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Abstract. Composite chiral bands, corresponding to the $\pi g_{9/2}\nu(h_{11/2})^2$ quasiparticle configuration, were observed in ^{103}Rh and ^{105}Rh. The behaviour of these bands were compared with that of the chiral bands with $\pi g_{9/2}\nu h_{11/2}$ quasiparticle configuration observed in the odd-odd ^{102}Rh and ^{104}Rh nuclei. This comparison shows in a model independent way that the energy separation pattern of the chiral partner bands depends strongly on the properties of the triaxial core while the dependence on the valence quasiparticle coupling and on the Fermi level is weaker.

Keywords: rotational bands, chirality, triaxiality
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INTRODUCTION

Rotating triaxial nuclei attain chiral character when the total angular momentum has considerable components in all the three principal axes. The chiral character manifests itself experimentally as two degenerate rotational bands of the same intrinsic configuration [1]. In certain triaxial odd-odd nuclei, where the two unpaired nucleons occupy particle- and hole-type high-j orbitals, it is energetically favourable if the angular momentum vectors of the core rotation, the particle and the hole type nucleons are aligned with the intermediate axis, the short axis and the long axis, respectively [2]. This is the simplest realisation of nuclear chirality. Chiral partner bands have been observed in several odd-odd nuclei in the A∼130 mass region (for a review see Ref. [3]), and recently in the ^{102,104,106}Rh [4, 5, 6] and ^{100}Tc nuclei [7].

Three perpendicular angular momentum components can, however, also be formed in nuclei with more complex quasiparticle configurations. Since the concept of chirality is not restricted to the above two-quasiparticle configuration these composite configurations also manifest themself as degenerate rotational bands. The simplest such structures are three-quasiparticle configurations of triaxial odd-A nuclei where both the two alike unpaired particles align their angular momenta along the short axis while the hole aligns its angular momentum along the long axis. The first chiral band structure based on three-quasiparticle configuration was observed in ^{145}Nd [8]. We have studied the high-spin states of the ^{105}Rh and ^{103}Rh nuclei, the two odd-A neighbors of ^{104}Rh which is considered as the best example of nuclear chirality. Composite chiral bands were observed in these nuclei corresponding to the $\pi g_{9/2}\nu(h_{11/2})^2$ three-quasiparticle configuration.

EXPERIMENTAL DETAILES AND RESULTS

High-spin states of the ^{103}Rh and ^{105}Rh were studied using the ^{96}Zr(^{11}B,4n) and ^{96}Zr(^{13}C,p3n) fusion-evaporation reaction, respectively. The ^{103}Rh experiment was performed with the GAMMASPHERE spectrometer at LBNL, Berkeley, while the ^{105}Rh experiment with the EUROBALL IV γ-ray and the DIAMANT charged-particle spectrometers at IReS, Strasbourg. The collected events were sorted off-line into 2-d, 3-d, and 4-d histograms in the Radware format [9]. The level schemes were constructed based on the triple- and quadrupole-coincidence relationships, as well as energy and intensity balances extracted for the observed γ-rays. Partial level schemes showing the chiral partner bands are plotted in Fig. 1. In order to facilitate spin and parity determination for the observed new levels directional correlation of oriented nuclei (DCO) ratios [10] were derived for the transitions of sufficient intensity. In case of ^{105}Rh the clover detectors placed around 90 degrees with respect to the beam direction also enabled determination of the linear polarization of the γ-rays.

DISCUSSION AND CONCLUSIONS

In both cases a new rotational band was found (band 4 in Fig. 1) linked with many transitions to the previously known $\pi g_{9/2}\nu(h_{11/2})^2$ band (band 3 in Fig. 1). The observed ΔI=1 rotational band doublets (band3 and band4 in Fig. 1) show the characteristics expected for chiral partner bands as listed below.

- Intense M1 and E2 linking transitions between levels of bands 3 and 4 are observed as expected for the same underlying single-particle configuration.
- The separation energy between states of the same spin in bands 3 and 4 decreases gradually with increasing spin. This is in contradiction to the. Cranked Shell Model predictions for the lowest quasiparticle excitation.
- In both nuclei a γ-band (band 2) coupled to the $\pi g_{9/2}$ band (band 1) was observed. The energy separation between the γ-band and the $\pi g_{9/2}$ band is on average increasing slightly as a function of spin in contrast to the trend observed for bands 3

