Lifetime measurements in ^{136}Pm

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Chirality of nuclear rotation is a novel collective feature which is predicted to occur for doubly-odd triaxial nuclei as a result of angular momentum coupling [1]. A spontaneous breaking of the chiral symmetry can take place for configurations where the angular momenta of the valence protons, valence neutrons and the core are mutually perpendicular. This can occur, for example, when the proton and neutron Fermi levels are located in the lower part of valence proton high-j (particlelike) and in the upper part of valence neutron high-j (holelike) subshells, and the core is triaxial. Under such conditions the angular momenta of the valence particles are aligned along the short and long axes of the triaxial core, while the angular momentum of the rotational core is aligned along the intermediate axis. The non zero components of the total angular momentum on all the three axes can form either a left-handed or a right-handed set and therefore, the system manifests chirality [2]. Since the chiral symmetry is dichotomic, its spontaneous breaking leads to doublets of closely lying rotational bands of the same parity [1–3].

In order to confirm or reject the hypothesis of nuclear chirality, next to establish the existence of almost degenerate rotational bands, it is necessary to determine also the electromagnetic transition probabilities. A consequence of chirality is that the reduced transition probabilities of the corresponding levels in both chiral candidate bands have to be identical. The best example of nuclear chirality based on the presence of the two almost degenerate bands was considered to be the ^{134}Pr nucleus [2, 3]. As it is reported in the recently published work [4], the absolute transition matrix elements in the two sister bands are different. In the angular-momentum region where the almost degeneracy of the energy levels of the two bands occurs ($I^\pi = 14^+$ - 19^+), the B(E2) values for Band 1 are a factor 2 to 3 larger than those of Band 2. This result is incompatible with the pure chiral picture (static chirality) where the intraband B(E2) transition strengths must be equal. Such findings point to the fact that the limit of static chirality is not reached in ^{134}Pr and the nucleus stays in a very soft vibrational regime. This result indicates that shape fluctuations are an essential ingredient for the proper description of the structure of the two bands. This fact supports the interpretation of Ref. [5] where the yrast band contains predominantly the ground state configuration of the triaxial core whereas the yrare band contains a major component of the γ-band.

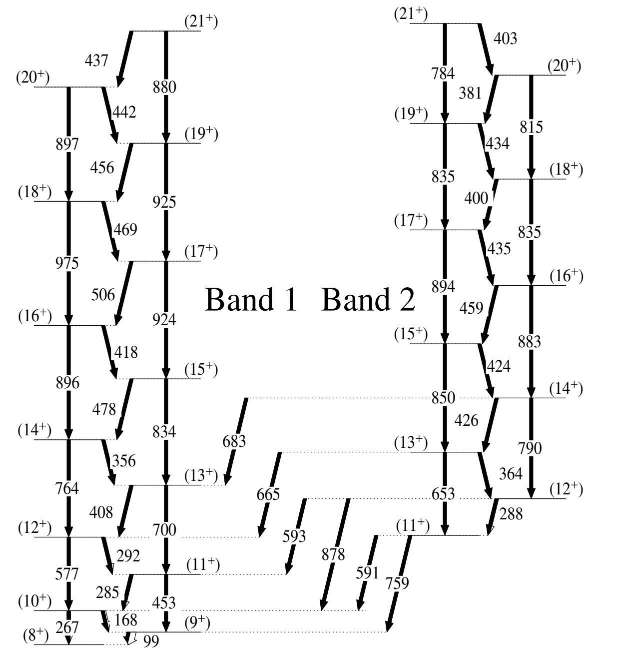

FIG. 1: *Partial level scheme of ^{136}Pm from Ref [6] Two nearly degenerate positive-parity bands, candidates for chiral partner bangs, are indicated as Band 1 and Band 2.*

The aim of the present work is to investigate the electromagnetic transition probabilities in the doublet bands of ^{136}Pm. These two bands have been observed up to $I^\pi = (21^+)$ [6]. Contrary to the case of ^{134}Pr, the B(M1)/B(E2) ratios take similar values within the error bars in ^{136}Pm[6]. This is a strong indication that there is considerable difference between the two nuclei. However, a lifetime measurement in ^{136}Pm is needed to shed light on the scale and the origin of the difference.

