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Shape transitions and triaxiality in neutron-rich odd-mass Y and Nb isotopes

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Abstract. New level schemes of ^{99,101}Y and ^{101,105}Nd are established based on the measurement of prompt γ-rays from the fission of ^{252}Cf at Gammasphere. Triaxial-rotor-plus-particle model calculations and fitting suggest that in the $A \approx 100$ neutron-rich nuclei triaxial shape is prevalent in the region with $Z > 41$.

PACS. 21.10.Tg Lifetimes – 25.85.Ca Spontaneous fission – 27.60.+j $90 \leq A \leq 149$

Studies of shape transitions and shape coexistence in neutron-rich nuclei with $A \approx 100$ has long been of major importance [1,2]. Large quadrupole deformations, onset of superdeformed ground states and identical bands, shape evolutions and shape coexistence were observed in the even-even Sr ($Z = 38$)-Zr ($Z = 40$)-Mo ($Z = 42$) region, and evidence of triaxiality was reported in Mo and Ru nuclei, *e.g.* [3,4].

However, less has been reported for the odd-Z nuclei in this region so far. Evidence of triaxiality was observed in Tc ($Z = 43$) and Rh ($Z = 45$) isotopes, *e.g.* [5,6]. A shape transition from axially-symmetric to triaxial deformation in odd-Z nuclei of this region is of particular interest. New level schemes of odd-Z ^{99,101}Y ($Z = 39$) and ^{101,105}Nb ($Z = 41$) are established in the present work based on the measurement of prompt gamma rays from the fission of ^{252}Cf at Gammasphere [6]. It was found that the quadrupole deformations of the $N = 60$ (and $N = 62$) isotones with $Z = 39$–45 follows a similar trend in the neighboring even-even neutron-rich nuclei of $Z = 38$–42.

The very small signature splitting and delay of band crossing observed for Y isotopes are in pronounced contrast to the results in Tc and Rh isotopes, and provide spectroscopic information concerning shape transition regarding triaxiality in this important region. Figure 1 shows the pronounced difference in experimental signature splittings between Y, Nb, Tc and Rh isotopes.

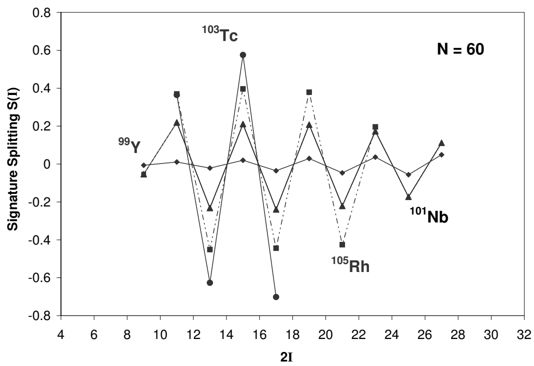

Fig. 1. Experimental signature splitting $S(I)$ of the ground-state bands in $N = 60$ isotones with odd-$Z = 39$–45. Data for ^{103}Tc and ^{105}Rh are taken from refs. [7] and [8].

Triaxial-rotor-plus-particle calculations [5] were performed to reproduce the level excitations, signature splittings and branching ratios of the observed bands in Y and Nb isotopes. The model calculations strongly support a pure axially symmetric shape with large quadrupole deformation, $\epsilon_2 = 0.41$, $\gamma = 0°$ and $\epsilon_2 = 0.39$, $\gamma = 0°$ in the $5/2^+[422]$ ground-state band of ^{99}Y and ^{101}Y isotopes,

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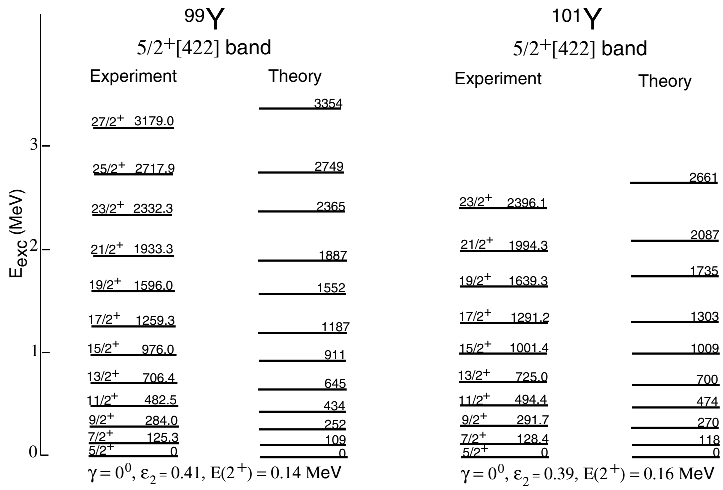

Fig. 2. Experimental and theoretical excitation energies of ground-state bands of ^{99,101}Y. Except for the $5/2^+$, $7/2^+$ and $9/2^+$ of ^{99}Y, all the spin/parity assignments are tentative.

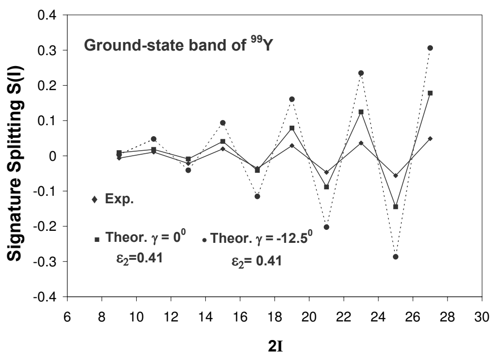

Fig. 3. Experimental and theoretical signature splittings of the ground-state band of ^{99}Y.

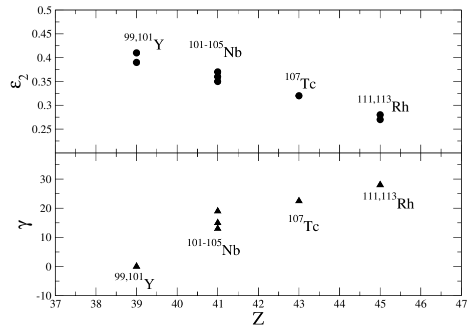

Fig. 4. Systematics of triaxiality and quadrupole deformations observed in the neutron-rich $Z = 39$, 41, 43, 45 isotopes. Data of ^{111,113}Rh and ^{107}Tc are taken from refs. [5] and [6], respectively.

respectively. Figures 2 and 3 compare experimental results with model calculations for the excitations of the ground-state bands of ^{99,101}Y and for the signature splittings of the band of ^{99}Y, respectively.

The model calculations yielded γ values ranging from $-19°$ to $-13°$ for the $5/2^+[422]$ ground-state bands of ^{101}Nb, ^{103}Nb and ^{105}Nb, and a γ value of $-5°$ for the two negative-parity bands in ^{101}Nb. The Nb isotopes are transitional nuclei regarding triaxial deformation. An anticorrelation of quadrupole deformation and triaxiality is seen in nuclei with Z ranging from 39 to 45 (see fig. 4). One may conclude that in the $A \approx 100$ neutron-rich nuclei triaxial shape is prevalent for the bands based on a one-quasiparticle $g_{9/2}$ proton state in the region with $Z > 41$.

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