KFKI
3/1969

ANOMALOUS HYPERFINE FIELD AT RECOILED Rh NUCLEI OF LOW ENERGY IN $Fe_{51.5}Rh_{48.5}$ ALLOY

L. Varga, I. Demeter, L. Keszthelyi, L. Pócs and Z. Szőkefalvi-Nagy

HUNGARIAN ACADEMY OF SCIENCES
CENTRAL RESEARCH INSTITUTE FOR PHYSICS

BUDAPEST

ANOMALOUS HYPERFINE FIELD AT RECOILED Rh NUCLEI
OF LOW ENERGY IN $Fe_{51.5}Rh_{48.5}$ ALLOY

L.Varga, I.Demeter, L.Keszthelyi, L.Pócs and Z. Szőkefalvi - Nagy
Central Research Institute for Physics, Budapest, Hungary

The rotation angles for the 298 keV and 362 keV states of ^{103}Rh were measured after Coulomb excitation with 2,5 MeV protons in $Fe_{51.5}Rh_{48.5}$ alloy, as- 0.0172 ± 0,0037 and + 0,0295 ± 0,0121 respectively. These values are interpreted by considering the existence of a transient field at such low energies, too.

Last year we reported the measurement of the g-factors of some nuclei in excited state by observing the angle $\omega\tau$ of integral rotation of the angular distribution of the γ-radiation from states produced by Coulomb excitation of nuclei in ferromagnetic alloys [1,2,3]. Recently an attempt was made to measure in FeRh with 48.5 at. % of Rh the g-factors of the 298 keV $3/2^-$ and 362 keV $5/2^-$ states of ^{103}Rh. The lifetimes of these states are τ_1= 9.1 psec and τ_2= 85 psec, respectively [4]. This alloy is ferromagnetic [5]. The static hyperfine field at Rh nuclei was measured at 1^oK as H_{st} = 130 ± kG [6] but its sign was not determined. The hyperfine field at the Fe nuclei varies very slowly with temperatures below the room temperature [5]. The same is assumed for the field at the Rh nuclei. The external field applied to saturate the Fe-Rh target was ~ 2000 kOe. The liquid nitrogen cooled target was bombarded with 2,5 MeV protons.

The angular distribution coefficients expressed in terms of cos 2ϑ neglecting b_4 were found to be

$$b_2 \text{ (298 keV)} = - 0{,}255 \pm 0{,}012$$

and

$$b_2 \text{ (362 keV)} = + 0{,}103 \pm 0{,}015$$

with the precession angles

$$(\omega\tau)_1 \text{ 298 keV} \triangleq - 0{,}0172 \pm 0{,}0037$$

$$(\omega\tau)_2 \text{ 362 keV} = + 0{,}0295 \pm 0{,}0121$$

Since ^{103}Rh is an odd proton nucleus, the Schmidt limits give positive g-factors for these states. Thus, the opposite signs of the measured $(\omega\tau)_1$ and $(\omega\tau)_2$ are in contradiction with the theoretical limits which are violated only exceptionally [7].

This contradiction, however, can be overcome, if one considers the appearance of a very intensive positive transient magnetic field H_t of short lifetime τ_t at the nuclei as a result of the slowing down process and similar to that observed in the IMPACT experiments of Grodzins et al. [8]. Then, the measured values of $\omega\tau_1$ and $\omega\tau_2$ can be described as

$$(\omega\tau)_i = -\frac{g_i \mu_N}{\hbar}(H_t \tau_t + H_{st}\tau_i)_i \qquad i=1,2 \qquad (1)$$

and the value of $H_t \tau_t$ can be calculated from the expression

$$H_t \tau_t = -H_{st}\tau_t \frac{g_1/g_2 - \frac{(\omega\tau)_1}{(\omega\tau)_2}\cdot\frac{\tau_2}{\tau_1}}{g_1/g_2 - \frac{(\omega\tau)_1}{(\omega\tau)_2}} . \qquad (2)$$

Considering the measured values of $(\omega\tau)_1$ and $(\omega\tau)_2$ as well as the Schmidt limits (0,043 - 7,3) of g_1 / g_2, the ratio in (2) must be positive. It follows that

1. The sign adopted from ref. [8] for H_t being positive, requires that of H_{st} to be negative. This is consistent with the measured positive sign of $(\omega\tau)_2$ and, if one accepts the Schmidt prediction of g_2, this positive sign is not inconsistent with the existence of H_t owing to the relatively high value of τ_2 .