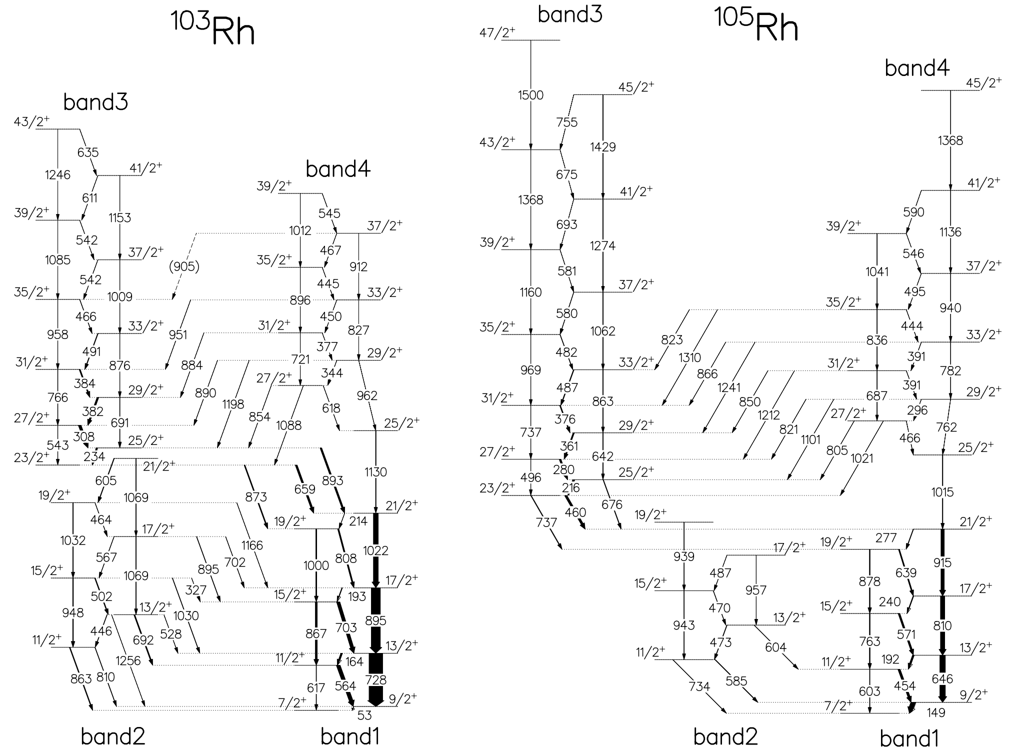

FIGURE 1. Partial level schemes of ^{103}Rh and ^{105}Rh showing the chiral partner band structure (band3 and band4).

and 4; this observation rules out a possibility that band 4 arises from a γ-phonon coupled to band 3.

- The energy level staggering as a function of spin measured by the $S(I) = [E(I) - E(I-1)]/2I$ function is small for bands 3 and 4. The small values of S(I) are consistent with a minimal impact of the Coriolis interactions following from the orthogonal coupling of angular momentum vectors.
- The $B(M1)/B(E2)$ ratios for the two bands are close to each other and show odd-even staggering as a function of spin (see Fig. 4).
- In the case of ^{105}Rh three dimensional tilted axis cranking (TAC) calculations were performed and the comparison of the experimental results with these calculations also supports the chiral interpretation [11].

In Fig. 2 the energy separation between states of the same spin in the chiral doublet bands are compared for the ^{102,103,104,105}Rh nuclei. In case of ^{102}Rh and ^{104}Rh the energy separations were taken from Refs. [4] and [5], respectively. The energy separation between the two bands is proportional with the tunneling between the right-handed and left-handed states in the intrinsic reference frame, thus it is the measure of the stability of the chiral geometry. Though the chiral interpretation of the band doubling emphasizes the role of the core in the energy separation, this separation can in principle depend also

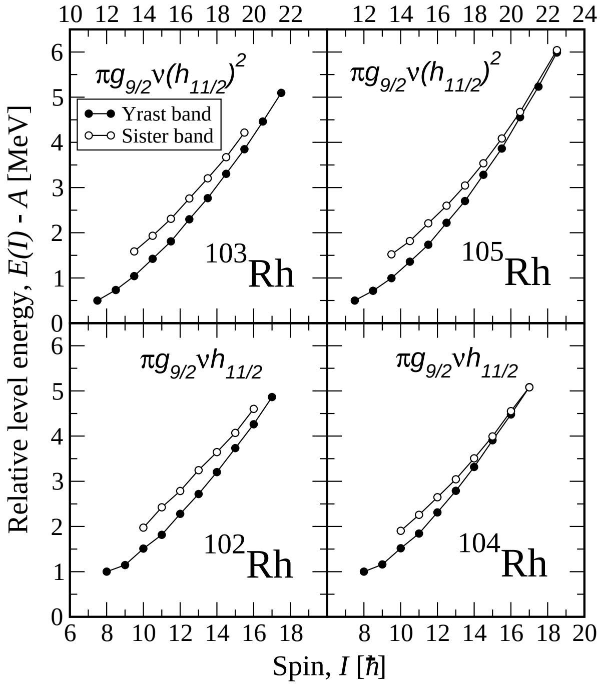

FIGURE 2. Comparison of the energy differences between the same-spin states of the chiral partner bands as a function of spin. Nuclei in the same column belong to the same triaxial core but to different quasiparticle structures while nuclei in the same row belong to the same quasiparticle structure but to different cores.

on the occupation probability of the valence quasiparticle orbitals, i.e. on the Fermi level, as well as on the details of the coupling between valence nucleons (two-quasiparticle vs. three-quasiparticle configurations). These dependencies can be studied in the model independent way by comparing this special quartet of chiral nuclei. Comparison of the doublet structures in Fig.2 shows that the band separation energy pattern depends strongly on the triaxial core and only to less extent on the valence particle configuration and the position of the Fermi level. Indeed the 2- and 3- quasiparticle bands in ^{102}Rh and ^{103}Rh, respectively, show the characteristics of chiral vibrators with persisting energy separation between partner bands. On the contrary, the corresponding bands in ^{104}Rh and ^{105}Rh show the characteristics of stable chiral rotors with nearly degenerate states at the top of the bands. We note here, however, that the observed strong impact of the core properties does not mean that the shape of the core itself is the same as the shape of the chiral nucleus. In Ref. [12] it was found that it is likely that ^{102}Ru attains a certain stiffness in the gamma-degree of freedom, which, with the addition of two valence nucleons evolves into rigid triaxiality in ^{104}Rh. The observed significance of the core properties is in a good qualitative agreement with the chiral expectations, thus it corroborates further the chiral explanation of the band doubling in these nuclei. It should be pointed out, however, that presently there is no nuclear model capable of addressing separations between chiral bands in odd-A nuclei. Thus the experimental information extracted for the discussed quartet of chiral nuclei awaits theoretical studies. A quasiparticle-rotor model for triaxial core and three valence quasi particles seems like a reasonable approach in view of the correspondence to the developed models for odd-odd nuclei.

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