# Angular Momentum Generation Mechanisms in mass-100 Region

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## Introduction

The nuclei of the mass-100 region exhibit single particle excitations and vibrations at low spins and collective rotation at high spins. Besides these well established angular momentum generation modes, they are also known to display a rich variety of exotic modes like the correlated single particle behavior namely, the magnetic and the anti-magnetic rotation. These two phenomena are known to manifest in nuclei of low deformation, as no other favorable modes of excitations are present. However, the co-existence of the collective rotation and the anti-magnetic rotation was never observed. The co-existence of these two modes was observed in both the isotopes of Pd, namely $^{104,105}$Pd during the course of this work [1]. Thus, these are the first instances when such a high spin phenomenon has been reported. It may be noted that the only way that these two mechanisms can be distinguished is through the life time measurement.

The behavior of the AMR bands in $^{104,105}$Pd have been well described by the numerical calculations based on the framework of SCPRM model [2]. It may be interesting to note that in both the cases a prolate deformation of $\beta \sim 0.13$ has been necessary to describe the transition rates. The co-existent collective bands also correspond to prolate shapes with $\beta \sim 0.19$. Thus, the two Pd isotopes were found to have prolate deformation at higher spins.

In the neighboring odd-odd isotope of $^{106}$Ag, a pair of doublet bands was already known and the moments of inertia (MOI) of these two bands were found to be different. During the course of the present work, the precise life time measurements for the levels of the doublet bands have been performed. These measurements led to a unique observation regarding these doublet bands that though the MOI of the two bands are different, their transition rates are very similar [3]. This novel observation has been reproduced by numerical calculations based on TPSM. This fact indicates that the doublet bands in $^{106}$Ag originate due to the triaxial deformation. On the other hand, its other two bands originate due to an interplay between the shears mechanism and the collective rotation. Their high spin behavior can be understood within the framework of SPAC model which in turn assumes a prolate shape for the collective rotation. Thus, $^{106}$Ag exhibits the co-existence of triaxial and axial shapes which is also supported by the TRS calcolation.

## Experiments

The high spin states of $^{104}$Pd and $^{105}$Pd were populated in one experiment through the reactions $^{96}$Zr($^{13}$C, 5n$\gamma$)$^{104}$Pd and $^{96}$Zr($^{13}$C, 4n$\gamma$)$^{105}$Pd using the $^{13}$C beam at 63 MeV from the 14-UD Pelletron at TIFR. In another experiment, also carried out at TIFR, the $^{106}$Ag was populated through $^{96}$Zr($^{14}$C, 4n$\gamma$)$^{106}$Ag reaction using the $^{14}$N beam at 68 MeV.

## Analysis

The de-exciting $\gamma$ rays were detected using the Indian National Gamma Array (INGA) which comprised of 20 Compton suppressed Clover detectors. The time stamped data from this array was sorted into various $\gamma-\gamma$ matrices and the $\gamma-\gamma-\gamma$ cube. The coincidence criteria was used to built the level schemes pertaining to these nuclei. The advantages of

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using Clover detector in addback mode and its use as a polarimeter are well known. The present INGA geometry also allowed the $\gamma$ gated angular distribution measurements of the various relatively weak low lying $\gamma$ transitions. The detectors at the forward and 90° rings were used for the DCO measurements of the $\gamma$ photons de-exciting the various excited levels that were populated during the fusion-evaporation reactions. These measurements were necessary for the spin assignment of each level. The parity assignments were performed by determining the electromagnetic character of the gamma transitions through PDCO measurements. The Doppler Dhift Attenuation Method (DSAM) was extensively used to measure the lifetimes of all the high spin levels in these nuclei which were in turn used to deduce the various transition rates. It may be noted that these rates are often very crucial for any physical interpretation.

## Conclusion

Thus, the present experimental investigation and comparison with the various macroscopic models indicates a rich varity of angular momentum generation modes in these three nuclei which are:

**(1)** Interplay between AMR and collective rotation in one band of $^{104}$Pd and two bands of $^{105}$Pd [1].

**(2)** Collective rotation of a prolate shape for two bands of $^{104}$Pd and one band in $^{105}$Pd. These rotational bands are also associated with signature quantum numbers.

**(3)** Co-existence of AMR and collective rotation in $^{104,105}$Pd [4].

**(4)** The doublet bands of $^{106}$Ag arising due to the triaxially deformed core [3].

**(5)** The other two bands of $^{106}$Ag arise due to an interplay between shears mechanism and collective rotation of a prolate core.

**(6)** co-existence of triaxial and axial deformation in $^{106}$Ag [5].

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