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The g-factor of the 27$^-$ isomer state of $^{152}$Dy has been measured using the Time-Integral Perturbed Angular Distribution (TIPAD) method. The high-spin states of $^{152}$Dy have been populated by $^{141}$Pr($^{16}$O,p4n)$^{152}$Dy reaction at $E = 115$ MeV from the new AVF cyclotron at CYRIC. An enriched $^{141}$Pr target of 6 mg/cm$^2$ thickness was placed in an external magnetic field ($B_{\text{ext}}$) of 20.3 kG applied perpendicularly to the beam-detector plane. Figure 1 shows the time-integral perturbed angular distributions of $\gamma$-rays emitted from the 27$^-$ state.

In the case of paramagnetic materials, such as rare earth elements, the effective magnetic field at the nucleus ($B_{\text{eff}}$) is obtained from the relation $B_{\text{eff}} = \beta B_{\text{ext}}$, where $\beta$ is called the paramagnetic correction factor, and must be measured independently to obtain the g-factor.

The paramagnetic factor of Dy ions in Pr target has been determined to be 4.2(5) by the Time-Differential Perturbed Angular Distribution (TDPAD) measurement of the 21$^-$ state of $^{152}$Dy. Because the g-factor of this 21$^-$ isomer state has been known to be +0.55(6)$^1$, we could deduce the effective magnetic field in case of this experimental condition by measuring the Larmor frequency of the nuclear spin precession of this state. Fortunately since both of high-spin isomer states of $^{152}$Dy have been populated simultaneously. Figure 2 shows a TDPAD spectrum of this state and the effective magnetic field has been obtained to be 8.50(95) T, which corresponds to $\beta = 4.2$. 

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As a result, the g-factor of the $27^{-}$ isomer state of $^{152}$Dy has been obtained to be $+0.09(5)$ and has been found to be much smaller than the expected value of $+0.39$. It has been deduced from a fully aligned configuration of $\pi (h_{11/2}^2) \otimes \nu (f_{7/2}^2 h_{9/2}^1 i_{13/2})^2$, which is expected as an yrast state as a result of Deformed Independent Particle Model (DIPM)\(^3\) calculation. As seen in Table 1, present data suggest the configuration of $\pi (h_{11/2} d_{3/2}) \otimes \nu (i_{13/2}^2 h_{9/2} f_{7/2})$, however the excitation energy of this configurations has been expected to be more than 2 MeV higher than that of the yrast state in the DIPM calculation. Systematic measurements in the high-spin isomer states of Dy isotope are needed to understand this contradiction, so we are planning to measure the g-factor of the high-spin state in other Dy isotopes.

References


Table 1. Expected g-factors for possible configurations.

<table>
<thead>
<tr>
<th>configuration</th>
<th>g (expected)</th>
<th>Ex (MeV)</th>
<th>deformation</th>
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</thead>
<tbody>
<tr>
<td>$\pi (h_{11/2}^2) \otimes \nu (f_{7/2}^2 h_{9/2}^1 i_{13/2})$</td>
<td>$+0.36$ (5)</td>
<td>$6.79$</td>
<td>$-0.097$</td>
</tr>
<tr>
<td>$\pi (h_{11/2} d_{3/2}) \otimes \nu (i_{13/2}^2 h_{9/2} f_{7/2})$</td>
<td>$+0.15$ (5)</td>
<td>$9.02$</td>
<td>$-0.091$</td>
</tr>
</tbody>
</table>
Figure 1. A TIPAD spectrum of 220.6 keV $\gamma$-ray emitted from 27$^+$ high-spin isomer state of $^{152}$Dy

Figure 2. A TDPAD spectrum of 262.4 keV $\gamma$-ray emitted from 21$^-$ high-spin isomer state of $^{152}$Dy