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The g-factor of the 659 keV level in ^{117}In

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Abstract. We have measured the g-factor of the 659 keV, $3/2^+$, state in ^{117}In, using time differential perturbed angular correlation technique. The spin precession of this state was measured in an external field of 20·2 kG. The values of the Larmor precession frequency ω and the g-factor are obtained to be $(60 \cdot 1 \pm 0 \cdot 3)10^6$ rads/sec and $0 \cdot 625 \pm 0 \cdot 007$ respectively.

Keywords. g-factor; TDPAC technique.

1. Introduction

The time differential perturbed angular correlation technique (TDPAC) is a very powerful technique for studying hyperfine interactions, specially at very dilute impurities. The 659 keV level in ^{117}In, which has a half-life of 58·6 nsec (Backlin *et al* 1967), is an ideal probe for such investigations. The quadrupole moment of this state has been measured to be $Q = 0 \cdot 64$ (4) b using this technique (Raghavan and Raghavan 1972, Haas and Shirley 1973). Recently this nucleus has been used as a probe for investigating quadrupole interaction and deriving therefrom the electric field gradients in different matrices (Devare *et al* 1975, Devare and Devare 1975 *a*). Similarly this probe could also be used to measure the hyperfine magnetic fields at In impurity in various magnetic lattices. However the accuracy of such measurements would be rather limited as the g-factor of this state, which has been measured earlier in this laboratory to be $0 \cdot 63 \pm 0 \cdot 05$ using TDPAC technique (Pandharipande *et al* 1967), has a rather large error. We have remeasured the g-factor of this state much more accurately using a larger magnetic field and TDPAC technique so that this state can also be a very suitable probe for studying magnetic interaction, particularly so in rare earth ferromagnets (Devare and Devare 1975 *b*). Moreover, it is of interest to know this g-factor accurately also, from the point of view of nuclear structure studies, as this state is interpreted as a member of the rotational band associated with the Nilsson orbital $1/2^+$ [431] (Macdonald *et al* 1974, Backlin *et al* 1967, Pandharipande *et al* 1967) although ^{117}In is expected to have a spherical ground state.

2 Experimental and Results

Levels in ^{117}In are fed in the β^- decay of 2·8 h ^{117}Cd. The ^{117}Cd source was obtained by irradiating $\sim 0 \cdot 5$ mgm of enriched ^{116}Cd in the form of CdO in a neutron flux of 10^{13} n/cm^2 for a period of 1 hr. The activity thus obtained was dissolved in dilute HCl and was used in liquid form. No chemical separation was done to remove the ^{117}In activity which decays to levels in ^{117}Sn, as it did not interfere with the measurements. The 89–345 keV gamma ray cascade through the 659 keV level is known to have a large anisotropy of $\sim$ 50% (Pandharipande *et al* 1967). We have used this gamma cascade for the measurements.

The time differential spectrum was observed with two NaI (Tl) counters at an angle of 135° using a time to amplitude converter calibrated with a known half-life and also by using delays of measured lengths along with a multichannel analyzer. The time resolution of the set up with the energies of interest was about 7·0 nsec (FWHM). The source was kept in a magnetic field of 20·2 kG provided by an electromagnet. The photomultiplier tubes were magnetically shielded and no light guides were required. Since the parent half-life is only $\sim$ 2·8 hr, the time spectrum was observed with only one direction of field. Several such time spectra were recorded with different samples. No shifts in the time spectra were observed during the course of the measurements. The time spectrum obtained after adding several runs is shown in figure 1. The modulated decay was fitted with the expression

$$N(\theta, H, t) = N_0 e^{-\lambda t} [1 + b_2 \cos 2 (\theta \quad \omega (t - t_0))] + C$$

where $\omega = - g\mu_N H/\hbar$ is the Larmor precession frequency. The fitted value of ω was obtained to be (60·1 ± 0·3) 10^6 rad/sec from which the value of the g-factor is obtained to be 0·625 ± 0·007. This includes a diamagnetic correction factor of 0·5% (Shirley and Ledorer 1974). This value is in very good agreement with

