SEARCH FOR CHIRALITY IN ^{128}Cs AND ^{132}La*

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The E2 and M1 intraband transition probabilities have been determined in ^{132}La and ^{128}Cs using the Doppler Shift Attenuation method. The B(E2) and B(M1) values suggest that ^{128}Cs is a better candidate for the presence of chiral bands than ^{132}La.

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1. Introduction

The interest of nuclear physics community in chirality has been triggered by the paper of Frauendorf and Meng [1]. In that paper, using Tilted Axis Cranking model, the possibility of chiral symmetry breaking in intrinsic system of atomic nucleus was shown. It was illustrated by reinterpretation of the ^{134}Pr level scheme given by Petrache *et al.* [2]. The main experimental evidence in favour of nuclear chirality was finding of partner bands with the same spins and nearly degenerate energies. It was shown that three mutually perpendicular angular momenta of $h_{11/2}$ proton particle and $h_{11/2}$ neutron hole and triaxial core rotating round its intermediate axis can be responsible for chirality. It is expected that such situation, with mutually perpendicular angular momentum vectors, occurs in odd–odd nuclei from the $A \approx 130$ region where triaxial deformation is known since many years (see *e.g.* [3]). About 10 examples of partner bands have been found in that

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mass region. To explain structure of the odd–odd nuclei the phenomenological Core Particle Hole Coupling model (CPHC) based on interaction of quadrupole moments of a core, a particle and a hole has been developed by Starosta *et al.* [4]. For the first time the model was applied to calculate the properties of ^{132}La. The calculations show that B(E2) and B(M1) probabilities should be similar in chiral doublet bands. The lack of experimental information on electromagnetic properties of supposed chiral bands was the reason that the lifetime measurements were undertaken and conducted in-beam of the Warsaw Cyclotron.

The preliminary results of our investigation of ^{132}La were presented at the Workshop on Spontaneous Symmetry Breaking in Atomic Nucleus (ECT* Trento 2003) and at the 10th Workshop on Nuclear Physics "Marie and Pierre Curie" in Kazimierz Dolny (2003) [5].

2. Experimental results

The lifetimes of the excited states in ^{132}La have been measured and analysed using the Doppler Shift Attenuation method. These states were populated in the ^{122}Sn(^{14}N,4n)^{132}La reaction at beam energy of 70 MeV. The ^{122}Sn 10 mg/cm^2 thick target has been used instead of thin one placed on a thick backing, that is usually used in the DSA method. The data have been analysed by means of the software developed by Pasternak [6, 7]. This software allows to work with thick as well as thin targets. The γ–γ coincidences have been collected by the OSIRIS II multidetector array with 10 Anti-Compton Shielded Germanium spectrometers.

The level scheme and the relative transition intensities determined in our experiment are shown in Fig. 1. Additionally to previously known bands [4] (the yrast band — band 2 and supposed the partner band — band 1) the third band (band 3) connected with the yrast band by six relatively strong interband transitions was found. The spin and parity assignment of band 3, shown in Fig. 1, were not uniquely determined since for the interband transitions (band 3 → yrast band) $R_{\rm DCO}$ and lifetime values allow on $\Delta I = \pm 1$, ± 2 without parity change and $\Delta I = 0$ (parity change cannot be excluded).

Bands similar to bands 1 and 2 have been obtained in the CPHC model calculation [4] where the $h_{11/2}$ proton particle and the $h_{11/2}$ neutron hole were coupled to the ^{130}Ba phenomenological core [8]. The model predictions [9] are shown in Fig. 2. Good agreement of experimental and calculated energies and intensity branching ratios for band 2 is observed. It seems that for band 1 the calculation does not reproduce the experimental data as well as for band 2 (compare Fig. 1 with Fig. 2).

