POSSIBLE CHIRAL BANDS IN THE DOUBLY-ODD ^{194}Tl NUCLEUS*

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High spin states in ^{194}Tl, excited through the ^{181}Ta (^{18}O, $5n$)^{194}Tl heavy-ion fusion evaporation reaction were studied at iThemba LABS using the AFRODITE array, which consisted of 8 clovers and 6 LEPS detectors. The yrast band built on the 8^- isomeric state has a $\pi h_{9/2} \otimes \nu i^{-1}_{13/2}$ configuration suitable for a chiral system. One of the new bands built on a new 10^- level has the same parity and similar excitation energy to those of the yrast band. This new band is linked to the yrast band by several transitions and may be a chiral partner to the yrast band.

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1. Introduction

The high spin states in the $A \sim 190$ mass region correspond to an excitation of the odd proton into the $K = 9/2$ $h_{9/2}$ intruder orbital, which drives the nucleus to oblate deformed shape. These nuclei posses interesting phenomena such as the large signature splitting observed in the strongly coupled $\pi h_{9/2}$ bands in the odd $^{193-197}$Tl which has been interpreted as a possible result of a non-axial deformation [1, 2]. The odd–odd nuclei are also very interesting because their yrast bands were assigned configurations involving high-K protons, and low-K neutrons, which are suitable for a chiral system. Possible chirality was suggested recently in ^{198}Tl [3].

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2. Experimental setup

High-spin states of ^{194}Tl were studied at iThemba LABS using the AFRODITE array. The ^{181}Ta(^{18}O, $5n$) fusion evaporation reaction at 91 and 93 MeV was used to populate high-spin states in ^{194}Tl. The experiment was performed for two weekends($\sim$ 4 days). The target consisted of stacks of three and two thin metallic tantalum foils with thickness of 0.5 mg/cm^2 each in the first and the second weekend respectively. The emitted γ-rays were detected by the AFRODITE array [4], which consisted of 8 clovers and 6 LEPS detectors. A total of $\sim 2.3 \times 10^6$ two or higher-fold clover events were accumulated and analyzed using the Radware package [5]. The analysis of the data involved *(i)* study of the γ-ray coincidence relationships, and *(ii)* directional correlation from oriented states (DCO) and linear polarization measurements to deduce the spin and parity of the levels.

3. Experimental results

The analysis of the γ coincidences for the ^{194}Tl data set resulted in the extension of the previously known negative parity band [6], here called Band 1. Four new bands were also observed. The spins and the parities were assigned to the new levels with the help of the results of the DCO ratio and the linear polarization measurements. The yrast band has been assigned a $\pi h_{9/2} \otimes \nu i_{13/2}$ configuration [6]. This particle–hole configuration is suitable for a chiral system. Two of the new bands (Bands 3 and 4) also have negative parity, as the yrast band. Band 4 develops above a 10^- state and is a 2-quasiparticle band. Among the orbitals close to the Fermi surface it is not possible to find a 2-quasiparticle configuration other than $\pi h_{9/2} \otimes \nu i_{13/2}$, which could match the observed spins and parity of Band 4. This band is linked to the yrast band by a series of $\triangle I = 1$ M1 transitions which probably indicates that they have similar configurations. Bands 1

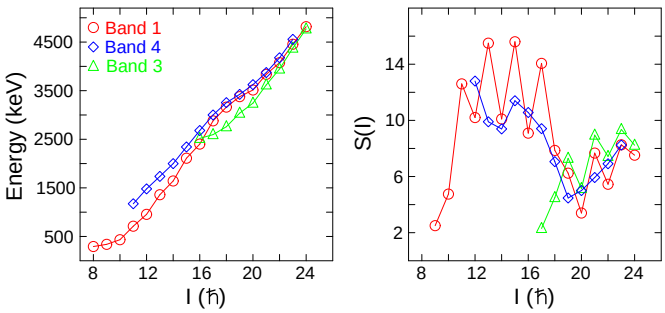

Fig. 1. Excitation energy (left panel) and staggering, $S(I) = [E(I) - E(I-1)]/(2(I))$ (right panel), in the negative parity bands in ^{194}Tl.

and 4 are observed through the band crossing, Band 3 only starts at high spin, and is thus most likely a 4-quasiparticle band. The excitation energy and the staggering plots for these bands in ^{194}Tl are shown in Fig. 1.

