RAPID COMMUNICATIONS

PHYSICAL REVIEW C **95**, 051301(R) (2017)

Novel evolution of the positive parity shears band in ^{106}Ag

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(Received 10 March 2017; published 8 May 2017)

The positive-parity band of ^{106}Ag has been extended up to $I = 25\hbar$ and the lifetimes of the high spin levels of this band have been measured. The deduced transition rates decrease with increasing spin until $I = 21\hbar$. Beyond this spin, the observed transition rates are substantially small and remain nearly constant. This is a novel observation for a shears band. The observed features have been described within the framework of the shears mechanism with a principle axis cranking calculation.

DOI: 10.1103/PhysRevC.95.051301

The shears mechanism was first identified in spherical Pb nuclei in the mass-200 region [1]. These bands are usually characterized by a sequence of strong magnetic-dipole ($M1$) transitions with increasing energies and exhibit a falling trend in their transition rates [$B(M1)$] as a function of spin. The crossover electric-quadrupole ($E2$) transitions are either absent or weak. According to this mechanism, the high-angular-momentum states are generated by the simultaneous closing of the angular-momentum vectors of the valance quasiparticles ($\vec{j}_1$ and $\vec{j}_2$) which are coupled perpendicularly at the bandhead and fully aligned at the highest spin ($\vec{I}_{\text{shear}} = \vec{j}_1 + \vec{j}_2$) along the direction of $\vec{I}_{\text{shear}}$. It is to be noted that the $\vec{I}_{\text{shear}}$ is tilted with respect to the principal axes and the tilt angle remains nearly constant as the band evolves to higher spin states. The shears mechanism has also been observed in moderately deformed nuclei with the suitable single-particle configuration to sustain the shears structure. In these cases, the crossover $E2$ transitions are found to be stronger and the core rotation ($\vec{R}$) also contributes in the generation of angular momentum. As a result, the shears band extends beyond the maximum possible spin $\vec{I}_{\text{shear}}$ to $\vec{I}_{\text{max}}$, where $\vec{I}_{\text{max}} = \vec{I}_{\text{shear}} + \vec{R}$ [2]. It is interesting to investigate the fate of a shears band after the blades are completely closed. One possibility is the termination of shears band, which has been proposed in ^{199}Pb [3]. The other possibility is the observation of higher quasiparticle shears structure, which is usually referred to as the crossing of shears bands [4]. However, it is important to note that all the reported shears bands throughout the nuclear chart and irrespective of the core contribution or band crossing exhibit the characteristic falling trend of $B(M1)$ values between bandhead and I_{max} [5].

In the present work, we revisit a previously reported positive-parity shears band in ^{106}Ag and extend it to $I = 25\hbar$. The transition-rate measurements show that the $B(M1)$ transition rates gradually decrease up to $I = 21\hbar$ and then remain nearly constant. This novel feature is investigated in the present work in the context of interplay between core rotation and the shears mechanism.

The high-spin states of ^{106}Ag were populated through the fusion-evaporation reaction ^{96}Zr(^{14}N,4n) using a 68 MeV ^{14}N beam from the Pelletron-LINAC facility at the Tata Institute of Fundamental Research (TIFR), Mumbai, India. An enriched ^{96}Zr of thickness 1 mg/cm^2 with 9-mg/cm^2-thick ^{206}Pb backing was used as the target. The deexciting γ rays were detected by using the Indian National Gamma Array (INGA) [6]. The placement of the detectors along with other experimental details are given in Ref. [7]. The two- and higher-fold coincidence data were recorded in a fast digital data-acquisition system based on Pixie-16 modules of XIA LLC and were sorted in γ-γ matrices and γ-γ-γ cube with a time window of 150 ns by using the sorting program MARCOS [8].

The partial level scheme of the positive-parity band of ^{106}Ag obtained in the present work is shown in Fig. 1. The cube and the symmetric matrix were analyzed by RADWARE programs GTKLEV and GTKESC [9], respectively, to construct this level scheme. The gated spectra projected at 90° were found to be useful to identify the high-spin crossover $E2$ transitions due to the presence of significant Doppler-broadened lineshapes. The sum gate of 258 and 295 keV (Fig. 2) shows the γ rays belonging to this positive-parity band of ^{106}Ag where the newly placed transitions are marked with "∗." The effect of the Doppler broadening at 90° is clearly visible in the inset of the Fig. 2 for the 1266, 1362, 1424, and 1538 keV transitions, whereas this effect is negligible in the case of the 1495 keV transition, since it is a retarded $E1$ transition. This observation is consistent with the present level scheme and confirms the same reported by He *et al.* [10] until $I^\pi = 21^+$ with few changes.

The previously placed 1212 keV transition between $22^+ \rightarrow 20^+$ is found to be inconsistent because it does not exhibit Doppler broadening whereas the immediately lower $E2$ transition; namely, 1091 keV ($20^+ \rightarrow 18^+$), is Doppler broadened. In addition, the 629 keV ($22^+ \rightarrow 21^+$) transition is not present

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