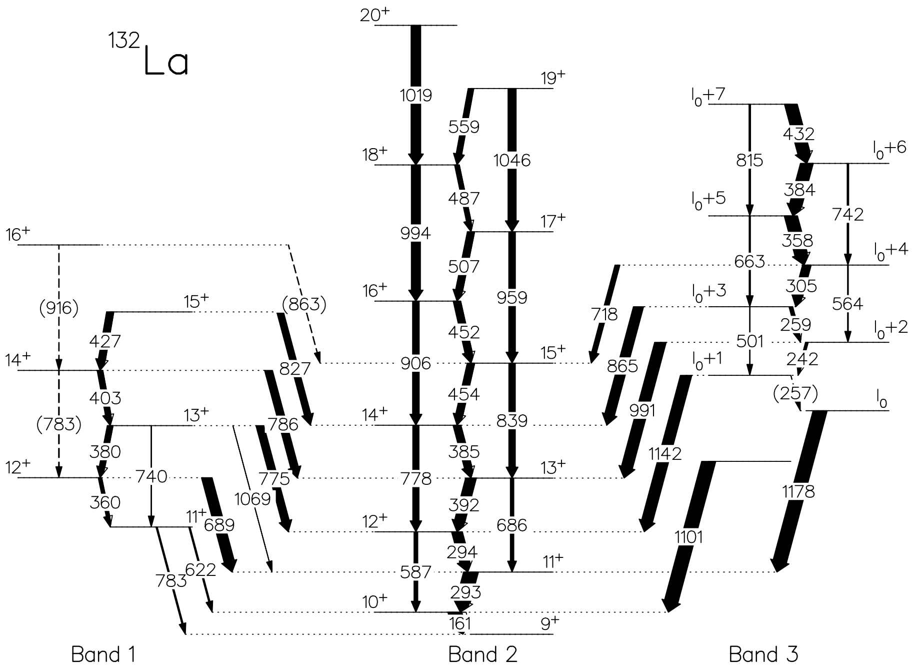

Fig. 1. ^{132}La level scheme obtained in the present experiment. The spin and parity assignment for levels belonging to bands 1 and 2 are based on Refs [4, 10]. Arrow width is proportional to relative transition probability. Sum of transition intensities, leaving given level, is normalized to unity.

Our lifetime data have been used to calculate E2 and M1 intraband transition probabilities. When the B(E2) values for the $I \rightarrow I-1$ transitions were assumed to be the same as corresponding values for the $I \rightarrow I-2$ transitions, then admixture of E2 multipolarity to M1 multipolarity has been found smaller than 10%. That was the reason that for the intraband $I \rightarrow I-1$ transitions pure M1 multipolarity has been assumed. In Fig. 3 the experimental values of B(E2) and B(M1) are shown for the band 1 (supposed chiral partner) and band 2 (yrast). These values of B(E2) for the band 2 and band 1 differ considerably. It contradicts an expected similarity of electromagnetic properties of chiral partner bands. It is worth to notice that the B(M1) probabilities in band 1 and 2 are not so different as the B(E2) ones. The values of the B(E2) probabilities in the band 3 are similar to those from the band 2.

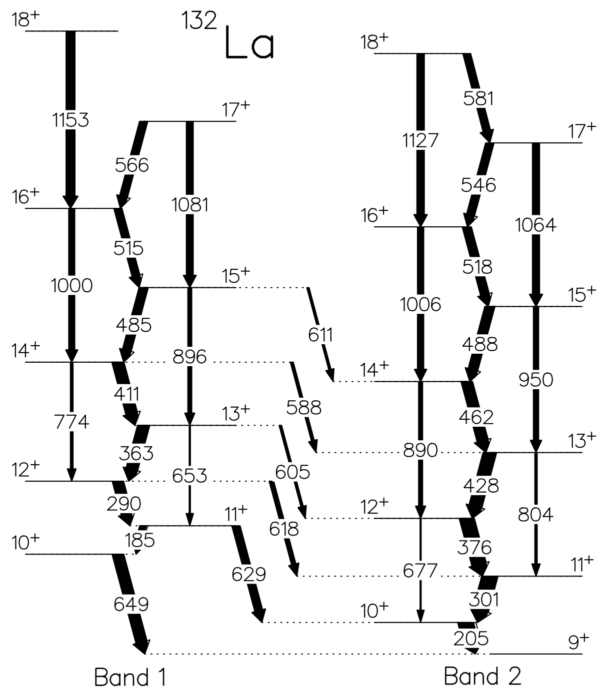

Fig. 2. Results of calculation in frame of the CPHC model [4] using phenomenological core described in [8]. For arrow width, see caption of Fig. 1.

To test the electromagnetic properties of supposed chiral bands we have also measured lifetimes of the levels belonging to bands found by Koike *et al.* [11] in ^{128}Cs. The experiment was carried out at the Warsaw Cyclotron. The OSIRIS II array was applied to the DSAM study of excited states produced in the ^{122}Sn(^{10}B,4n)^{128}Cs reaction at $E(^{10}\mathrm{B}) = 55$ MeV. At the moment, only preliminary results for ^{128}Cs can be presented. In Fig. 4, the B(E2) and B(M1) values for intraband γ-transitions in the yrast band and the partner bands (analogous to the band 1 of ^{132}La) are shown. No additional excited band (corresponding to band 3 in ^{132}La) coupled by the strong transitions to the yrast band has been found. It follows from Figs 3 and 4 that measured electromagnetic properties of supposed chiral partner bands are much closer to each other in ^{128}Cs than in ^{132}La nucleus.

