STUDY OF THE *K* QUANTUM NUMBER DEPENDENCE ON THE DEFORMATION IN ^{165}Ho NUCLEUS* **

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This work is devoted to the Coulomb excitation of ^{165}Ho. Experiments were performed at the Heavy Ion Laboratory of Warsaw University. A model-independent analysis using the GOSIA code yielded a set of reduced matrix elements values coupling the low-lying collective excited states. A *quadrupole sum rules* approach was used to determine the deformation of the states. A remarkable change of quadrupole moment in one of the γ-vibrational bands was found.

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1. Introduction

The scope of this work covers about three last years of experiments and data analysis devoted to the Coulomb Excitation of the ^{165}Ho nucleus.

The ground state level of the nucleus under study may be understood as built by the single proton occupying the Nilsson orbital [523] around a ^{164}Dy core which gives the spin of 7/2 and negative parity. A sequence of states with the spin increasing by one and same parity is interpreted as a rotational ground state band of a K quantum number equal to 7/2.

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The nucleus may undergo a γ vibration and the spin of a phonon may be subtracted or added to the ground state spin and these two possibilities give two other rotational γ bands starting from the states $3/2^-$ and $11/2^-$, respectively. K numbers of 3/2 and 11/2 are assigned to these bands.

The discussed level scheme is presented in figure 1 and is only a sub-set of known excited states, described with more details in the work of Gervais, Radford *et al.* [1].

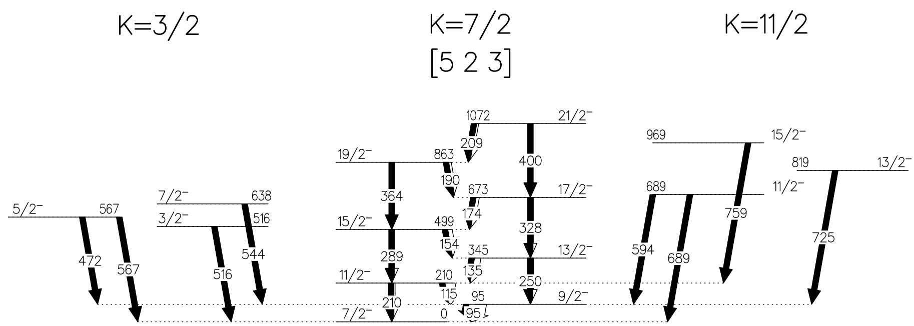

Fig. 1. Simplified ^{165}Ho nucleus level scheme showing observed γ transitions.

2. Experiments

A set of three experiments with 50 MeV ^{20}Ne (March 1998) and 130 MeV ^{40}Ar (June 1999) beams were performed with use of dedicated Coulomb Excitation set-up called **CUDAC** (Coulex Universal Detector Array Chamber) [2] [3] and also with the 55 MeV ^{16}O (January 2000) beam and the **OSIRIS** multi-detector HPGe array (moved from Jülich to Warsaw few years ago) — for an inclusive experiment with the oxygen beam.

3. Data analysis

After relatively simple raw data elaboration a set of γ transition intensities was obtained. Thick target stopped the radiating recoils and the Doppler shift correction was not required. Observed γ transitions are plotted in figure 1.

Reduced matrix elements determination

Excited levels layout (energies, spins and parities) were not a subject of the study and were adopted after an on-line database of NNDC Brookhaven [4]. Measured γ intensities, combined with available spectroscopic data were used as an input to the Coulomb Excitation Least Squares Fitting code GOSIA [5]. As an output, a set of reduced matrix elements values and its errors was obtained. A set was rich and precise enough to perform further analysis of the nucleus shape.

Quadrupole Sum Rules method and shape parameters

The $E2$ operator expressed in the principal nucleus axes frame may be parameterized using two parameters only: quadrupole moment of the charge distribution Q and non-axiality parameter δ:

$$\begin{aligned} E(2,0) &= Q\cos\delta\,; \\ E(2,1) &= E(2,-1) = 0\,; \\ E(2,2) &= E(2,-2) = \frac{1}{\sqrt{2}}\,Q\sin\delta\,. \end{aligned}$$

However, some invariant is needed to express intrinsic deformation parameters with quantities measured in laboratory frame.

