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^{149}Gd: WHAT'S CONFIRMED? WHAT'S NEW?*

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A long run performed with EUROGAM II allowed remeasuring the ^{149}Gd superdeformed (SD) band 1. The $\Delta I = 4$ bifurcation in band 1 is confirmed and two resolved γ-ray transitions linking the SD band 1 and the normal deformed states have been observed.

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1. Introduction

Since the discovery of the first discrete superdeformed (SD) band [1], nuclear structure sudies in the second potential well have developed in a spectacular way. If new and delicate phenomena like the $\Delta I = 4$ staggering were discovered, basic information is still lacking : in the $A \simeq 150$ mass region, transitions linking the two potential wells have not yet been observed. In spite of the performance of new γ-detector arrays, high statistics experiments are required to track them down or to confirm them. In this spirit, a ten-day run has been made with the EUROGAM II spectrometer at the VIVITRON accelerator of the IReS laboratory in Strasbourg.

2. The experiment

The ^{149}Gd nucleus was populated by ^{124}Sn (^{30}Si,5n) fusion-evaporation reaction at 158 MeV bombarding energy with a stack of two 470 μg/cm^2 98% isotopically enriched tin targets. In this experiment, 4.10^9 events were collected with an average fold of 4.9. The large amount of data gathered allowed us to reinvestigate this nucleus in details, paying special attention in the analysis to obtain very clean and pure coincidence spectra.

3. What is confirmed : $\Delta I = 4$ bifurcation

The $\Delta I = 4$ bifurcation was first observed in the yrast SD band of ^{149}Gd [2]. Instead of an ordinarily smooth behaviour of the moment of inertia, this band exhibits a regular staggering pattern in the energy sequence of the SD transitions. This subtle phenomenon shifts alternately up and down the energy of consecutive transitions by a small amount. Following that observation, several cases of $\Delta I = 4$ bifurcations have been reported in $^{131-133}$Ce [3], ^{148}Eu [4], ^{148}Gd [4], [5], ^{192}Hg [6] and ^{192}Tl [7]. Some cases have been confirmed, others questioned or rejected. In this experiment we have reinvestigated the staggering in the ^{149}Gd SD band 1. Simulation studies have been done to determine how to obtain the cleanest possible spectra, and to avoid contamination effects in the energy determination of the SD transition. Following that, in the analysis we have selected the highest possible n fold events with a set of gates equal to n-1, using an ellipsoidal gating procedure with a spike-free incrementation. Fig. 1 show the observed staggering pattern in ^{149}Gd (1), using 5-fold events and sets of 4 gates. The oscillation has the same amplitude and phase as in Ref. [2] and definitely confirms the existence of the phenomenon.

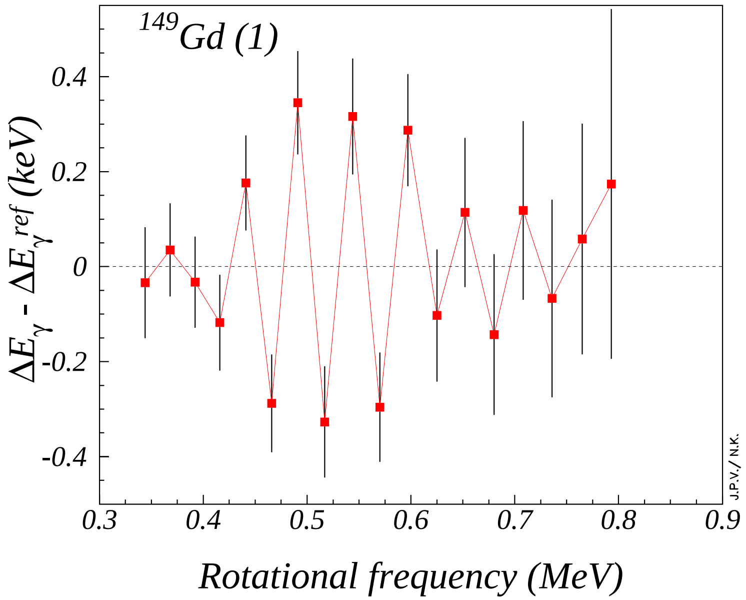

Fig. 1. Staggering plot *versus* rotational frequency for the ^{149}Gd yrast SD band.

4. What is new: candidates for linking transitions

The observation of discrete linking transitions from the SD to the normal deformed (ND) well is the only way to determine experimentally spin, parity and excitation energy values in the SD band. In spite of the vast SD dataset, only a few cases of linking transitions have ever been observed and these were in the $A \simeq 190$ mass region : ^{194}Hg [8] and ^{194}Pb [9] nuclei.

