Rotation of ^{89}Y nucleus about the longest principal axes

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Introduction

In near-spherical nuclei, shell-model excitations are mostly responsible for angular momentum generation (in the present work $Z \simeq 40$ and $N \simeq 50$). In contrast, collective rotation is a favored way to generate angular momentum in deformed, non-spherical nuclei. The high-spin states of nuclei near closed shells (in A $\approx$ 90 and 140) have developed considerable interest in terms of collectivity via rotation of the nucleus about the classically unfavored longest principal axis [1, 2]. However, triaxiality in a nucleus plays a leading role in determining the possibility of rotation around any of the three principal axes. Variation of $\gamma = 0° \rightarrow +60°$ represents rotation of nucleus around the shortest principal axis, $\gamma = 0° \rightarrow$ -60° represent rotation of nucleus around the intermediate axis and = -60° $\rightarrow$ -120° represent rotation around the longest principal axis.

A couple of bands each with positive and negative parity states respectively were reported experimentally in ^{89}Y by Z. Q. Li *et al.* [3]. If the characteristics of these bands are compared with the neighboring ^{89}Zr [1, 4], these should be potential candidates for rotation around the longest axis.

In this paper, we discuss the evolution of dipole bands with perspective to the nuclear rotations about various axes in ^{89}Y nucleus within the framework of cranked Nilsson-Struitinsky model (CNS).

Model Calculations

Pairing independent CNS model helps in nurturing the collective properties of a nucleus. In CNS calculations, the coefficient of $\mathbf{l} \cdot \mathbf{s}$ and $\mathbf{l^2}$ in the nuclear potential was derived for $A = 80$ region [5]. The total energy is calculated as a sum of the rotating liquid drop energy and the shell energy, using the Strutinsky shell correction formalism [6, 7]. The static liquid drop reference used is the Lublin-Strasbourg drop (LSD) [8]. The rigid body moment of inertia is calculated with a radius parameter of $r_0 = 1.16$ fm and diffuseness of a = 0.6 fm [9]. The calculations minimize the total energy for the different configurations with respect to deformation parameters, ε_2, ε_4, and γ , at different angular momenta. The configurations are labeled as per the nomenclature: $[p_1 p_2, n_1 n_2]$, where, p_1 is the number of proton holes in the fp shell and p_2 represents the number of protons in the $g_{9/2}$ shell. As well, n_1 is the number of neutron holes in the $g_{9/2}$ shell, and n_2 shows the number of neutrons in gds orbitals. For a complete description of a configuration, the signature in the sub-shells or group of sub-shells must be specified. Thus, for an odd number of particles in a group, the signature might be given by a subscript, + for signature $\alpha = 1/2$ and - for α = -1/2.

Results and Discussion

Initially, configuration-independent energy minimization is performed with respect to the deformation parameters. The probable nuclear shapes are discussed in Fig.1 which shows the evolution of stable nuclear shapes as a function of spin. For states up to I = 15.5$\hbar$ the energetically favorable minimum corresponds to negative γ values with $\gamma \approx$ -90° and $\varepsilon_2 \approx 0.15$. i.e., rotation around the longest principal axis. However, for high-spin levels, the energetically favorable configura-

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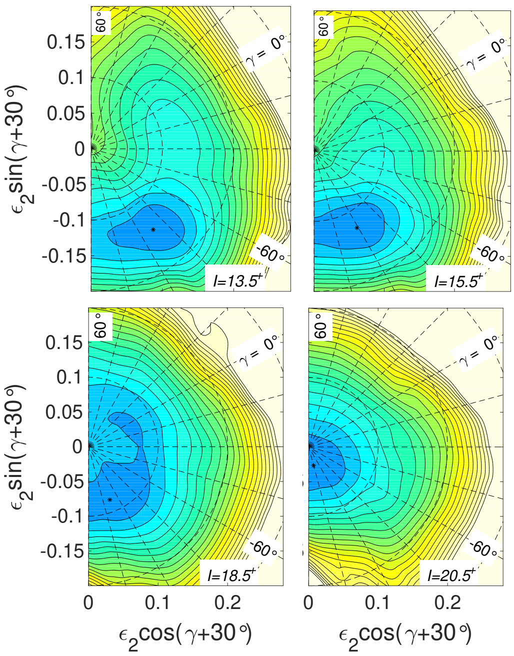

FIG. 1: (Color online)Calculated total energy surfaces plots for spin of 13.5$\hbar$, 15.5$\hbar$, 18.5$\hbar$ and 20.5$\hbar$ for [43;11] $\pi((fp)^{-4}(g_{9/2})^3 \otimes \nu(g_{9/2})^{-1}(gd)^1)$ in ^{89}Y . The contour line separation is 0.25 MeV.

tion [43;11] $\pi((fp)^{-4}(g_{9/2})^3 \otimes \nu(g_{9/2})^{-1}(gd)^1)$ is stabilized with $\gamma \approx$ -120° and $\varepsilon_2 \approx$ -0.1, which is non-collective prolate as per Lund convention.

On the other hand, potential energy surfaces for the configuration [32;22] $\pi((fp)^{-3}(g_{9/2})^2 \otimes \nu(g_{9/2})^{-2}(gd)^2)$ show that the configuration [32;22] is stabilized with a shape at γ values around -20° that corresponds to rotation around the intermediate principal axis at high spin. However, for spin values up to I = 18.5$\hbar$, the lowest minimum corresponds to positive γ values and $\varepsilon_2 \approx$ 0.12, i.e., rotation around the shortest principal axis.

Similar observations were made in ^{89}Zr (Z = 40, N = 49) by S. Saha *et al.* [4] where the rotation around the longest principal axes shows up very clearly with γ values around -60°. In ^{142}Gd (Z = 64, N = 78) [2] the observed minima at $\gamma \approx$ -75° represents tne rotation around the longest axis. In both the case ^{89}Zr and ^{142}Gd, the nucleus rotates around the longest axis due to the distribution of neutron holes since nuclei in both the mass regions have comparable Fermi space $(\nu(g_{9/2}^{-2}(dg)^1)$ and $\nu((ds)^{-2}h_{11/2}^{-2})$ respectively). On the other hand, ^{89}Y (Z = 39, N = 50) shows a highly favorable rotation around the longest axis with higher negative $\gamma \approx$ -90° due to the distribution of proton holes $(\pi((fp)^{-4}(g_{9/2})^3))$.

Details of each configuration along with detailed insight into the Fermi space will be presented during the conference.

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