Linear Polarization Measurement of Gamma Rays in ^{151}Er

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High-spin isomers were reported in $N = 83$ isotones systematically [1], namely ^{143}Nd, ^{144}Pm, ^{145}Sm, ^{146}Eu, ^{147}Gd, ^{148}Tb, ^{149}Dy, ^{150}Ho and ^{151}Er. Their lifetimes range from 10 ns to a few μs. The excitation energies of those isomers are close each other ranging between 8.5 and 11.0 MeV. In the high-spin region of these nuclei, the angular momenta of individual valence particles align to the symmetry axis, so that the overlaps of nucleon wave functions become to be maximum. Then the shape suddenly changes from near spherical to oblate. This sudden shape change causes the high-spin isomers. The spins and parities of the high-spin isomers are deduced experimentally [1] and theoretically [2] to be $49/2^+$ for odd nuclei and 27^+ for odd-odd nuclei, respectively, in $N = 83$ isotones with $60 \leq Z \leq 66$. As to ^{151}Er (Z=68) nucleus, $J^\pi = 67/2^-$ isomer at 10.6 MeV was reported by C. Foin *et al.*, [3]. This spin-parity could not be reproduced by a theoretical calculation of a deformed independent particle model [2]. This model predicts the spin-parity of the isomer would be $49/2^+$ or $61/2^+$. Therefore, in order to study for the isomerism in ^{151}Er, γ-ray angular distribution and linear polarization measurements which clarify the spins and parities of excited states has been undertaken.

The experiment has been performed at EN course in Research Center for Nuclear Physics (RCNP), Osaka University. Excited states in ^{151}Er were populated using the reaction ^{116}Sn(^{40}Ar,5n)^{151}Er. The ^{116}Sn target of 1.4 mg/cm^2 was enriched to 90% and has the backing of 11 mg/cm^2 lead to stop the reaction products. This target was bombarded by ^{40}Ar^{8+} beam of 197 MeV with intensity of around 25 enA. The beam was provided by the upgraded AVF cyclotron. Three co-axial and one clover type Ge detectors were used for prompt and delayed $\gamma\gamma$-coincidence measurements. In addition to these detectors, a 5 $\times$ 5 segmented planner type Ge detector was used for a linear-polarization measurement. The total detection efficiency was 0.9% for 1.3-MeV γ ray in the singles mode. A total of 7.6 $\times$ 10^9 coincidence events were recorded in event-by-event mode.

In this paper, we report the results of γ-ray linear-polarization(LP) analyses. The LP information was extracted by using a spectrum taken by the segmented Ge detector. The segmented Ge detector acts as a Compton polarimeter [4]. When γ rays are linearly polarized, the Compton scattering cross section will be larger in a direction perpendicular to the electric field vector. Therefore, coincidence events in the segmented Ge detector were classified according to a condition whether the coincidence events come through either vertical (N_V) or horizontal (N_H). The linear polarization P is defined using the asymmetry of the two measured intensities N_V and N_H by a following equation,

$$P = (N_V - N_H)/(N_V + N_H).$$

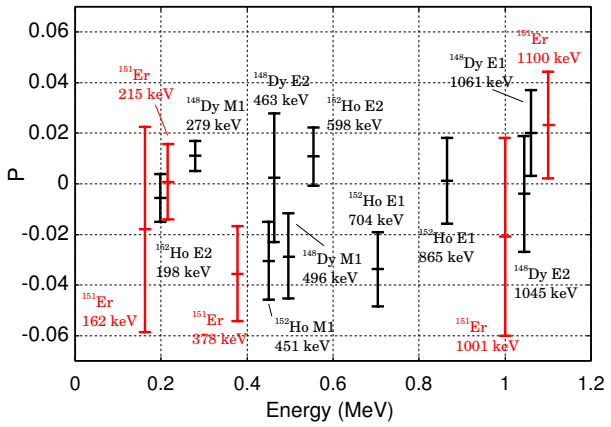

Figure 1: Measured linear polarization values. The transition energies and nucleus are shown by labels.

The positive and negative values of P indicate electric and magnetic transitions, respectively. The ratio of N_V to N_H in case of unpolarized γ rays are normalized by using a standard calibration source. The measured LP values are shown in Fig. 1. From the sign of the LP, the known electric and magnetic types of γ-ray transitions in ^{149}Dy and ^{152}Ho (black) are well reproduced. The types of 2 transitions in ^{151}Er (red) are tentatively determined to be electric for 1100-keV γ rays, and magnetic for 378-keV γ ray. The further analyses including angular distributions are now in progress.

References

[1] Y. Gono *et al.*, Eur. Phys. J. A **13**, 5 (2002) and references there in.
[2] T. Døssing, *et al.*, Phys. Scr. **24** 258 (1981).
[3] C. Foin, *et al.*, Eur. Phys. J. **8**, 451 (2000); A. André. *et al.*, Z. Phys. A **337** 349 (1990).
[4] A. von der Werth, *et al.*, Nucl. Inst. and Meth. A **357**, 458 (1995);