Triaxial deformations in neutron-rich nuclei with Z = 41 – 46, A ~ 100 – 116 based on prompt fission γ spectroscopy

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Abstract. The paper reviews the systematic studies of triaxial deformations, new mode excitations and shape evolutions with regard to triaxial deformation in the neutron-rich nuclei with Z = 41-46, A~100-116.

1 Introduction

The neutron-rich nuclei in this region are intermediate between the strongly deformed Sr (Z=38) – Y (Z=39) – Zr (Z=40) nuclei and the spherical doubly magic ^{132}Sn [1-4]. The Fermi levels relative to the high-j subshell, $\nu h_{11/2}$, $\pi g_{9/2}$ locate at bottom, middle, to upper half of the shells, favoring triaxial prolate, through large triaxial deformations to triaxial oblate, and oblate shapes providing good opportunities for studying shape transition and new excitations with regard to triaxial deformations. The studies are based on the fission γ spectroscopy using spontaneous fission of ^{252}Cf at Gammasphere [2,4].

2 Systematic studies of triaxial deformations of the nuclei in the region [4, and the references therein]

Great successes have been achieved in intensive systematic work in identifications of unknown neutron-rich nuclei, studies of triaxial deformations, shape evolutions with regard to triaxial deformations in the nuclear region. Maximum triaxiality, rigid rotors, $\gamma \sim -30^0$ were identified in Ru (Z=44) isotopes [4, 5]. Less pronounced triaxiality was found in Pd isotopes [6]. Stable $\gamma \sim -41^0$ was deduced in ^{114}Pd, a minimum energy gain 0.32 MeV, in contrast to 0.67 MeV in Ru isotopes. In Ag (Z=47) isotopes, one sees softness towards triaxiality and very rich structure. In Cd (Z=48) isotopes, quasi-particle couplings, vibrations, onset of collectivity, quasi-rotations, soft triaxiality $\gamma \sim -10^0$ and so on were proposed [4]. In the region below Ru ($Z \leq 44$) [4], Tc (Z=43) with large triaxiality, $\gamma \sim -22^0 - -26^0$, and Mo (Z=42) with large triaxiality, rigid rotors, $\gamma \sim 20^0$ were deduced. In Nb (Z=41) isotopes coexisting triaxiality and transitional behavior from $\gamma \sim 2^0$ to 15^0 were proposed. However, axially-symmetric shapes with large $\varepsilon_2 \sim 0.40$ were deduced in Y (Z=39) and Zr (Z=40) for A < 104, and onset of triaxiality was confirmed in ^{104,106}Zr .

3 New excitations and shape evolutions found in the triaxial nuclei in the region

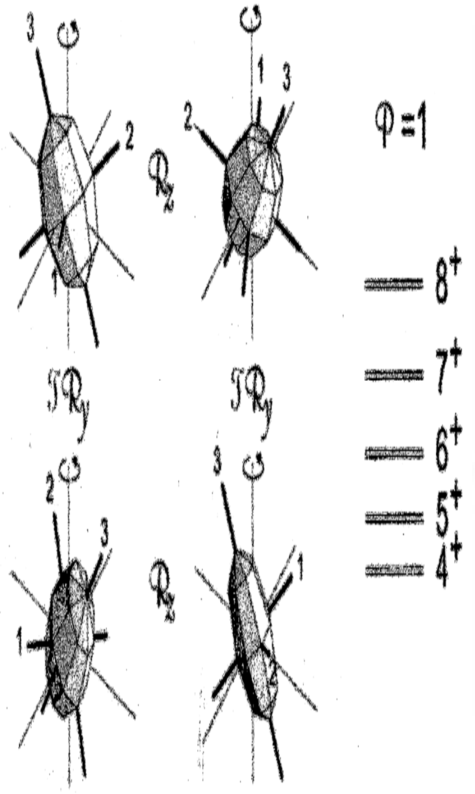

Fig. 1 Chiral breaking in triaxial nuclei.

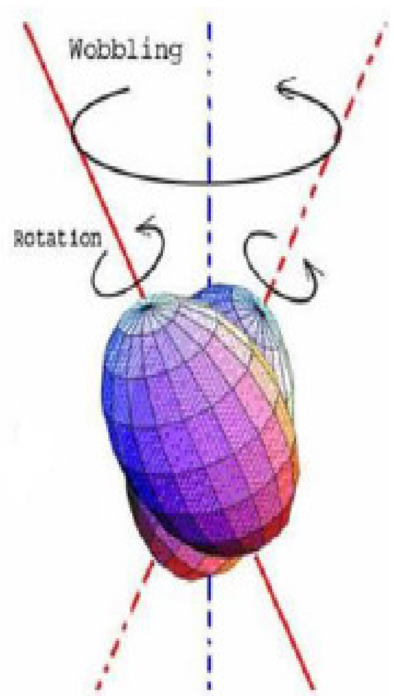

Fig. 2 Wobbling motion in triaxial nuclei.

In this neutron-rich region chiral symmetry breaking has been identified in ^{104,106,108}Mo, ^{100}Tc, ^{110,112}Ru, $^{103\text{-}106}$Rh and ^{104,105}Ag, with disturbed chirality, by soft- and less-pronounced triaxiality, proposed in ^{108}Ru and ^{112,114,116}Pd, respectively [4-6]. The fingerprints of chirality, that is energy degeneracy, similar electro-magnetic properties of the partner levels, and small and nearly constant signature splitting of the doublet bands have been studied in chiral nuclei. While one has seen the evolution of chiral symmetry breaking with maximum triaxiality in ^{110,112}Ru to disturbed chirality by $\boldsymbol{\gamma}$ - softness in ^{108}Ru (from N = 66, 68, to N=64), the evolution of chiral symmetry breaking along the N=66, 68 isotonic chain from Z=44 to Z=46 has also been seen in chiral ^{110,112}Ru with maximum triaxiality to disturbed chirality in Pd isotopes with less-pronounced triaxial deformations. The doublet bands in ^{104}Mo recently identified (Fig. 3) show the best energy degeneracy, that is the smallest and most stable energy differences of the partner levels (Fig. 4), and near zero level staggering in this nuclear region (The latter not shown here in the paper because of the page constraint) [7].

