Staircase bands in ^{105,107,109}Ag: Fingerprint of interplay between Shears Mechanism and Collective Rotation

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Introduction

Shears mechanism in weakly deformed nuclei has been firmly established by numerous experimental observations since its inception by S. Fruaendorf [5] in early nineties. On the contrary, the scope of Shears mode of excitation in moderately deformed nuclei is a less explored teritory. The Shears mechanism is primarily identified in bands having strong $M1$ transitions with increasing energies as well as falling $B(M1)$ rates as a function of angular momentum. On the other hand, the presence of M1 energy staggering in odd and odd-odd nuclei indicates that the signature is a good quantum number which corresponds to collective rotation. It is interesting to note that nuclei near Z=50 shell closure are moderately deformed as well as Shears structure develop at higher excitation with quasi-particles alignment. To be specific, the moderately deformed Ag nuclei are good candiates for such study as the high spin states are predominantly generated by the valance neutrons in low-Ω orbitals of $h_{11/2}$ and the valance protons in high-Ω orbitals of $g_{9/2}$ which forms a Shears structure.

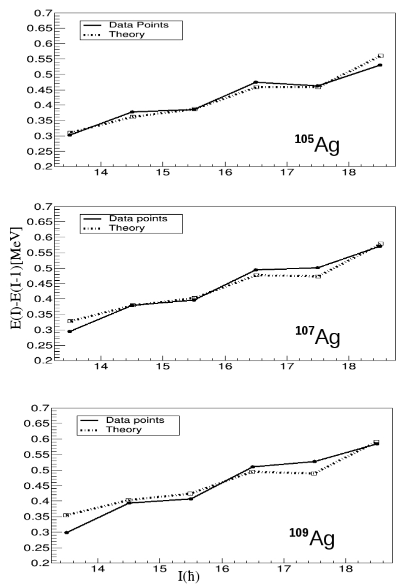

FIG. 1: Staircase[E(i)-E(i-1)] plot for +ve parity bands in Odd-Ag nuclei

Theory of Stairecase bands

The possitive-parity staircase bands in odd-Ag nuclei are generated after neutron alignment takes place in $h_{\frac{11}{2}}$ orbital, where proton is in $g_{\frac{9}{2}}$ orbital. The proton in high-Ω orbital and neutrons in low-Ω orbital opens up a pair of shear. However, the maximum angular-momentum observed in the band is higher than the angular-momentum that can be generated by the complete closing of the shears blade. This implies a significant contribution from collective rotation. The interplay between shears mechanism and core rotation

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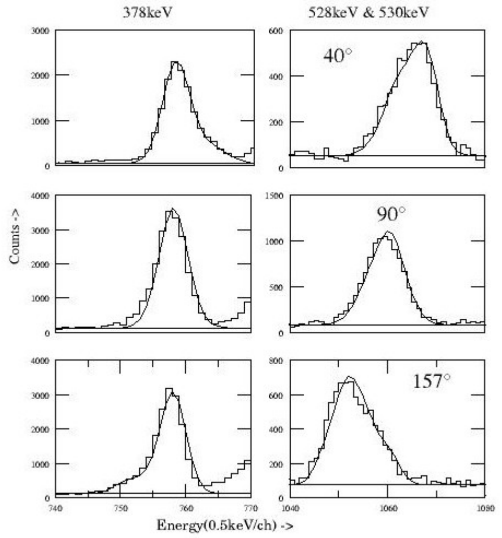

FIG. 2: Gamma-ray Lineshapes from ^{105}Ag nucleus

can be incorporated in the total energy as

$$E = \frac{R^2}{2J(I)} + V(\frac{3cos^2(\theta) - 1}{2}) \qquad (1)$$

Where θ is the 'Shear-Angle '.
Now to reproduce the unusual energy-staggering of staircase bands a variable moment of inertia of the form

$$J(I) = J_0[1 - a(-1)^{I+\frac{1}{2}}(I + \frac{1}{2})/(I^2 + 1)] \quad (2)$$

is taken, where 'a 'is the *Signature Quantum Number* and 'J_0 'is the *Core Moment of Inertia*. These parameters can be fixed by fitting the ground band of these nuclei. The unique shears angle θ for each angular momentum state can be found by setting $\frac{dE}{d\theta} = 0$. FIG. 1 shows the comparison between the experimental and calculated routhian for ^{105}Ag, ^{107}Ag and ^{109}Ag nuclei from this model. The good agreement indicates that the origin of these unique staircase bands is due to the coupling between the shears mechanism and the collective rotation with signature staggering.

In order to investigate further, the transition rates need to be reproduced from this theory. The high spin level lifetime in ^{105}Ag has been carried out as a part of this work. These states of ^{105}Ag were populated through the ^{96}Zr(^{14}N, 5n) reaction using a 68 MeV ^{14}N beam from the 14-UD Pelletron at Tata Institute of Fundamental Research (TIFR). The Lineshape analysis has been carried out to measure the level-lifitemes of the high-spin states of +ve parity band of ^{105}Ag nucleus. Examples of few lineshapes are shown in FIG. 2. The measured B(M1) rates are also in good agreement with the calculated value.

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