Continuous evolution from quasi particle excitation mode to collective excitation: study of +ve parity band in ^{106}Ag nucleus

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Introduction

The theory of shears mechanism came as a surprise to solve the puzzle of high-spin M1 bands in near spherical Pb isotopes [1] with falling B(M1) rates. The commonly observed shears bands, also known as the *magnetic rotation* bands are generated when the quasi-particle angular momenta of particle-type and hole-type align themselves perpendicularly at the band-head, forming blades of a shear. The repulsive nature of the particle-hole interaction give rise to a band by closing these shear blades simultaneously. Apart from a near spherical nucleus the shears structure can evolve in a sufficiently deformed nucleus, in which case it competes with the core rotation to generate the high-spin states.

Analysis

The high-spin states of ^{106}Ag nucleus was populated through ^{96}Zr(^{14}N,4n) reaction with a 68 MeV ^{14}N beam from 14UD Pelletron at TIFR, Mumbai. In the present work the only +ve parity band of ^{106}Ag was extended up to 25^+, by adding three new M1 γ transitions on the top of the band, namely 682, 742 and 796 keV along with the cross-over E2 transitions. The transition rates were extracted from the measured level lifetimes using DSAM technique, and are plotted in Fig. 1. The B(M1) and B(E2) values exhibits a falling trend up to 21^+ and remain nearly constant beyond 21^+.

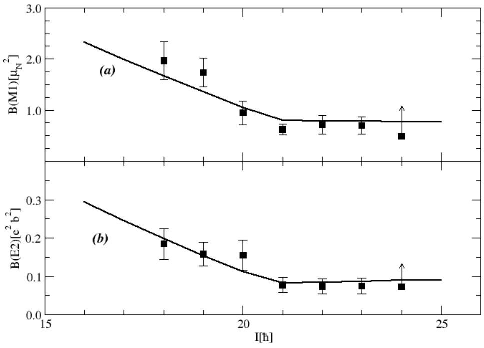

FIG. 1: The measured and theoretical B(M1) and B(E2) values. Solid lines represent the calculated theoretical values.

The falling nature of the transition rates may be attributed to the phenomena of magnetic rotation [1], however the transition rate characteristic beyond 21^+ remains unexplained. In the earlier works [2], this band up to 22^+ was assigned with the quasi-particle configuration $\pi g_{9/2}^{-1} \otimes \nu[(g_{7/2}/d_{5/2})^1 h_{11/2}^2]$. A shears structure is evident from the above mentioned configuration, as the rotation aligned neutron($j_\perp$) and deformation aligned proton angular momentum($j_\parallel$) construct two blades of a shear. However the closing of these two shears blades cannot reproduce the band up to 25^+. The excess spin can be attributed to the core rotation, which had an interplay with the shears mechanism to generate the

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*Electronic address: `bd.physics@gmail.com` band spin up to 21^+. To describe this interplay the *Shears with Principal Axis Cranking*(SPAC) model [3] has been implemented. In the present version of the model the direction of $\vec{j}_\perp$ stays rotation aligned because of the Coriolis force, and the shear closes by the sole alignment of $\vec{j}_\parallel$ [3]. As a result the energy of the spin state I takes the form

$$E = \left|\vec{R}(I,\theta)\right|^2/2\mathfrak{J} + V_2 P_2(\theta) \qquad (1)$$

where $\left|\vec{R}(I,\theta)\right|$ is the core angular momentum, $\mathfrak{J}$ is the effective moment of inertia and V_2 is the shears energy. To obtain the shears angles the energy minimisation is done using Eq.[1](Fig. 2(a)). It is to be noted that shears angles are obtained for the spin states up to 21^+ only, as evident from the transition rates. For $I > 21^+$ the energy states are generated by the core rotation only with freezed quasi-particle configuration. The whole picture comes naturally from the framework of SPAC model. A smooth cross-over in the angular momentum generation mechanism is encountered by varying $\mathfrak{J}$ from $9\hbar^2/MeV$ to $10.5\hbar^2/MeV$ continuously in the spin domain. The theoretical routhian plot can be seen in Fig. 2(c), with $V_2 = 1.1MeV$, and the spin contribution from core is plotted in Fig. 2(b).

With the shears angles obtained, the B(M1) rates can be calculated as

$$B(M1) = \frac{3}{8\pi}[j_\parallel g_\parallel^* sin(\theta - \theta_I) - j_\perp g_\perp^* sin(\theta_I)]^2 \qquad (2)$$

where $g_\parallel^* = g_\parallel - g_R$, $g_\perp^* = g_\perp - g_R$, $g_R = (Z/A)$; $g_\parallel$ and $g_\perp$ are the g-factors for the deformation aligned and the rotation aligned quasi-particles respectively;θ_I is the angle of $\vec{I}$ with respect to the rotation axis, Z and A are atomic number and mass number of the nucleus respectively. It can be seen in Fig. 1(a) that the B(M1) rates in the whole spin regime can be reproduced in the framework of SPAC model.

Again in this framework, the B(E2) values are fitted with the formula

$$B(E2) = \frac{15}{128\pi}[eQ_{eff} sin^2\theta_j + eQ_{coll} cos^2\theta_I]^2 \qquad (3)$$

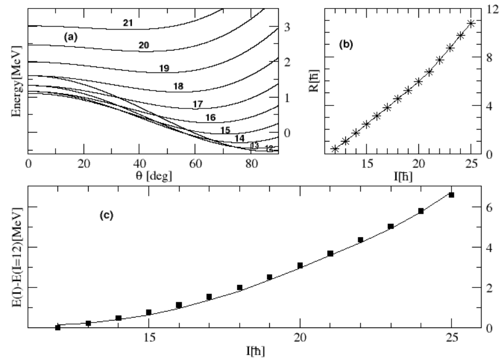

FIG. 2: (a) The energy minimization plot using SPAC. (b) The core angular momentum as a function of spin.(c) The measured and calculated routhian.

where eQ_{eff} and eQ_{coll} are the quasi particle and the collective quadrupole moments respectively. For the best fit we get $eQ_{eff} = 3.75eb$ and $eQ_{coll} = 0.6eb$. The fitted value along with the experimental B(E2) values are shown in Fig. 1(b). The value of eQ_{eff} accounts for the core polarisation effect [1]. A core polarisation charge of $\sim 2e$ is obtained, which is consistent with the single proton-hole configuration $(\pi g_{9/2}^{-1})$.

Acknowledgments

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