2. Within the limits of the Schmidt prediction of g_1 / g_2 the value of $H_t \tau_t$ is always > 0 and lies in the range of the transient field values observed in high recoil energy experiments on the neighbouring elements (Pd, Rn, Cd): 9.10^{-6} Gauss sec [8] (see Fig.1).

If, we attribute the 20% difference of the measured $(\omega\tau) = 0{,}077 \pm 0{,}005$ of the 328 keV state of ^{194}Pt obtained on Coulomb excitation with 2,5 MeV protons [3] from the static value $\omega\tau = 0{,}095 \pm 0{,}003$ [9] not as in [3] to crystalline effect, but to that of the transient field, we get for $H_t \tau_t =$ $= + (11{,}6 \pm 4{,}3)\ 10^{-6}$ Gauss sec, in surprisingly good agreement with the $+ (16{,}2 \pm 4{,}1).\ 10^{-6}$ Gauss sec. evaluated from IMPACT experiments at 12 MeV recoil energies of ^{194}Pt.

The effect of the recoil energy on the value of $\omega\tau$ for the 847 keV state in ^{56}Fe has been already investigated in two experiments [10,11]. Their results are contradictory. The present result confirms the observations in the latter experiment [11].

The existence of the high intersity transient field even at recoil energies of maximum 100 keV, which seems to be evident from the present experiment, cannot be attributed to the electron processes suggested for the explanation of the transient field observed in IMPACT measurements. The velocities at such low recoil energies are too small for picking up electrons from Fe, the energy loss is mainly nuclear [8] since electron processes, such as ionization, charge exchange cease to be important. However, the similar values of the transient field at the high and low recoil energies suggest a common origin. This is thought to be the final stage of the slowing down process when the slow moving recoiled nuclei approache in the collisions the polarized Fe host atoms by which the s-electrons of the recoil particle become strongly polarized, too, and produce a transient field by core polarization. The observed effect of $H_t \tau_t$ seems to be the integrated contribution from these invidual collisions.

To get a better insight into these intricate phenomena, it would be of interest to continue their study, possibly, by varying the energy of the recoiled particles.

References

1. L.Keszthelyi, I.Demeter, Z. Szőkefalvi-Nagy and Z.Zámori, in Hyperfine Structure and Nuclear Radiation, ed. by E.Matthias and D.A.Shirley /North-Holland Publishing Company, Amsterdam, 1968/. p.192.

2. L.Keszthelyi, I.Demeter, Z.Szőkefalvi-Nagy and L.Varga, Nucl.Phys. A120 (1968) 540.

3. L.Varga, I.Demeter, L.Keszthelyi, Z.Szőkefalvi-Nagy and Z.Zámori, Phys.Rev. /to be published/.

4. F.K.McGowan and P.H.Stelson, Phys.Rev. 109 (1958) 901.

5. G.Shirane, C.W. Chen, P.A.Flinn and R.Nathans, Phys.Rev. 131 (1963) 183.

6. B.Dreyfus, P.Stetsenko and D.Thoulonze, Phys. Letters 24A (1967) 454.

7. E. Bodenstedt and J.D.Rogers, in Perturbed Angular Correlations, ed. by E.Karlsson, E.Matthias and K.Siegbahn /North-Holland Publishing Company, Amsterdam, 1964./ p.91.

8. L.Grodzins, in Hyperfine Structure and Nuclear Radiation, ed.by. E.Matthias and D.A.Shirley /North-Holland Publishing Company, Amsterdam, 1968/.p.6o7.
R.R.Borchers, J.D.Bronson, B.Herskind, L.Grodzins, R.Kalish and D.E. Murnick, Phys. Rev. Letters 20 (1968) 424.

9. R.Beraud, I.Berkes, J.Daniere, M.Lévy, G.Marest, R.Rougny, H.Bernas and D.Spanjaard, in Hyperfine Structure and Nuclear Radiation, ed.by. E.Matthias and D.A.Shirley /North-Holland Publishing Company, Amsterdam, 1968/ p.199.

10. R.Kalish and W.J.Kossler, Phys.Rev.Letters 20 (1968) 271.

11. D.E.Murnick, I.R.McDonald, R.R.Borchers, G.Heestand and B.Herskind, Conference on Ion Implantation and Hyperfine Interactions, London, 1968. /unpublished/.

