Eur. Phys. J. A **25**, s01, 375–376 (2005)
DOI: 10.1140/epjad/i2005-06-054-8

EPJ A direct
electronic only

High-spin shape isomers and the nuclear Jahn-Teller effect

A. Odahara[1,a], Y. Wakabayashi[2,3], T. Fukuchi[3], Y. Gono[4], and H. Sagawa[5]

[1] Nishinippon Institute of Technology, Kanda, Fukuoka 800-0394, Japan
[2] Department of Physics, Kyushu University, Hakozaki, Fukuoka 812-8581, Japan
[3] Center for Nuclear Study (CNS), University of Tokyo, Wako-shi, Saitama 351-0198, Japan
[4] RIKEN, Wako-shi, Saitama 351-0198, Japan
[5] University of Aizu, Aizu-Wakamatsu, Fukushima 965-8580, Japan

Received: 14 November 2004 / Revised version: 26 January 2005 /
Published online: 6 May 2005 –

Abstract. High-spin isomers were systematically studied in $N = 83$ isotones. These isomers are of stretch coupled configurations and have oblate shapes. High-spin isomers can be categorized to be high-spin shape isomer, as they are caused by the sudden shape change from near spherical to an oblate shape. These isomers are considered to be a good example of the nuclear Jahn-Teller effect. By the systematic study of high-spin isomers, several results were obtained, such as (1) change of $Z = 64$ sub-shell gap energy and (2) experimental pairing gap energy at high-spin states. The $Z = 64$ sub-shell gap energy was found to decrease from 2.4 to 1.9 MeV as the proton number decreases from 64 to 60. Paring gap energies of high-spin states were experimentally extracted by the three-point expression using binding energies and excitation energies of high-spin isomers. These pairing gap energies at high-spin states are as large as those of the ground states, even though isomers have oblate shapes($\beta \sim -0.19$).

PACS. 21.10.-k Properties of nuclei; nuclear energy levels – 27.60.+j $90 \le A \le 149$

1 Introduction

High-spin isomers in $N = 83$ isotones have been systematically studied [1]. Figure 1 shows the systematics of high-spin isomers. Their spin-parities are $49/2^+$ and 27^+ for odd and odd-odd nuclei, respectively. Life times of these isomers range between ~ 10 ns and $\sim \mu$s.

High-spin isomers were theoretically studied using a deformed independent particle model(DIPM) [2].

Configurations of high-spin isomers are deduced experimentally and theoretically to be $[\nu\,(f_{7/2}\,h_{9/2}\,i_{13/2})\,\pi\,h^2_{11/2}]^+_{49/2}$ for odd nuclei and $[\nu\,(f_{7/2}\,h_{9/2}\,i_{13/2})\,\pi\,(d_{5/2}\,h^2_{11/2})]^+_{27}$ for odd-odd nuclei. These isomers are of stretch coupled configurations and have oblate shapes.

2 High-spin shape isomers

The deformation parameter β values of yrast states obtained by using the DIPM calculation are shown in fig. 2 as a function of spin. Filled squares and open circles indicate the β values for ^{145}Sm and ^{147}Gd, respectively. The experimental deformation parameters of the $13/2^+$, $27/2^-$ and $29/2^+$ isomers in ^{147}Gd were deduced from the quadrupole

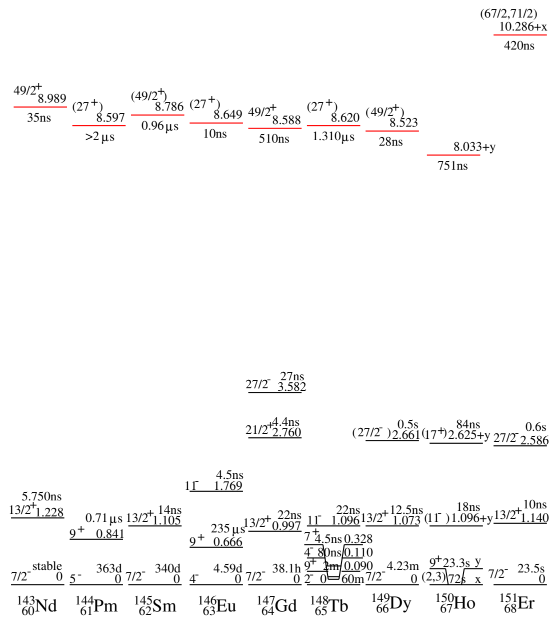

Fig. 1. Systematics of high-spin isomers in $N = 83$ isotones [1].

moments [3]. Experimental values are shown by cross points. They were well reproduced by the DIPM calculation. The β values of the DIPM calculation are nearly

