Signatures of Chirality in ^{104,106}Rh Nuclei

A. K. Rana[1,3], H. P. Sharma[1*], Md. Anser[1], Ishika Sharma[1], A. K. Gupta[1], S. S. Tiwary[2], S Sihotra[3]

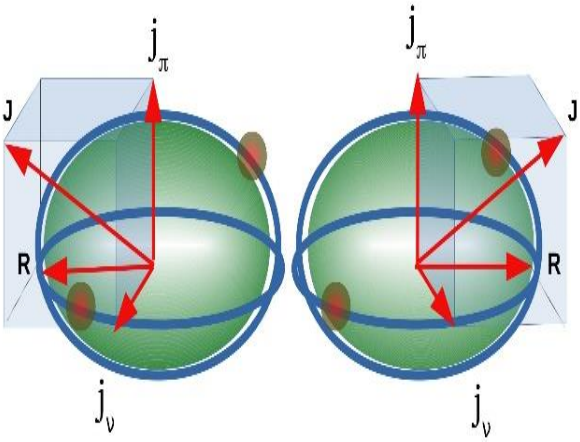
[1]*Department of Physics, Institute of Science, Banaras Hindu University, Varanasi 221005, India.*
[2]*Department of Physics Manipal University Jaipur 303007, India.*
[3]*Department of Physics, Panjab University chandigarh,160014 India.*

1. Introduction

The chiral handedness, in the angular momentum space of nuclei was first described by Frauendorf and Meng [1]. If the angular momentum of a rotating triaxial nucleus coupled to orthogonal proton and neutron angular momenta, the resulting total angular momentum would be aplanar of the plane of any two of the above angular momentum vectors and thus the left- and right-handed rotations can be defined (fig.1). The rotation of the left and right-handed systems will give rise rotational bands with identical properties such as energies, alignments, Routhians, moments of inertia and intra- and inter-band $B(M1)$ and $B(E2)$ reduced transition probabilities [2-5]. Several examples of chirality were found in the odd-odd nuclei from the mass A~130 regions, where $h_{11/2}$ protons couple to $h_{11/2}$ neutrons.

However, investigation of chiral partner bands in the A~100 mass regions are limited and found associated with $\pi(g_{9/2})^{-1}$ $\nu(h_{11/2})$, and $\pi(g_{9/2})^{-1}$ $\nu(h_{11/2})^2$ configurations. Evidence of chirality were reported in Rh, Tc and Ag nuclei [6-8].

A ~ 100 mass region			
Nucleus	Single-particle configuration	Type of nucleus	E.M measurement
$^{106}_{42}Mo_{64}$	$\nu h_{11/2} \otimes \nu(d_{5/2}, g_{7/2})^{-1}$	even-even	No
$^{100}_{43}Tc_{57}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}$	doubly-odd	No
$^{108}_{44}Ru_{64}$	$\nu h_{11/2} \otimes \nu(d_{5/2}, g_{7/2})^{-1}$	even-even	No
$^{110}_{44}Ru_{66}$	$\nu h_{11/2} \otimes \nu(d_{5/2}, g_{7/2})^{-1}$	even-even	No
$^{112}_{44}Ru_{68}$	$\nu h_{11/2} \otimes \nu(d_{5/2}, g_{7/2})^{-1}$	even-even	No
$^{102}_{45}Rh_{57}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}$	doubly-odd	No
$^{103}_{45}Rh_{58}$	$\pi(g_{9/2})^{-1} \otimes \nu h^2_{11/2}$	odd-mass	Yes
$^{104}_{45}Rh_{59}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}$	doubly-odd	Yes
$^{105}_{45}Rh_{60}$	$\pi(g_{9/2})^{-1} \otimes \nu h^2_{11/2}$	odd-mass	No
$^{106}_{45}Rh_{61}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}$	doubly-odd	No
$^{105}_{47}Ag_{58}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}(d_{5/2}, g_{7/2})$	odd-mass	No
$^{106}_{47}Ag_{59}$	$\pi(g_{9/2})^{-1} \otimes \nu h_{11/2}$	doubly-odd	No



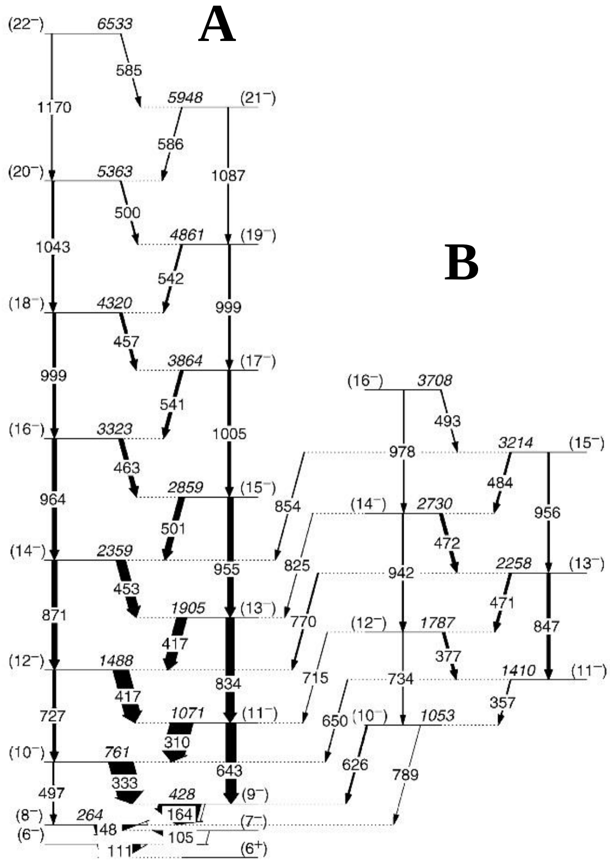


Fig.1: Chiral systems in a triaxial odd-odd nucleus both left-handed and right-handed configurations [9].

