Eur. Phys. J. A **1**, 123–124 (1998)

THE EUROPEAN PHYSICAL JOURNAL A

Short note

Dipole and quadrupole cascades in the yrast region of ^{143}Gd

M. Sugawara[1], H. Kusakari[2], Y. Igari[2], K. Myojin[2], D. Nishimiya[2], S. Mitarai[3], M. Oshima[4], T. Hayakawa[4], M. Kidera[3,4], K. Furutaka[4], Y. Hatsukawa[4]

[1] Chiba Institute of Technology, Narashino, Chiba 275, Japan (e-mail: p21sugaw@cc.it-chiba.ac.jp)
[2] Chiba University, Inage-ku, Chiba 263, Japan
[3] Department of Physics, Kyushu University, Hakozaki, Fukuoka 812, Japan
[4] Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki 319-11, Japan

Received: 1 November 1997
Communicated by B. Herskind

Abstract. The high spin states of ^{143}Gd have been studied via the ^{111}Cd(^{35}Cl, $1p2n$) reaction at 170 MeV. One dipole cascade has been newly found and two dipole cascades have been extended to higher spin states. A relatively long E2 cascade consisting of irregular transition energies has been found, which has only weak connections to the other dipole and quadrupole cascades. This resembles the ones recently found in ^{142,143,144}Eu and ^{144}Gd. The dipole and quadrupole cascades have been found to appear by turns in an energy increment of about 0.2MeV above the yrast line.

PACS. 21.10.-k Properties of nuclei nuclear energy levels – 27.60.+j $90 \leq A \leq 149$ – 23.20.Lv Gamma transitions and level energies

Europium and gadolinium nuclei just below the semi-magic ^{146}Gd core are rather spherical at low excitation energy. However, as the excitation energy and the spin get higher, many different nuclear structures are showing up along the yrast line. One of the most interesting characters is the coexistence of the dipole and quadrupole cascades in the yrast region. In fact such cascades were found in ^{142,143,144}Eu and ^{144}Gd recently [1,2]. The main purpose of this study is to search for such cascades coexisting along the yrast line in ^{143}Gd.

We made an in-beam spectroscopic study on high spin states of ^{143}Gd by the reaction of ^{111}Cd(^{35}Cl, $1p2n$)^{143}Gd. A 7-mg/cm^2 thick Cd foil, enriched in ^{111}Cd to 96.30% was bombarded with a 170-MeV ^{35}Cl beam provided by the tandem accelerator at Japan Atomic Energy Research Institute(JAERI). Gamma-rays from excited states populated after the reaction were measured by a γ-ray detector array [3] consisting of 11 BGO anti Compton spectrometers in coincidence with charged particles detected by a Si ball [4] made up of 21 detector segments. Approximately 3.1×10^8 two- or higher fold γ-γ events were collected and sorted into an individual $E_\gamma - E_\gamma$ matrix tagged with the number of protons and α particles detected in the Si ball. A relatively clean matrix for the $1pxn$-channel was obtained by subtracting $2p$ and $1p1\alpha$ contributions from the $1p$ matrix. We constructed the level scheme of ^{143}Gd as shown in Fig. 1 using this matrix. The spins and parities were deduced from the DCO ratios evaluated using the spectra gated by the appropriate stretched E2 transitions at lower excitation energy.

Before this experiment, two $\Delta I = 1$ and one $\Delta I = 2$ sequences (denoted by "(A)", "(B)" and "(C)" in Fig. 1 respectively) were known up to $\frac{31}{2}^+$, $\frac{35}{2}$, $\frac{31}{2}^-$ states respectively [5]. We could extend these sequences to higher spin states as shown in Fig. 1. We could identify a new γ-ray of 70 keV at the bottom of the sequence "(B)" which was overlooked in [5]. The existence of this transition was finally confirmed by the observation of a new dipole cascade (denoted by "(D)" in Fig. 1) decaying to both "(A)" and "(B)".

Also we could observe the unfavored $I_{\max} - 1$ members of the coupling $(\nu h_{\frac{11}{2}}^{-1}) \otimes (2^+, 4^+$ in ^{144}Gd) slightly above the favored $I_{\max}$ members. Corresponding states have been already observed in the $N = 79$ isotone ^{141}Sm[5] at similar excitation energies.

Moreover three new quadrupole cascades denoted by "(E)", "(F)" and "(G)" have been found. Among them the sequence "(G)" is of a peculiar character that it has only weak connections to the other dipole and quadrupole cascades and decays mostly through an irregular sequence of E2 transitions between 500 and 800 keV. This feature resembles those of the similar sequences recently observed in neighboring nuclei [1,2]. Unfortunately we could observe too few transitions decaying out from the sequence "(G)" to account for its population intensity.