This high statistics experiment allowed us to look for high energy γ-rays connecting the SD band and the ND states. In the high energy part of the triple gated spectra of the yrast band, three peaks can be identified (*cf.* Fig. 2): a doublet 1995-2001 keV and a single 2188 keV line with respective intensities 0.6(3)%, 0.5(3)% and 2.4(6)% of the SD plateau. Based on coincidence relationship, these lines have been placed in the decay scheme. The 2188 keV ray is in coincidence with a 2585 keV line, corresponding to a two-step decay-out of the SD band. Combined coincidences with two gates on the high energy SD transitions and alternately one gate on the 664 keV or 617 keV transition establish that the 2188 keV and 2585 keV rays decay out of the band just above the 617 keV line, and feed the $45/2^+$ ND state (combined gating with the SD and the 186 keV or 371 keV transitions) [10]. The 2778 and 2785 keV lines have been observed in the 20 MeV range coincidence spectra.

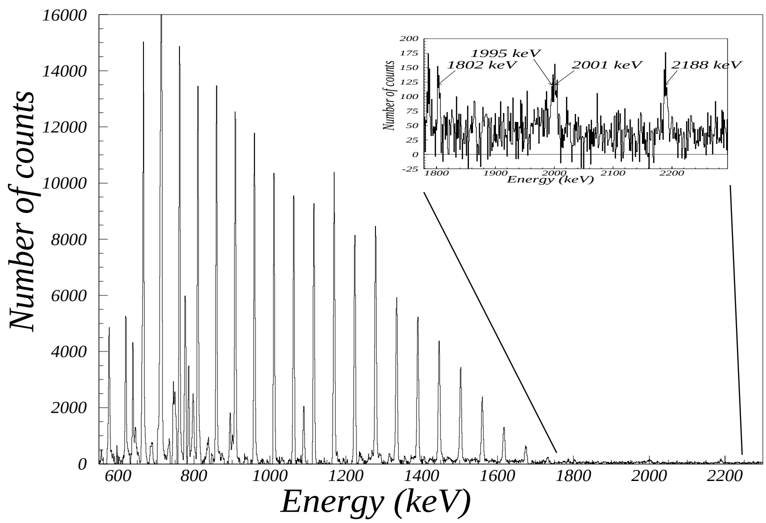

Fig. 2. Triple gated, background-subtracted spectrum of the ^{149}Gd yrast SD band. The high energy part of the band is shown in the insert.

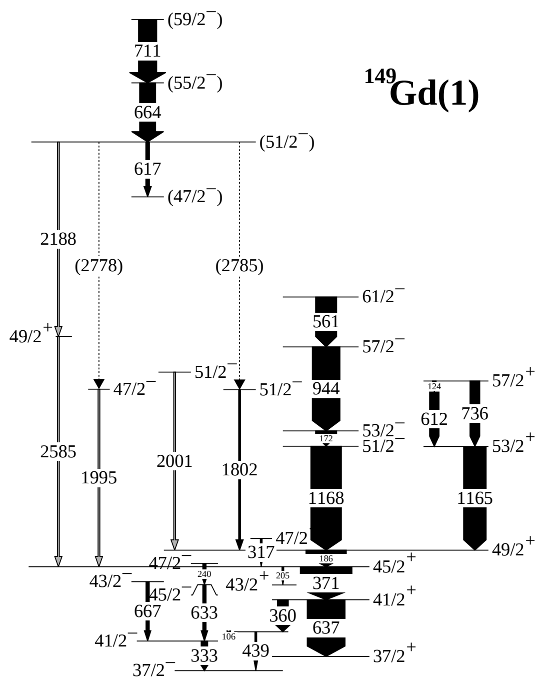

Fig. 3. Decay-out level scheme for the SD ^{149}Gd yrast band.

Information on the multipolarity of linking transitions has been obtained for the 1995, 2001 and 2188 keV lines by measuring angle-dependent intensity ($I_\gamma(\theta)$) ratios using a method derived from Directional Correlations of decays from Oriented nuclear states (DCO ratio). These are dipole transitions and most likely E1. The DCO ratio could not be extracted for the 2585 keV line due to its weak intensity. Considering that the yrast SD band has been assigned negative parity, the 2585 keV γ-ray is of an E2 or M1 nature. An E2 character for this transition agrees with the Ragnarsson spin assignment [11]. The lowest SD state of the ^{149}Gd SD band 1 is a $47/2^-$ state and lies 4121 keV above the ND yrast line at $47/2\hbar$ or on an absolute scale at 10625 keV above the $7/2^-$ ground state. These results are in rather good agreement with theoretical calculations using the Hartree-Fock Method with a Skyrme force (SkM^*) which predict a 5 MeV energy gap between the $47/2^-$ SD-ND states in this nucleus [12].

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