Fig. 1 Variation of $H_t \cdot \tau_t$ with g_1 / g_2.
The arrows mark the limits of the Schmidt prediction.
The estimated error of τ_1 and τ_1 / τ_2 is 10 %.

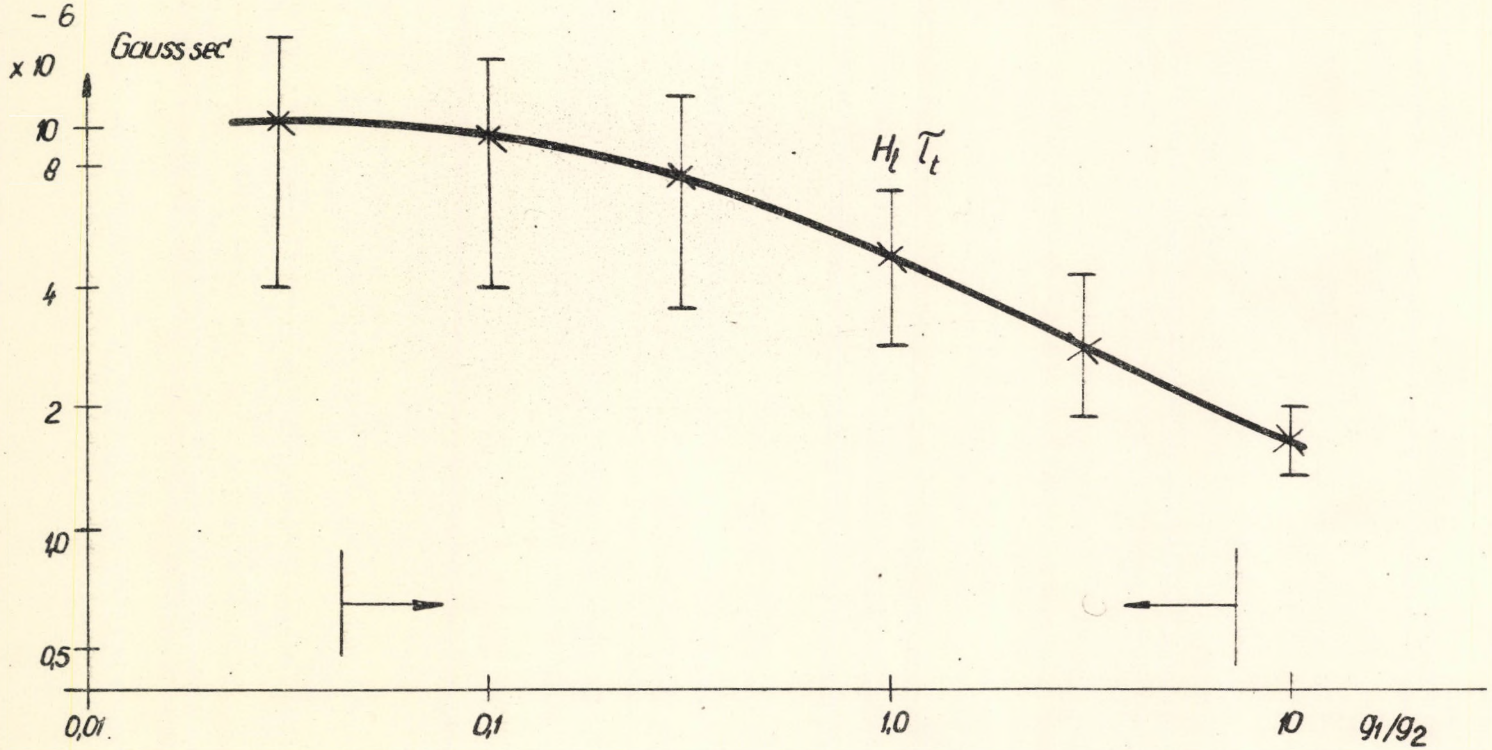

Fig. 1.

Printed in the Central Research Institute for Physics, Budapest

Kiadja a Könyvtár- és Kiadói Osztály. O.v.: dr. Farkas Istvánné
Szakmai lektor: Zámori Zoltán. Nyelvi lektor: Kovács Jenőné
Példányszám: 100 Munkaszám: KFKI 4170 Budapest, 1969 január 3.
Készült a KFKI házi sokszorositójában. F.v.: Gyenes Imre