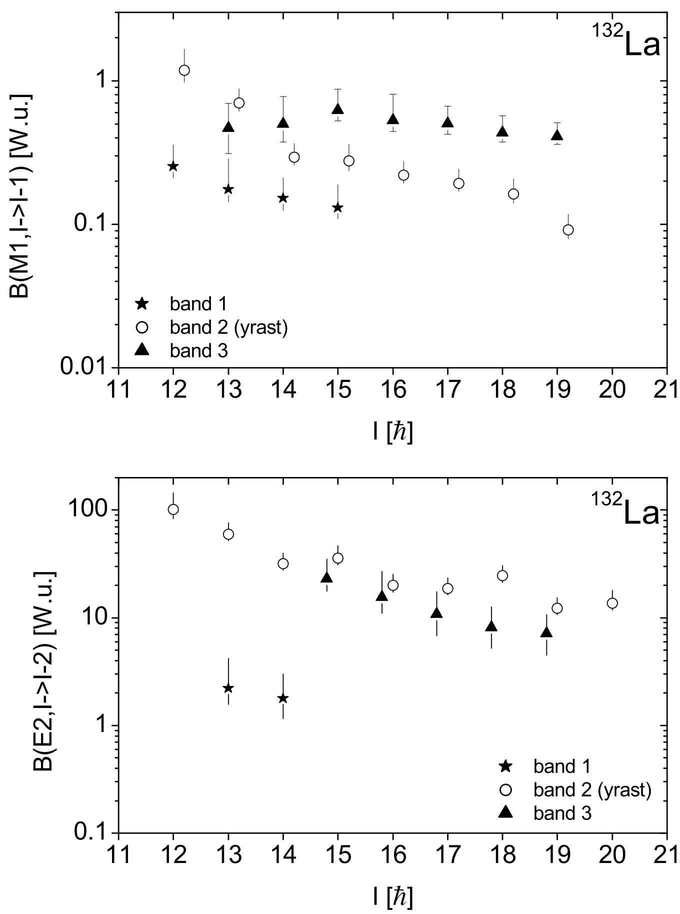

Fig. 3. Intraband B(M1) and B(E2) transition probabilities in ^{132}La. For band 3 $I_0 = 12$ is arbitrarily chosen.

3. Summary

In the $A \approx 130$ region about 10 candidates for chiral bands have been found. Their experimental identification is mainly based on the energy schemes. A new information concerns the lifetime measurements in the supposed chiral bands. For ^{128}Cs and ^{132}La our measurements show some discrepancy between observed and predicted by theory electromagnetic properties. In these nuclei the B(M1) values are much closer in both hypotethical chiral bands than the B(E2) ones. In ^{132}La the B(E2) values in the yrast band (band 2) are about 10–30 times larger than in band 1, while the B(M1) values are only a few times larger. In ^{128}Cs the B(E2) values in the yrast band are only a few times larger than in band 1, but B(M1) are nearly equal.

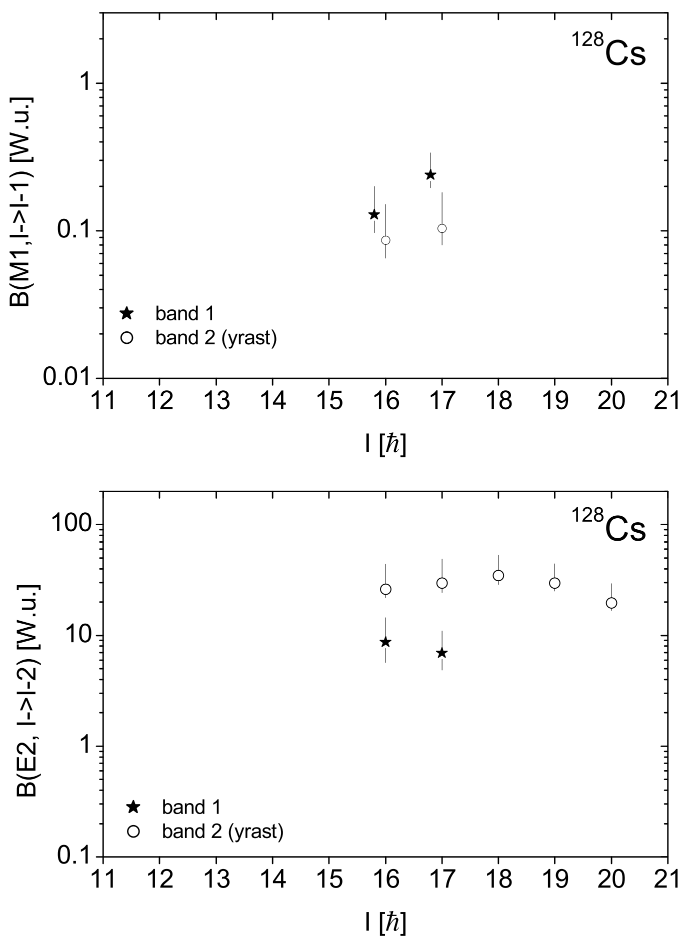

Fig. 4. Preliminary data of the ^{128}Cs intraband B(M1) and B(E2) transition probabilities. Calculation of B(M1) and B(E2) from our lifetime data is based on the ^{128}Cs level scheme given in [11] where our band 1 is named "side band".

It is in line with energy splitting between bands: in ^{128}Cs splitting is about two times smaller than in ^{132}La. When account is taken on the experimental level energy as well as absolute M1 and E2 transition probabilities one can conclude that ^{128}Cs is better candidate for the presence of chiral bands than ^{132}La.

Extension of the lifetime measurements on the other nuclei where hypothetical chiral bands were found would elucidate our understanding of chirality phenomenon.

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