4. Discussion of the results

In the region of $I = 18$–$20\hbar$ Band 1 and Band 4 undergo band crossings, at about the same rotational frequency of about 0.3 MeV. Band 3 crosses Band 1 at a rotational frequency of 0.275 MeV. Bands 1 and 4 have the same alignments of about $18\hbar$ above the band crossings, while the alignment of Band 3 is about $16\hbar$. Such large alignments and moderate band crossing frequencies are consistent with excitation of two more $i_{13/2}$ neutrons. The interesting question then will be whether some of these bands are chiral partners. In particular, Band 1 and Band 4 may be good candidates for chiral bands. Band 4 has relative excitation energy of about 377 keV with respect to yrast band at $I = 13$, which decreases at higher spins. Above the band crossing it is only 37 keV at $I = 21$. The measured quasiparticle alignments, kinematic moments of inertia and the preliminary $B(\mathrm{M1})/B(\mathrm{E2})$ reduced transition probability ratios for the three negative parity bands are presented in Fig. 2. Many of the properties of Bands 1 and 4 agree with the

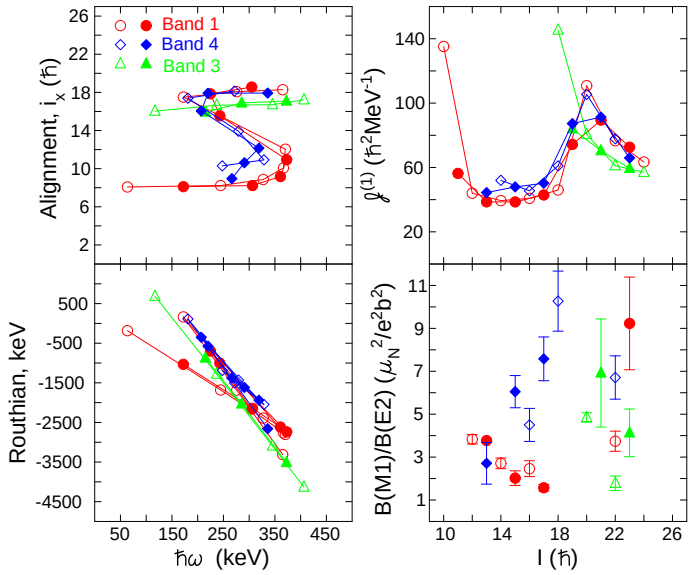

Fig. 2. Experimental quasiparticle alignments, and Rothians, (calculated with reference parameters $J_0 = 8\hbar^2/\mathrm{MeV}$ and $J_1 = 40\hbar^4/\mathrm{MeV}$), kinematic moment of inertia, and preliminary values for the $B(\mathrm{M1})/B(\mathrm{E2})$ ratios of the reduced transition probabilities, for the negative parity bands in ^{194}Tl.

fingerprints for chirality such as: *(i)* the small relative excitation energy of Band 4 with respect to Band 1. *(ii)* similar alignments, in particular above the band crossing, *(iii)* similar moments of inertial, in particular above the band crossings, *(iv)* similarity in the band crossing regions of both bands. Indeed both bands undergo band crossings at about the same rotational frequency. Some of their properties, however, disagree with the fingerprints for chirality such as: *(i)* Band 1 exhibits energy staggering with a large amplitude while Band 4 shows no energy staggering. These patterns persist also after the band crossings. *(ii)* The preliminary $B(\mathrm{M1})/B(\mathrm{E2})$ ratios seem to differ.

5. Summary and conclusions

High spin states in the doubly odd ^{194}Tl were studied and the previously known level scheme was significantly extended. Transitions were assigned a multipolarity and electromagnetic character following the results of the DCO and linear polarization measurements. Two of the new bands have the same parities as the yrast band and exhibit small energy degeneracy with respect to the yrast band, which is expected for chiral structures. It is possible that these bands (in particular Bands 1 and 4) are chiral partners.

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