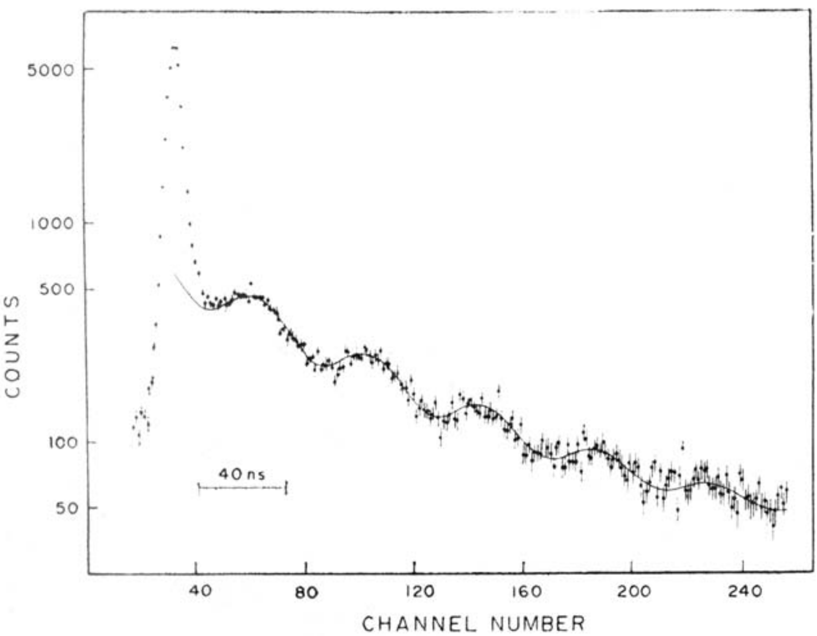

Figure 1. TDPAC spectrum in an external field of 20·2 kG.

the earlier reported value (Pandharipande *et al* 1967). The great improvement in the accuracy of our measurement compared to the earlier one (Pandharipande *et al* 1967) results from the following factors: (1) Much better statistical accuracy of measured data points. (2) Use of a higher magnetic fields resulting in several cycles of modulation and (3) Accurate calibration of the time to amplitude converter. This improvement in accuracy with which the g-factor is known (almost an order in magnitude) makes it a very useful probe for measurement of magnetic fields in magnetic materials. This value of the g-factor also agrees with the value $g = 0 \cdot 53 \pm 0 \cdot 09$ for a similar state at 828 keV in ^{115}In (Badica *et al* 1974). The value of the half-life for this state was also obtained from the fits to the data to be $(53 \cdot 3 \pm 0 \cdot 3)$ nsec. This value is lower than the one reported by Backlin *et al* (1967) but in very good agreement with that of Raghavan and Raghavan (1972), $T_{1/2} = 53 \cdot 5$ secs.

3. Discussion

The $3/2^+$ state at 659 keV has been proposed by Backlin *et al* 1967 to be the first rotational level of a $K = \frac{1}{2}$ band associated with the Nilsson orbital [431]. From the measured value of the transition probability of the intraband transition $1/2^+ \rightarrow 3/2^+$, they have also calculated the intrinsic quadrupole moment of this band as $3 \cdot 18\ b$ and hence the deformation parameter to be $0 \cdot 22$. The quadrupole moment of the $3/2^+$ state has recently been measured yielding for the intrinsic quadrupole moment a value of $2 \cdot 9 \pm 0 \cdot 3\ b$ (Haas and Shirley) and $3 \cdot 2 \pm 0 \cdot 2\ b$ (Raghavan and Raghavan). These measurements lend further support to the earlier interpretation of this state being of rotational character. Dietrich *et al* (1975), using the Strutinsky normalization procedure, have very recently calculated the potential energy curves for the Indium isotopes with the odd proton in different Nilsson orbitals. They have obtained a minimum, associated with the [431] 1/2 orbital, in the potential energy curve for a prolate deformation, $\epsilon = 0 \cdot 18$, in good agreement with the experimentally observed deformation. The magnetic moment for this state can be calculated on the basis of the Nilsson model (Nilsson 1955). Assuming it to be a rotational state on the $K = 1/2^+$ [431] Nilsson state, and using the wave functions tabulated by Nilsson the following values of magnetic moment have been calculated.

Deformation	Calculated value μ*	a	Measured value μ	a**
$\eta = 2$	$0 \cdot 913\ \mu_N$	$-2 \cdot 76$		
			$(0 \cdot 938 \pm 0 \cdot 01)\ \mu_N$	$-3 \cdot 1$
$\eta = 4$	$0 \cdot 731\ \mu_N$	$-1 \cdot 93$		

* Taking $g_R = Z/A$ and g_s effective $= 0 \cdot 55\ g_s$ free (obtained from the g-s moment of ^{115}In)
** Taken from Dietrich *et al* 1975.

The good agreement with the measured value of the magnetic moment definitely establishes the earlier proposition by Backlin *et al* (1967) and Pandharipande *et al* (1967) for this state to be a rotational level based on the $K = 1/2$ band.

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