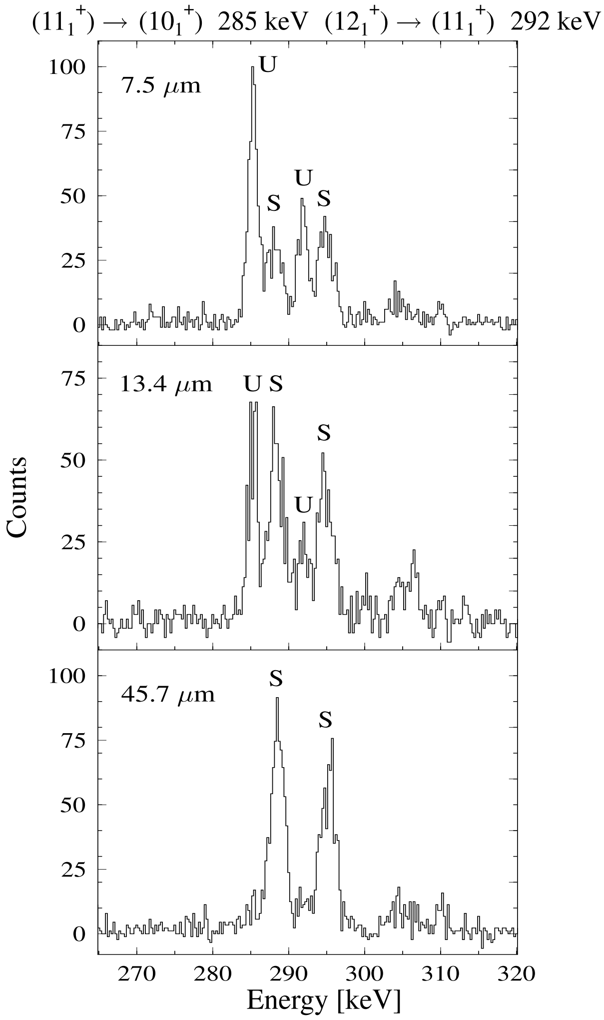

FIG. 2: *Gated γ-ray spectra of ^{136}Pm taken at three different distances. The summed spectra from all detectors positioned at the forward angle 34.6 ° with respect to the beam axis are shown. The evolution with the distance of the shifted and unshifted components of the* $11_1^+ \rightarrow 10_1^+$ *and the* $12_1^+ \rightarrow 11_1^+$ *transitions are presented. We note that the intensity of* $11_2^+ \rightarrow 10_1^+$ *591 keV transition is negligible and therefore* $12_2^+ \rightarrow 11_1^+$ *288 keV transition does not contaminate the spectra.*

The reaction ^{24}Mg + ^{116}Sn at 130 MeV beam energy has been used to populate states of ^{136}Pm at moderate excitation energy and angular momentum. The experiment, performed in June 2005 with the GASP detector array in configuration II at the Tandem accelerator of LNL, includes Doppler-shift attenuation (DSAM) and recoil distance Doppler-shift (RDDS) measurements. For the RDDS measurement the target consisted of 0.5 mg/cm^2 ^{116}Sn evaporated on a 1.5 mg/cm^2 ^{181}Ta foil facing the beam. The recoils, leaving the target with a velocity of 1.4(1) % of the velocity of light, were stopped in a 7.9 mg/cm^2 gold foil. For the DSAM measurement, the target consisted of 0.7 mg/cm^2 ^{116}Sn evaporated on a 9.0 mg/cm^2 ^{197}Au baking used to stop the recoils.

In the RDDS case data were taken at 8 target-to-stopper distances ranging from the electrical contact to 45.7 μm. Examples of spectra taken at different distances for two γ-ray transitions in ^{136}Pm are shown in Fig. 2.

The preliminary analysis show that similarly to the lifetime analysis of ^{134}Pr the RDDS measurement will be utilized to measure lifetimes of the levels with I^π from $10_1{}^+$ to $13_1{}^+$ and $13_2{}^+$ to $14_2{}^+$. For the higher lying states the DSAM measurement will be used.

For the analysis of RDDS data, the standard version of the Differential decay-curve method (DDCM) [7, 8] will be employed.

For the analysis of the DSAM data, we performed a Monte Carlo simulation of the slowing-down histories of the recoils using a modified [9, 10] version of the program DESASTOP [11].

The second goal of the present measurement is to extract the branching ratios and to investigate the level-scheme of ^{136}Pm. The data analysis is in progress.

D.T. express his gratitude to Ivanka Necheva for her outstanding support. This research has been supported by a Marie Curie Fellowship under contract number HPMF-CT-2002-02018, by the BMBF under contract number 06K167 and by the European Community FP6 - Structuring the ERA - Integrated Infrastructure Initiative - contract EURONS number RII3-CT-2004 - 506065. L.A. is supported in part by the Bulgarian Science Fund under contract VUF06/05.

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