Fig.2. Partial level scheme for ^{106}Rh taken from ref. [11]

2.Results and Discussion

The observation of signature inversion in the band was interpreted as a change in shape from near-oblate to prolate. A systematic study of the nearly degenerate negative-parity bands in the mass region has been performed and it is found that the yrast band in Ag and its side band B show different behaviours with those expected from a pair of chiral bands (fig.2). One of the important signatures of chirality, is the small amplitude of energy staggering S(I) = [E(I)− (I −1)/(2*I)] of the partner bands. Due to the effect of the Coriolis force, the staggering is large in the odd-odd nuclei where the rotation is confined in the plane

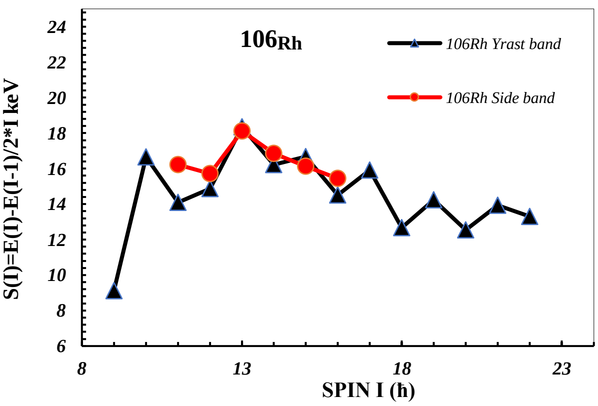


Fig.3 Signature splitting in ΔI=2 bands based on (I^{π}=7$^-$ state at 216 keV) and (I^{π}=8$^-$ state at 264 keV) in ^{106}Rh.

containing the spin vectors of the proton and neutron. However, in the case of chiral rotation, angular momentum vectors are out-planer and hence, staggering amplitude is reduced significantly [10]. In the A~100 mass regions, the chiral symmetry was associated with bands built on the $\pi(g_{9/2})^{-1}\otimes\nu(h_{11/2})$. The odd proton (neutron) occupying the highest-energy (lowest-energy) orbital in the $g_{9/2}$, ($h_{11/2}$) shell at the deformation parameters used for the core were β_2=0.23 and γ=−30^0 [12,13]. This is interesting since ^{106}Rh was expected to possess better chiral geometry than ^{104}Rh because the triaxiality was predicted to be closer to γ=−30◦. In the present work the signature splitting of the ΔI=2 bands, viz. bands (I^{π}=7$^-$ state at 216 keV) and (I^{π}=8$^-$ state at 264 keV) in ^{106}Rh nucleus. The energy staggering index S(I) is plotted as a function of spin up to 22ħ for the yrast band and found to be nearly increasing up to 12ħ in ^{106}Rh nucleus. The staggering index S(I) values, two bands (yrast band A and side band B) in ^{106}Rh yrast band S(I) values change in comparison of previous result [14]. The newly calculated value of S(I) which shows signature inversion nearly spin around 13ħ (fig.3). Hence small signature splitting is observed around 18-keV near spin 13ħ after signature splitting smoothly decreasing near spin 22ħ. S(I) values observed in ^{106}Rh are similar to those observed in ^{104}Rh, suggesting that these two quantities are stronger than the energy separation between the chiral bands against fluctuations in the chiral geometry. Further a γ-soft core may also have effect on the chiral geometry [15]. The TRS calculation at a rotational frequency of 0.4MeV/$\hbar^{-1}$ show that the nucleus ^{106}Rh prefers a triaxial shape, for the $\pi(g_{9/2})^{-1}\otimes\nu h_{11/2}$ configuration, with the value of γ~-30^0 [16]. It is also clear that the triaxial minimum is γ-soft. This could explain why the partner bands do not become degenerate but give rise to what has been called chiral vibrations.

3.Summary

The "lowest- and highest-energy orbitals of a high-j shells and the odd proton and the odd neutron are restricted to one orbital each located at the lowest- and highest-energy orbitals or vice versa" are where Fermi surfaces are found in this mass area. The signature inversion around spin 13ħ is observed in the yrast band A of ^{106}Rh nuclei, indicating the nucleus' triaxiality. Following the 13ħ gradually descending onto 22 ħ, the signature split. The side band B S(I) produces an almost constant value of ~15 keV/ħ$^{-1}$, which is consistent with the expectation for ideal chiral nuclei, and also rather well reproduces the experimental amplitudes for the yrast band A and side band B in ^{106}Rh.

4.Acknowledgments

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