A product of $E2$ operators coupled to zero is such an invariant and may be also written using reduced matrix elements thanks to intermediate state expansion formula:

$$\frac{1}{\sqrt{(2I_i+1)}}\sum_t \langle i\|E2\|t\rangle\langle t\|E2\|i\rangle \left\{ \begin{array}{ccc} 2 & 2 & J \\ I_i & I_i & I_t \end{array} \right\}$$
$$= \langle i|\,[E2\times E2]_0\,|i\rangle = \frac{Q^2}{\sqrt{5}}\,,$$

where t extends over all the levels which may be reached in single $E2$ transition.

A sum, appearing in the expansion, consists of products of experimentally available reduced matrix elements. One may consider $E2\times E2$ loops starting and ending in a chosen state and visiting intermediate states, as seen in figure 2.

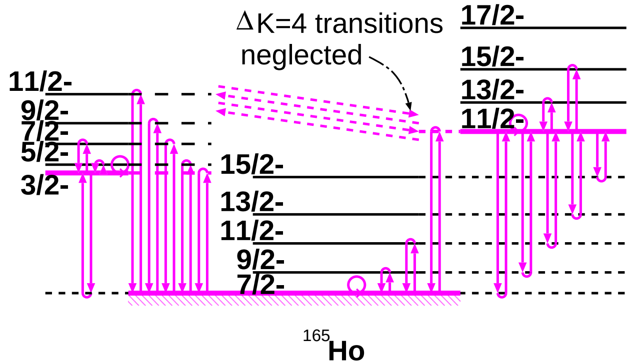

Fig. 2. $E2\times E2$ loops involved in $<Q>$ determination for bandhead states.

4. Quadrupole moments determined for excited states belonging to different rotational bands

Figure 3 shows the results of averaged quadrupole moments calculation. One may note that the Q value is almost conserved for the ground state (K=7/2) band members and for the K=3/2 band levels, but is almost two times smaller for the lowest states in the K=11/2 rotational band, thus demonstrating a clear K-dependence.

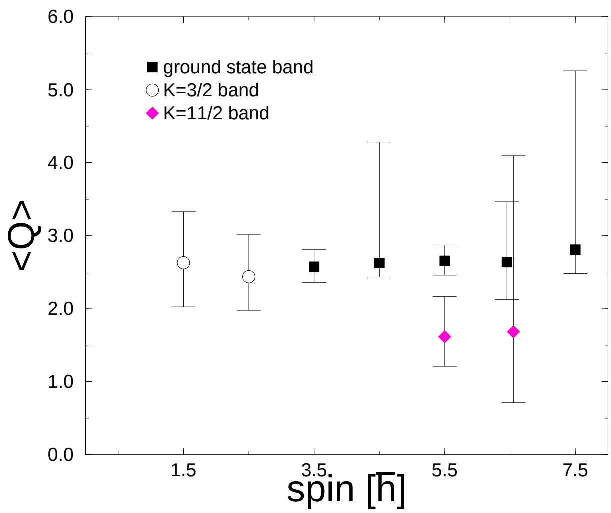

Fig. 3. $<Q>$ values determined for chosen states of the ^{165}Ho nucleus.

5. Summary

Two side bands discussed in this work were known to be highly collective from the previous Coulomb excitation experiments with very heavy ions, which suggested that these bands are associated γ bands (see [1]).

Using very heavy beams the accuracy of the measurement of the most important lowest matrix elements is lost due to the fact, that most of the observed gamma intensity comes from the higher states deexcitation. Present experiments were designed to achieve the maximum sensitivity to the low-lying $E2$ transitional and diagonal matrix elements.

As a result an unexpected difference between the deformations of the associated γ bands has been found.

We wish to express our regards for the Warsaw Cyclotron crew for excellent cooperation and maintaining high quality beams throughout all experiments.

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