g-factors of the ground state rotational band of $^{158}$Dy

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Abstract. The g-factors of the four lowest states of the ground state rotational band of $^{158}$Dy have been determined as $g(2^+) = +0.362(23)$, $g(4^+) = +0.340(20)$, $g(6^+) = +0.207(36)$ and $g(8^+) = +0.21(11)$. The g-factors of the $2^+$ and $4^+$ states were measured by the IPAC method with radioactive samples of 2.4 h $^{158}$Er in external magnetic fields. To investigate the higher states, for the first time an on-line $\gamma-\gamma$ IPAC experiment was performed with the reaction $^{156}$Gd($\alpha$, $2n$)$^{158}$Dy by use of the static hyperfine field of DyGd.

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1. Introduction

The investigation of the g-factors in ground state rotational bands of strongly deformed even-even nuclei is a challenging open field in nuclear structure physics. For rising spins the increased rotational frequencies cause increasing Coriolis forces and thus increasing changes of the intrinsic nuclear structure. The nuclear g-factors should react on these changes. In spite of the great endeavour of many groups who use especially the transient field technique, the existing experimental information is still incomplete and rather inaccurate. In most cases where the g-factors have been determined for several states within one rotational band the accuracy is not sufficient to show a significant variation of the g-factors with increasing spins.

We have started a new systematic investigation by on-line and off-line IPAC measurements with our twelve detector apparatus [1]. We reach with this system such a high statistical accuracy that for the first time quite accurate on-line $\gamma-\gamma$ IPAC measurements of $g(I)$ up to $I = 6$ or 8 are possible by application of pure static hyperfine fields. We think that this method is a valuable alternative to the transient field method for $I \leq 8$. Both methods are complementary in the sense that any possible sources of systematic errors are of quite different nature.

We have chosen $^{158}$Dy for our first experiment since a transient field measurement had been performed before [2] for this typical backbender which gave the important result that the g-factor is strongly reduced in the backbending region ($I \approx 14$). On the other hand $g(2^+)$ was unknown, the value for $g(4^+)$ quoted in [2] relies on an uncertain field calibration, $g(6^+)$ was unknown and the value for $g(8^+)$ derived in the transient field experiment [2] has rather large errors.

In the $\beta$-decay of 2.4 h $^{158}$Er through $^{158}$Ho to excited states of $^{158}$Dy several $\gamma-\gamma$ cascades are populated which allow a direct measurement of $g(2^+)$ and $g(4^+)$ by the IPAC technique with liquid sources in external magnetic fields.

The very large static hyperfine field at the nuclear site of Dy impurity atoms in ferromagnetic hosts allows to observe integral Larmor precession angles in the $4^+$, $6^+$ and $8^+$ states in an on-line IPAC experiment by exciting the rotational band through the reaction

$^{156}$Gd($\alpha$, $2n$)$^{158}$Dy.

A Gd metal target was used which provided simultaneously the ferromagnetic host. The effective static hyperfine field can be calibrated by use of the measured $g(4^+)$. This calibration is necessary since it is known from earlier perturbed angular distribution measurements [3, 4] that the effective field may be much smaller than observed by NMR-experiments [5].

1 The quoted value was derived from the observed integral rotation of the angular distribution of the $4^+-2^+$ $\gamma$-transition in the static hyperfine field of DyFe. The field calibration was done with the $4^+$ state of $^{164}$Dy with the assumption that the unknown value of $g(4^+)$ should be identical with the measured $g(2^+)$ of the same nucleus since $^{164}$Dy is a "good rotor". This assumption may not be correct
2. Measurements

2.1. \( g \)-factors of the \( 2^+ \) and \( 4^+ \) states of \( ^{158}\text{Dy} \)

The radioactivity, 2.4 h \( ^{158}\text{Er} \), was produced by the reaction

\[
^{150}\text{Sm} \rightarrow ^{12}\text{C}, 4n \rightarrow ^{158}\text{Er}
\]

with the 81 MeV \( ^{12}\text{C} \)-beam of the cyclotron of our laboratory. We used thin targets (3.5 mg/cm\(^2\)) of \( ^{150}\text{Sm} \), enriched to 95\%, in form of \( \text{Sm}_2\text{O}_3 \) covered with a 27 \( \mu \text{m} \) aluminium foil which reduced the \( ^{12}\text{C} \) energy to about 69 MeV, which is slightly below the maximum of the cross section for the \( (^{12}\text{C}, 4n) \) channel. The reaction is very selective. Small contributions by the \( (^{12}\text{C}, 3n) \) reaction do not disturb because of the short half-life of \( ^{159}\text{Er} \). The measured Ge-spectrum showed no contaminating activities. Therefore no chemical purification was necessary.

Liquid samples were prepared in form of \( \text{Sm}^{3+} \) ions in 1 M HCl and filled into cylindrical plexiglass containers of a few mm\(^3\) volume. They were mounted inside the room temperature access in the centre of the superconducting magnet of the twelve detector apparatus [1]\(^2\).

The decay scheme, shown in Fig. 1, was drawn according to the extensive spectroscopic investigations by Abdurazakov et al. [6] and Anderson et al. [7] and shows all \( \gamma \)-transitions with intensities larger than 0.7\% of the \( ^{158}\text{Er} \) decays. One realizes that the 218-99 keV and the 1791-218 keV cascades are most suitable for the \( g \)-factor measurements of the \( 2^+ \) and \( 4^+ \) states, respectively.

Two runs of about 3 d each were performed for both \( g \)-factor measurements. The strength of the magnetic field was 1.04 T and 0.93 T for the measurements of \( g(2^+) \) and 4.5 T for the measurements of \( g(4^+) \). The samples had

\(^2\) See Fig. 1 of [1] and text below