# MAGNETIC ROTATION IN THE NUCLEUS $^{141}$Eu*

Z. Marcinkowska, T. Rzaca-Urban, Ch. Droste, T. Morek
B. Czajkowska, W. Urban, R. Marcinkowski, P. Olbratowski

Institute of Experimental Physics, Warsaw University, Poland

R.M. Lieder, H. Brans, W. Gast, H.M. Jager, L. Mihailescu

Institut fur Kernphysik Forschungszentrum Julich, Germany

D. Bazzacco, G. Falconi, R. Menegazzo, S. Lunardi,
C. Rossi-Alvarez

Istituto Nazionale di Fisica Nucleare, Sezione di Padova, Italy

G. de Angelis, E. Farnea, A. Gadea, D.R. Napoli
and Z. Podolyak

Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Italy

*(Received November 6, 2002)*

The previously known level scheme of $^{141}$Eu nucleus was revised and substantially extended. Three dipole cascades, characterized by large B(M1)/B(E2) ratios, have been found. Spin and parity assignments were based on the angular distribution ratios and linear polarizations of $\gamma$-rays. The experimental results have been compared with the calculations of Tilted Axis Cranking (TAC) model.

PACS numbers: 21.10.Re, 21.60.Ev, 23.20.En, 27.60.+j

## 1. Introduction

One of the most interesting results of last few years in nuclear spectroscopy is observation of rotational bands in almost spherical nuclei. This new type of excitation is represented by the rotation of a large magnetic dipole around nuclear spin and is called Magnetic Rotation (MR) [1]. In the

* Presented at the XXXVII Zakopane School of Physics "Trends in Nuclear Physics", Zakopane, Poland, September 3–10, 2002.

contrary to the single-particle nature of the low-spin states, the dipole MR bands exhibit enhanced M1 transition strength. This kind of excitation has been observed in some nuclei with small deformation and with protons and neutrons numbers close to magic ones (*e.g.* $^{105}$Sn, $^{110}$Cd, $^{139}$Sm, $^{198,199}$Pb).

## 2. Experimental methods

The study of high-spin states in the nucleus $^{141}$Eu was carried out with the $\gamma$-detector array EUROBALL III and the charged-particle detector array ISIS at the XTU tandem — linear accelerator (ALPI) combination of the Laboratori di Legnaro, Italy. The EUROBALL III spectrometer consisted of CLUSTER, CLOVER and TAPERED detectors. To populate high-spin states in $^{141}$Eu the $^{99}$Ru($^{48}$Ti, $3p3n$) reaction at a beam energy of 240 MeV has been used. The $^{99}$Ru target, enriched to 95%, consisted of four self-supporting metal foils with a total thickness of 0.84 mg/cm$^2$. The recoil velocity was $v/c = 3.4\%$. We have collected over $4.5 \times 10^9$ high fold events.

$\gamma$–$\gamma$–$\gamma$ cubes and matrices of various types have been sorted using the software package "Ana" [2]. Data from ISIS arrays were used to select reaction channel. Angular distribution ratios and $\gamma$-ray linear polarizations (measured using CLOVER detectors [3]) of $\gamma$-transitions in $^{141}$Eu have been deduced from the EUROBALL data to establish the spin and parity of excited states.

## 3. Results and discussion

The partial level scheme of $^{141}$Eu resulting from our data analysis is shown in Fig. 1. It has been considerably extended in excitation energy and spin with respect to the schemes previously published [4,5].

In our data we have observed three dipole bands in the $^{141}$Eu nucleus, one, DB1 (Fig. 1.), for the first time. Results of angular distribution ratios and preliminary results of analysis of polarization confirm M1 character of $\gamma$-transitions belonging to considered bands.

The previously known dipole bands DB2 and DB3 have been extended. New E2 crossover transitions enable the ordering of the $\gamma$-ray transitions to be established. The properties of observed dipole bands were calculated in the frame of Tilted Axis Cranking (TAC) model. The parameter $\kappa$ of the $QQ$ interaction used in the TAC model calculations was scaled from the Pb region according to $\kappa \sim A^{-5/3}$. Pairing was taken into account by using gap energies of $\Delta_\pi = 0.92$ and $\Delta_\nu = 1.04$ MeV as deduced from odd–even mass differences. These values are taken from the work of Lieder *et al.*, [6] and were used for the neighboring nucleus $^{142}$Gd. The chemical potentials were chosen to reproduce the valence particle numbers. For DB2 and DB3 bands the quadrupole deformation parameter $\varepsilon_2$ was equal to $-0.10$ and $-0.15$, respectively (in both cases $\varepsilon_4$ was taken to be 0).