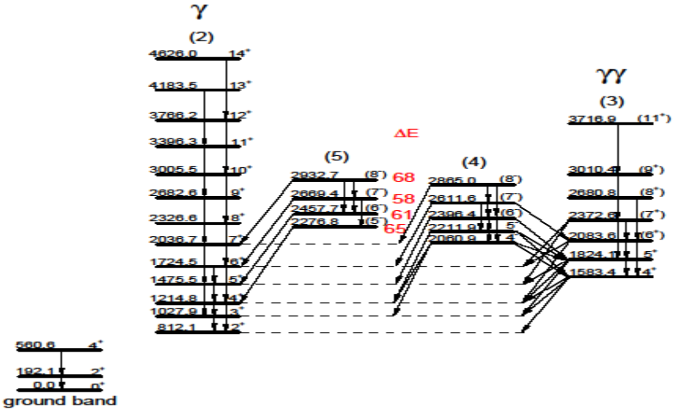

Fig. 3 Chiral symmetry breaking was recently identified in ^{104}Mo. Fingerprints for chirality of a nucleus were confirmed in the doublet bands 4 and 5 [7].

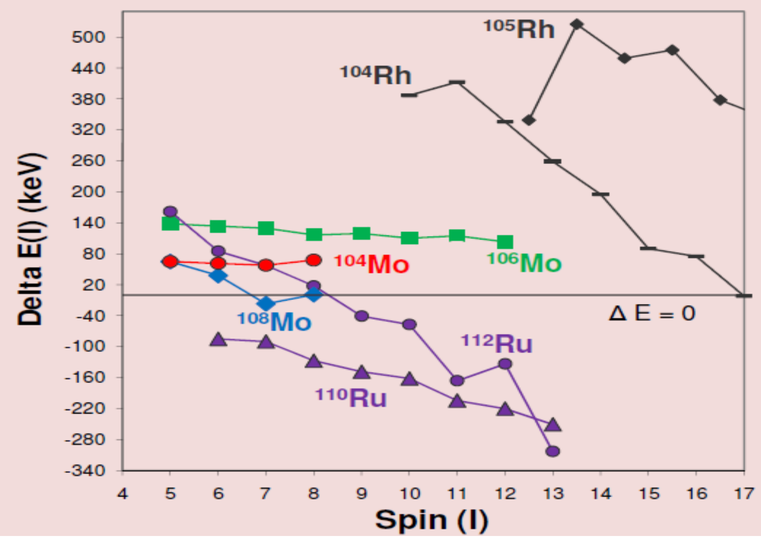

Fig. 4 Energy degeneracy of the partner levels in the doublet bands of the chiral nuclei identified in this nuclear region. The doublet bands in ^{104}Mo show the smallest and most stable energy differences of the partner levels among all the chiral nuclei.

The wobbling motion predicted in triaxial nuclei constitute a revolving motion of J about an axis of a triaxial nucleus. Wobbling motion manifest itself as a fingerprint that the excitations of the α = 0 wobbling (even-spin members of the γ band) are above those of the α = 1 wobbling (odd-spin members of the γ band) in an even-even nucleus. The N=68 isotones ^{112}Ru and ^{114}Pd were identified as the first and second even-even wobbler at moderate spins in the region [4].

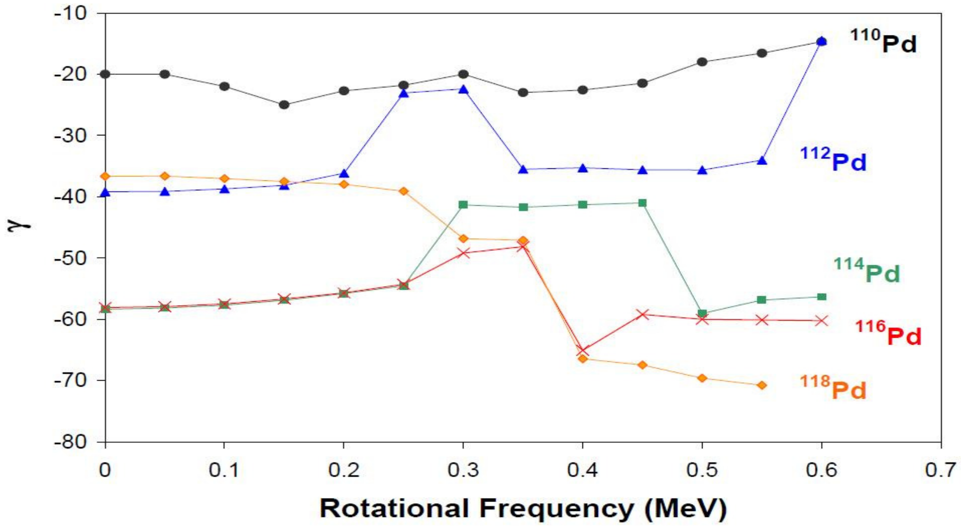

Fig. 5 γ values corresponding to the minima of TRS calculations, indicating the triaxial deformations changing with the rotational frequency and neutron number in Pd [6].

An overall shape evolution from triaxial prolate via triaxial oblate to oblate was identified in even-even $^{110\text{-}118}$Pd (see Fig. 5), showing a more complete and complex shape transition than predicted long time ago [6].

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