[a] Conference presenter; e-mail: odahara@nishitech.ac.jp

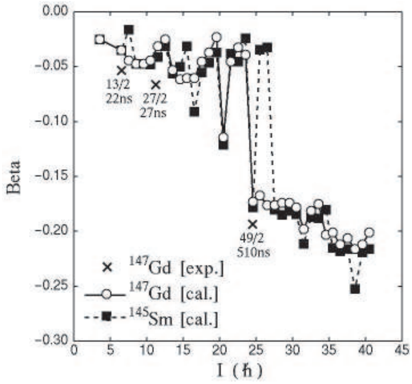

Fig. 2. Deformation parameters β of yrast states as a function of spin.

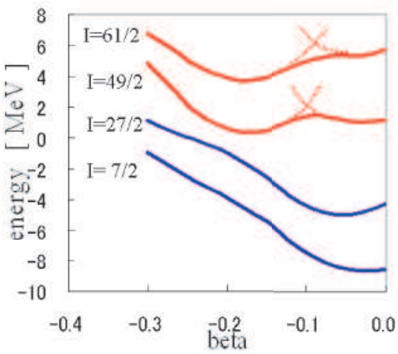

Fig. 3. Deformation dependence of total energy for ^{147}Gd calculated by DIPM.

-0.05 below the spin of 49/2. However, these values above this spin are larger than -0.16. This indicates that high-spin isomer may be caused by the sudden shape change from near spherical to oblate shape. Therefore, these isomers could be categorized to be high-spin shape isomers.

It is considered that high-spin isomers maybe a good example of nuclear Jahn-Teller effect. Figure 3 shows the deformation dependence of total energy for ^{147}Gd calculated by DIPM. The mixing amplitude of two wave functions with different shapes was experimentally deduced to be $\sim 10^{-2}$ from the reduced transition probability of the transition directly deexciting the high-spin isomer. As this value is so small, their coupling is weak. The DIPM calculation reproduces well this weak coupling.

3 Systematic study of high-spin isomers

Systematic study of high-spin isomers in $N = 83$ isotones gave several results, such as a change of $Z = 64$ sub-shell gap energy and experimental paring gap energies for high-spin states.

3.1 Z = 64 sub-shell gap

The experimental excitation energies of high-spin isomers are almost constant between 8.5 and 9.0 MeV for $N = 83$ isotones with $60 \leq Z \leq 66$, as shown in fig. 1. However, theoretical ones calculated by DIPM increase as the proton number decreases. In order to reproduce the experimental values, calculations were made by changing the $Z = 64$ proton sub-shell gap energies between $2d_{5/2}$ and $1h_{11/2}$ orbits. As a result, these gap energies decreases from 2.4 to 1.9 MeV as the proton number decreases from 64 to 60. This shows the softness of the $Z = 64$ sub-shell closure.

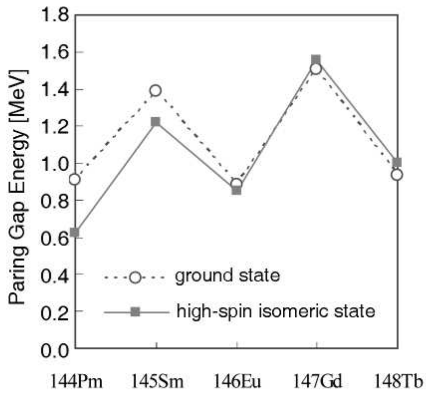

Fig. 4. Paring gap energies at high-spin isomeric and ground states.

3.2 Paring gap energy for high-spin isomeric states

Pairing gap energies at high-spin isomeric states were experimentally deduced from the binding energies as well as excitation energies of high-spin isomers based on the three-point expression [4]. Figure 4 shows the extracted pairing gap energies at high-spin states (filled squares) and ground states (open circles). It was found that the pairing energies at high-spin states are as large as those of the ground states, although the high-spin isomers have oblate shapes of $\beta \sim -0.19$.

4 Summary

Systematic studies for high-spin isomers were carried out experimentally and theoretically. Paring gap energy at high-spin states deduced experimentally are as large as those of ground states.

References

1. Y. Gono *et al.*, Eur. Phys. J. A **13**, 5 (2002) and references therein.
2. T. Døssing *et al.*, Phys. Scr. **24**, 258 (1981).
3. O. Häusser *et al.*, Nucl. Phys. A **379**, 287 (1982); E. Dafni *et al.*, Nucl. Phys, A **443**, 135 (1985).
4. W. Satula *et al.*, Phys. Rev. Lett. **81**, 3599 (1998).