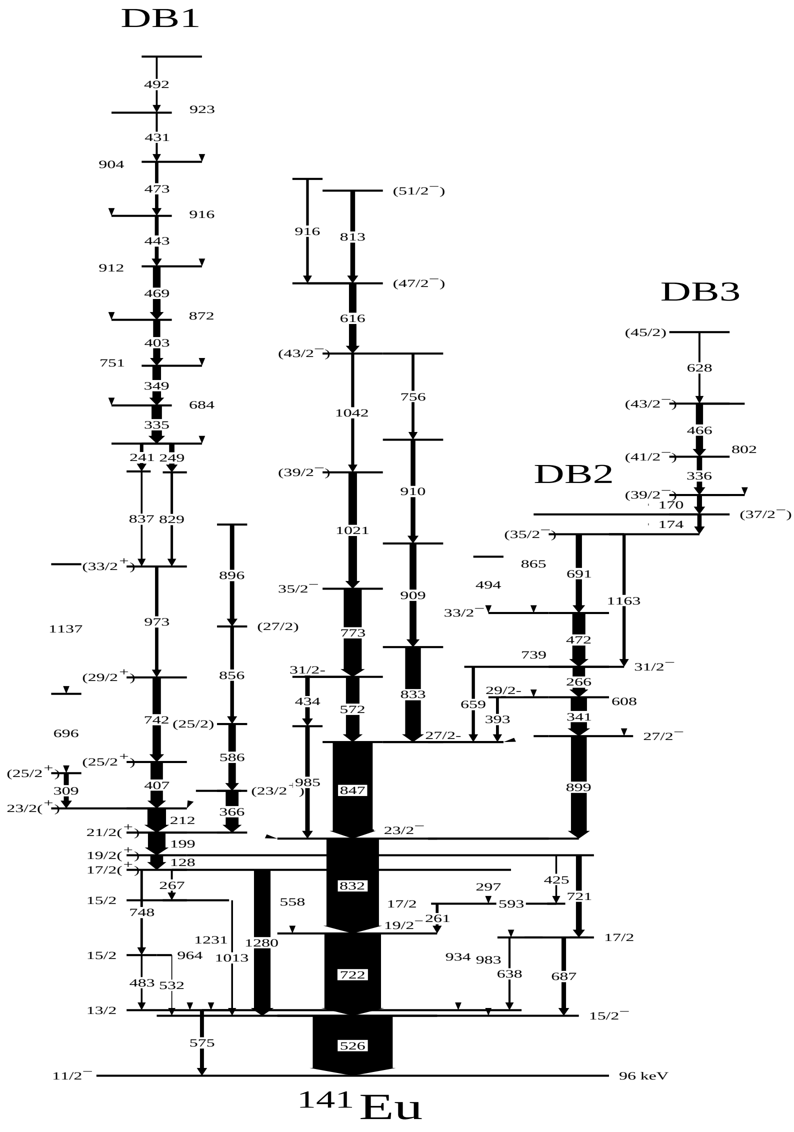


Fig. 1. The partial level scheme of the $^{141}$Eu nucleus.

The bandhead of DB2 was interpreted in [4,5] as arising from the $\nu h^{-2}_{11/2}\pi h_{11/2}$ configuration. This configuration is in agreement with results of our TAC calculations, which assumed rotational-magnetic character of the band.

The DB3 band ($\nu h^{-2}_{11/2}\pi h_{11/2} g^{-2}_{9/2}$) results from DB2 due to breaking of the $g_{9/2}$ proton–hole pair.

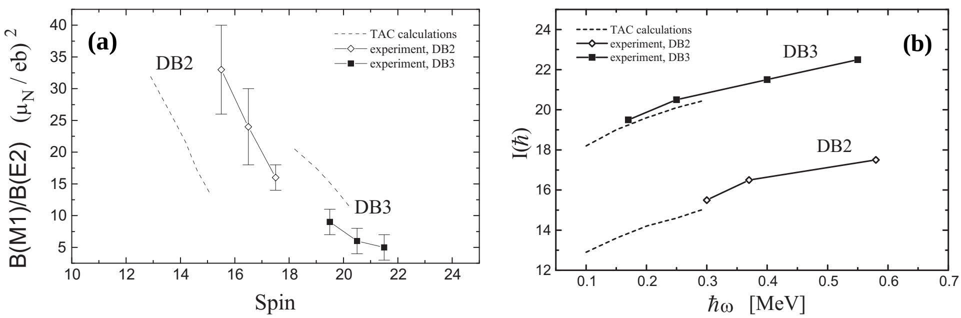


Fig. 2. (a) B(M1)/B(E2) ratio *vs.* spin for the dipole bands DB2 and DB3 in $^{141}$Eu. (b) Angular momentum *vs.* rotational frequency for the dipole DB2 and DB3 bands in $^{141}$Eu. The thin lines connect the data points. The broken lines result from the TAC model calculations.

The experimental values of the B(M1)/B(E2) ratio for the DB2 and DB3 bands obtained in this work are presented in Fig. 2(a), and compared with results of the TAC model calculations. The slopes of both the theoretical curve and experimental one are similar. Fig. 2(b) shows the plots of angular momentum *vs.* rotational frequency. For the DB3 band there is reasonable agreement between experimental points and results of theoretical calculations was obtained. In case of DB2 it was difficult to follow the appropriate configurations due to the large level density and the presence of many level crossings.

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