for it.

The level scheme, the properties of the partner bands in ^{98}Tc and the systematics of chiral bands in the neighbouring A $\sim$ 100 nuclei will be discussed in the presentation.

Acknowledgments

We would like to thank all the members of the INGA collaboration. The help of personnel of Pelletron group and the target laboratory of IUAC, New Delhi, are highly acknowledged. Authors would like to thank Dr. Pankaj Joshi for valuable discussions and TRS calculations.

References

[1] P. Joshi *et al.*, J. Phys. **G**: Nucl. Part. Phys. **31**, S1895 (2005).
[2] P. Joshi *et al.*, Phys. Rev. Lett. **98**, 102501 (2007).
[3] R.K. Sinha *et al.*, DAE-BRNS Int'l Symp. on Nucl. Phys. **V54**, 62 (2009).
[4] R.K. Sinha *et al.*, Int'l Conf. on *Nuclear Structure 2010*, Berkeley, 2010.
[5] S. Muralithar *et. al.*, Nucl. Instrum. Methods **A 626**, 281 (2010).
[6] S.C.Pancholi, *Exotic Nuclear Excitations*, Springer Tracts in Modern Physics, Vol. 242 (2011) p. 81.
[7] A.M. Bizzeti-Sona *et al.*, Phys. Rev. **C 36**, 2330 (1987).
[8] Ding Hui-Bo *et al.*, Chin. Phys. Lett. **27**, 072501 (2010).