NUCLEAR g-FACTOR OF THE 113 keV ROTATIONAL LEVEL IN ^{177}Hf

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Nuclear g-factor of 113 keV state in ^{177} Hf was measured using the method of integral angular correlation in the external magnetic field of 26 300 gauss. The value 0.245 ± 0.032 was obtained.

^{177}Hf represents an even-odd nucleus in the deformed nuclei region. Its rotational band with $K=7/2$ is well established. For odd A nuclei described by the collective model g_R and g_K nuclear factors can be calculated from two of the following experimental values: 1. the magnetic moment of the ground state μ_0, 2. the magnetic moment of the excited rotational state μ_e, 3. the magnetic dipole transition probability between any two rotational states $B(M1)$. Bernstein and de Boer (1960) determined the g-factors for ^{177} Hf from the measured quantities μ_0 and $B(M1)$. They obtained $g_R=0.215 \pm 0.014$ and $g_K=0.162 \pm 0.010$. It would be interesting to calculate g factors from μ_0 and μ_e or from μ_e and $B(M1)$ using the same model. The magnetic moment of the 113 keV excited state has been measured by Manning and Rogers (1960), but their result $\mu_e=0.99 \pm 0.28$ is not sufficiently accurate for such calculation.

The aim of this work was to measure μ_e for 113 keV excited level with better accuracy and to compare g_R and g_K nuclear factors with the values calculated by Bernstein and de Boer.

The measurements were performed using the well known method of the rotation of the angular correlation pattern for γ-γ cascade when the source is located in the external magnetic field perpendicular to the plane of the emission of the two successive γ rays. We carried out the measurements of the coincidence counting rates for two opposite field directions and for the angles 135° and 225° between the counters detecting 208 keV and 113 keV γ rays of the cascade going through the 113 keV excited state. The source was obtained by irradiation of Lu_2O_3 in the Warsaw reactor and prepared in the form of a dilute aqueous solution of $Lu(NO_3)_3$. For aqueous solution of the nitrate the angular correlation of 208—113 keV cascade is believed to be unperturbed (Behrend 1958). Both scintillation counters were provided with 22 cm long light pipes whose light collection was about 75 per cent. The photomultipliers were adequately shielded from the stray magetic field. With 18 nsec resolving time of the fast-slow coindicence circuit the ratio of chance to true coincidences was below 5 per cent.

For each angle between the detectors we calculate the expression

$$R = 2\,\frac{N_+ - N_-}{N_+ + N_-}\,,$$

where N_+ and N_- are the coincidence rates for the magnetic field directions up and down respectively. In the case of the investigated cascade the angular correlation coefficient A_4 is negligible (probably zero) (West *et. al.* 1961) and the mean larmor precession angle $\omega\tau \ll 1$. Then R can be written in a very simple form

$$R = \pm\,\frac{2A}{1+0.5A}\,\omega\tau\,,$$

where A is the experimental anisotropy of the angular correlation measured for the same geometry (with the source in the electromagnet gap) and signs + and — correspond to angles 135° and 225° between the detectors. Measurements were performed in the field $B = \pm(26\,300 \pm 240)$ gauss. Values of R obtained for the two counter settings are the following:

for 135° $\quad R = +(0.876 \pm 0.127) \times 10^{-2}$

for 225° $\quad R = -(0.707 \pm 0.108) \times 10^{-2}$.

The weighted mean is $|\overline{R}| = (0.784 \pm 0.080) \times 10^{-2}$.

Taking into account the measured anisotropy $A = -(0.183 \pm 0.004)$ and adopting for the half life of 113 keV state the value $T_{1/2} = (0.52 \pm 0.04)$ nsec (Hauser *et. al.* 1961) we obtained $g = \pm 0.245 \pm 0.032$ and $\mu_e = (1.10 \pm 0.14)\mu_N$. The diamagnetic correction (below 1 per cent) is neglected. The limits of error are due to the uncertainties in R, A, τ and B determinations.

The magnetic moment predicted by the collective model is

$$\mu = \frac{K^2}{I+1}\,g_K + \frac{I(I+1) - K^2}{I+1}\,g_R \qquad \text{for } K = 1/2.$$

Combining the values of the ground state ($7/2^-$) magnetic moment $\mu_0 = 0.61 \pm 0.03$ (Speck 1956) and the magnetic moment of 113 keV excited state ($9/2^-$) $\mu_e = 1.10 \pm 0.14$ g_R and g_K can be calculated separately

$$g_R = 0.374 \pm 0.084 \text{ and } g_K = 0.120 \pm 0.030.$$

The disagreement with Bernstein and de Boer's values is well above the limits of error. If we assume that our g-factor measurements are correct then g_R for ^{177}Hf is rather close to g_R's for even-even nuclei while it is well known that the Coriolis force correction for an odd neutron has the tendency to suppress g_R.

If we calculate g's from $B(M1)$ and μ_e the following result is obtained:

$$g_R = 0.271 \pm 0.033 \text{ and } g_K = 0.218 \pm 0.034.$$

These values are much more reasonable which seems to indicate that the μ_0 determination was not correct.

When preparing this paper for publication we were informed by private communication that Matthias, Karlsson and Lerjefors (1962) in Uppsala had measured the g-factor for 113 keV state of ^{177}Hf with even better accuracy using the source in the form of an aqueous solution of $LuCl_3$. Their result $g=0.232\pm0.013$ is in full agreement with our value.

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