I. 7. Nuclear g-factor of the 1229 keV 13/2+ Isomer in $^{143}$Nd

Kawamura N., Higashino I., Kanazawa M., Hayashi S. and Fujioka M.*

Department of Physics, Faculty of Science, Tohoku University
Cyclotron and Radioisotope Center, Tohoku University*

The lowest 13/2$^+$ isomers in $N = 83$ isotones of $^{143}$Nd, $^{145}$Sm and $^{147}$Gd are lying at the excitation energies in the range of 1 MeV to 1.2 MeV; they are considered as states with a main configuration of the $v_{13/2}$ orbital$^1$ due to their almost same energies. The experimental reduced transition probabilities $B(E3; 13/2^+ \rightarrow 7/2^-$ g.s.) for these states, however, had indicated that they included collective components, exhibited by an enhancement of the $B(E3)$ in comparison with the single particle estimates$^{1,2}$. A further decisive evidence was shown by a measurement of the nuclear g-factor of the 997 keV 13/2$^+$ state in $^{147}$Gd$^3$, where a significant admixture from the octupole excitation built on the f$_{7/2}$ ground state was confirmed. It is, therefore, interesting to investigate the g-factor of the other isomers in the neighboring isotones, especially, the 1229 keV 13/2$^+$ state in $^{143}$Nd, which has been interpreted as the most pure $v_{13/2}$ state among the three isomers$^1$.

In order to study the nuclear g-factor of the 1229 keV state, we have carried out experiments of in-beam gamma ray spectroscopy through the $^{142}$Ce($\alpha$, 3n)$^{143}$Nd reaction at an $\alpha$-beam energy of 36 MeV. The bombarding energy was determined by the excitation functions measured in the energy range of 30-40 MeV. A $^{142}$Ce target enriched to 97 % was prepared by depositing the oxide powder to 11 mg/cm$^2$ thick on a 4 $\mu$m Mylar film. Fig. 1 shows an energy spectrum of the in-beam gamma rays measured with a 230 cm$^3$ HPGe detector placed at 64°.

The time integral perturbed angular distributions(TIPAD) of the gamma ray of 1229 $\rightarrow$ 0 keV transition has been measured using an external magnetic field of 1.8 T with up- or down-ward direction applied perpendicularly to the beam-detector plane. The in-beam gamma rays were measured with the 230 cm$^3$ detector at angles between 64° and 130° in steps of 11°. Yields of gamma rays at the different angles were normalized to the gamma yields obtained by another 70 cm$^3$ HPGe detector fixed at 90° on the opposite side. Fig. 2 shows the experimental TIPADs of the 1229 keV $\gamma$-rays de-exciting the isomers. The data were fitted to an expression:
\[ W(\theta; \pm B_{\text{eff}}) = A_0 + \sum_n A_n G_n P_n(\cos[n(\theta+\theta_n+\delta)]) \quad (n = 2 \text{ and } 4) \]  

and

\[ \theta_n = (1/n)\arctan(\omega \tau) \quad (n = 2 \text{ and } 4), \]

where \( \theta_n \) is the mean angular shift due to the Larmor precession with an angular velocity: \( \omega \) during the mean life: \( \tau \), and \( \delta \) is an angle of deviation from the 90° symmetry in the experimental arrangement of the detector. The nuclear g-factor is evaluated by the relation:

\[ g = -\omega h/\mu_N B_{\text{eff}}, \]

where \( \mu_N \) is the nuclear magnetron and \( B_{\text{eff}} \) the effective magnetic field at the nucleus.

The \( \delta \) was determined by the usual angular distributions measured without magnetic field. Results of the least squares fits are shown in Fig. 2 by solid lines. Though the data are yet preliminary, a remarkable result is obtained that the sign of the g-factor of the 1229 keV state is positive.

Although the relation (1) is too simple because it neglects the effect due to the Larmor rotations of the upper states, a TIPAD of the 791 keV \( \gamma \)-ray, which has almost all intensities of transitions feeding the 1229 level, shows only a small rotation. Therefore it does not give rise to significant effect to the present result. Much more uncertainty comes from the lifetime of the isomer; we must know the mean life of the state to deduce the g-factor from the relations (2) and (3). However, the experimental lifetimes reported in Refs. 1) and 2) are not in agreement with each other; the values of \( \tau = 10.1(6) \) and 5.6(1.8) ns in Refs. 1) and 2), respectively.

Using these lifetimes temporarily (our experiment on the lifetime is in progress), the g-factor is to be +0.081(30) or +0.0465(94), where we used the paramagnetic correction factor of \( \beta = 1.71(30) \) \(^4\) to get the effective magnetic field at the site of the Nd nucleus in the target material. We obtain a g-factor of \( g = +0.0496(90) \) from the weighted mean as a tentative value for the 1229 keV isomer. The present result indicates an obvious admixture of the configuration of the \( f_{7/2} \) neutron coupled to the 3\(^-\) excitation of the even-even core.

References

Fig. 1  A gamma ray spectrum obtained by the $^{142}$Ce + $\alpha$ reaction at $E_\alpha = 36$ MeV. Peaks denoted the energy belong to $^{143}$Nd.

Fig. 2  The time integral perturbed angular distributions of the 1229 keV gamma ray measured in the external magnetic fields of +1.8 T (represented by open squares) and -1.8 T (black squares).