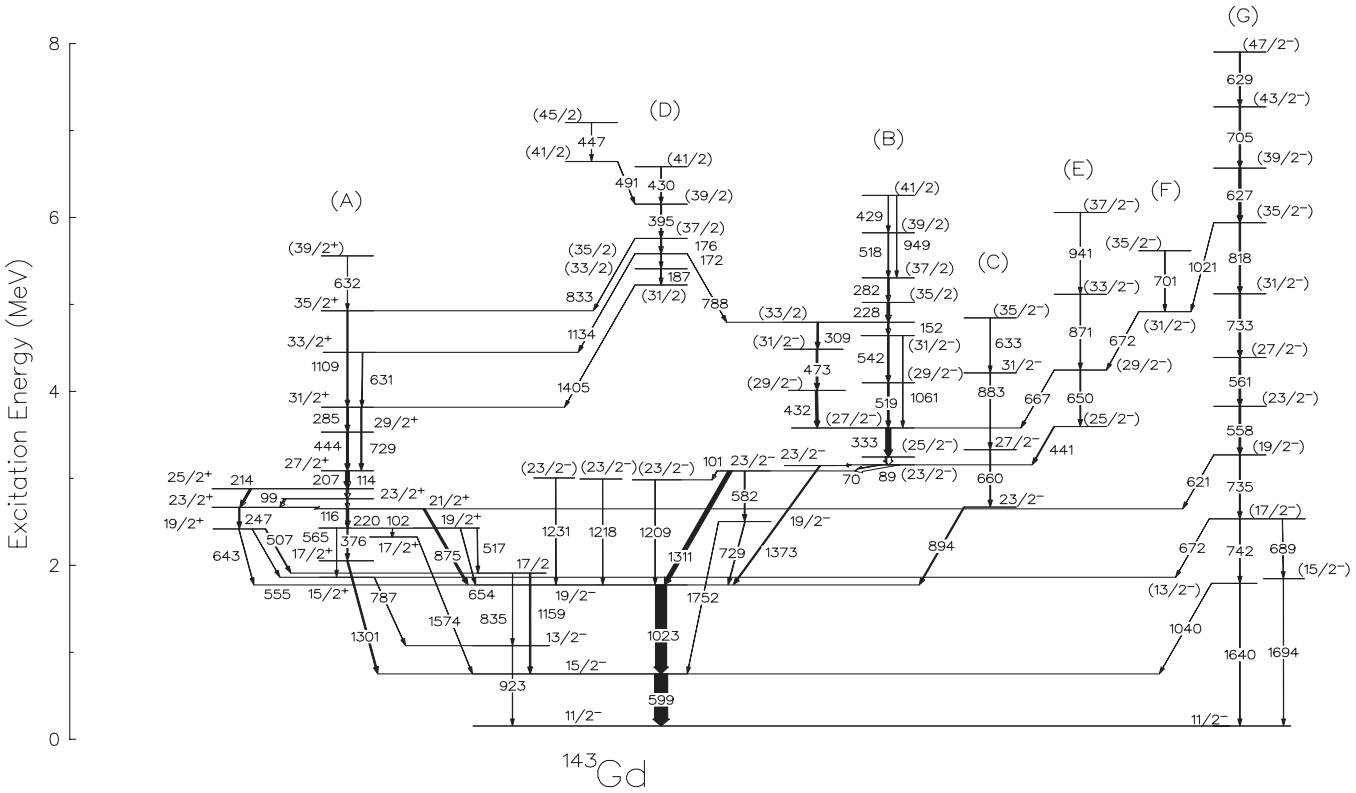

Fig. 1. The level scheme of ^{143}Gd

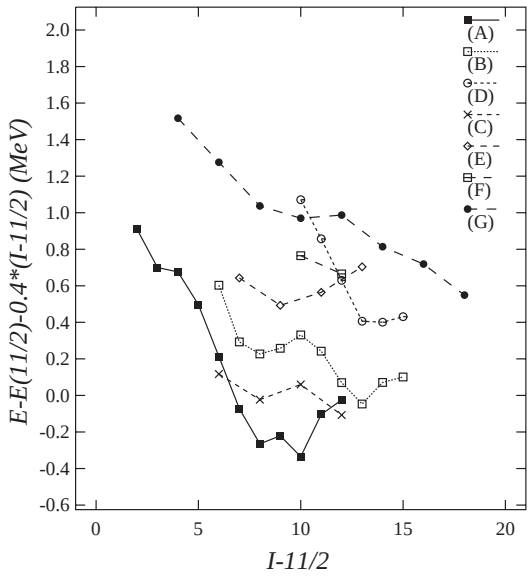

Fig. 2. The excitation energies of the sequences from "(A)" to "(G)" were shown as functions of the spin increments relative to the $\frac{11}{2}^-$ state. The ordinate is the excitation energy relative to the $\frac{11}{2}^-$ state from which the average yrast line($0.4*(I-\frac{11}{2})$) is subtracted

B(M1)/B(E2) ratios have been deduced to be 7.9(5), 44(6) and 51(17) $(\mu_N/\mathrm{eb})^2$ for the decays from the $\frac{31}{2}^+$ state in "(A)", the $(\frac{31}{2}^-)$ and $(\frac{41}{2})$ states in "(B)" respectively. This means that more high spin proton particles or neutron holes are involved in the sequence "(B)" than in "(A)". In the cascade "(D)" which is of the highest excitation energy among the dipole cascades identified here, there were no crossover E2 transitions observed.

The excitation energies of the sequences from "(A)" to "(G)" were shown as functions of the spin increments relative to the $\frac{11}{2}^-$ state in Fig. 2. The ordinate is the excitation energy relative to the $\frac{11}{2}^-$ state from which the average yrast line($0.4*(I-\frac{11}{2})$) is subtracted. It is interesting to see that the dipole and quadrupole cascades appear by turns in an energy increment of about 0.2MeV above the yrast line. Theoretical study is necessary for understanding this phenomenon.

Software written by D.C.Radford was used in the data analysis. We thank the crew of the JAERI tandem accelerator for providing the heavy-ion beams.

References

1. M. Piiparinen et al.: Nucl. Phys. A**605**, 191 (1996)
2. T. Rzaca-Urban et al.: Nucl. Phys. A**579**, 319 (1994)
3. M. Oshima et al.: Nucl. Instr. and Meth. (1997) to be published.
4. T. Kuroyanagi et al.: Nucl. Instr. and Meth. A**316**, 289 (1992)
5. M. Lach et al.: Z. Phys. A**345**, 427 (1993)