Nuclear Magnetic Moments of 2.0 h ^{89}Nb and 78 h ^{89}Zr $^{\diamond}$

B. Hinfurtner, G. Seewald, E. Hagn, and E. Zech

1. Summary

Nuclear magnetic resonance on oriented nuclei was applied to ^{89}Nb ($I^\pi = 9/2^+$; $T_{1/2} = 2.0$ h) and ^{89}Zr ($I^\pi = 9/2^+$; $T_{1/2} = 78$ h). The zero-field hyperfine splitting frequency $\nu_{\mathrm{M}} = |g\mu_N B_{\mathrm{HF}}/h|$ was determined to be 278.55(12) MHz for $^{89}\mathrm{Nb}\underline{\mathrm{Fe}}$ and 51.57(3) MHz for $^{89}\mathrm{Zr}\underline{\mathrm{Fe}}$. With the known magnetic hyperfine fields $B_{\mathrm{HF}}(\mathrm{Nb}\underline{\mathrm{Fe}}) = -264.54(19)$ kG and $B_{\mathrm{HF}}(\mathrm{Zr}\underline{\mathrm{Fe}}) = -284(6)$ kG, the magnetic moments are decuced to be $\mu(^{89}\mathrm{Nb}) = 6.216(5)\ \mu_{\mathrm{N}}$ and $\mu(^{89}\mathrm{Zr}) = -1.072(23)\ \mu_N$.

2. Experimental Method and Results

Samples of ^{89}Nb ($I^\pi = 9/2^+$, $T_{1/2} = 4.3$d) in Fe and Ni were prepared by recoil implantation at the cyclotron in Karlsruhe via the reaction ^{89}Y(α,4n) with $E_\alpha = 55$ MeV. The samples were cooled to $\sim$ 10 mK with a ^{3}He-^{4}He-dilution refrigerator. NMR-ON measurements were performed in an external magnetic field of 1 and 6 kG. The resonance signals of the 920, 1259, 1627, 1833, 2960, and 3093 keV transitions were added with weights corresponding to the respective γ-anisotropies. The NMR-ON resonances are shown in fig. 1. The center frequencies are 277.51(8) and 272.31(19) MHz for $B_{\mathrm{ext}} = 1$ and 6 kG, respectively, from which the hyperfine splitting $\nu_{\mathrm{M}}(^{89}\mathrm{Nb}\underline{\mathrm{Fe}})$ = 278.55(12) MHz is obtained.

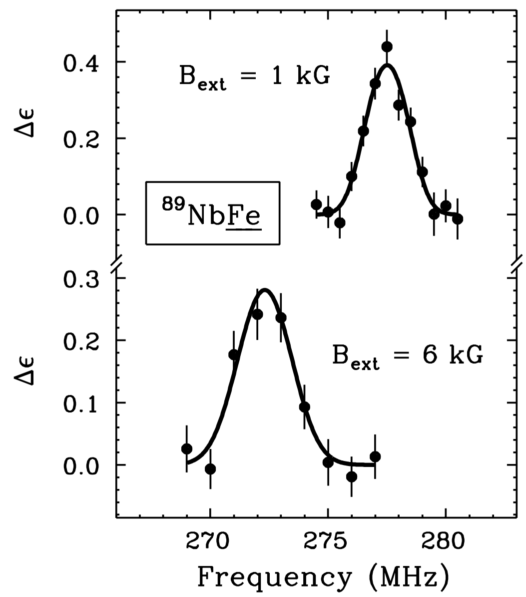

Fig. 1: NMR-ON resonances of $^{89}\mathrm{Nb}\underline{\mathrm{Fe}}$ measured with a modulation band width of $\pm$ 1 MHz.

In the decay of ^{89}Zr, there is no prompt γ-transition with sufficient intensity, as the EC, β^+-decay feeds directly the 16 s isomer ^{89m}Y. This isomer decays with a strong $M4$ γ-transition ($E_\gamma = 909$ keV, $I_\gamma = 99.9$ %). Thus, NMR-ON on ^{89}Zr can be observed only via the influence of the initial orientation (immediately after the EC, β^+-decay) on the (incomplete) reorientation in ^{89m}Y. This means, however, that the sign of the magnetic moment of ^{89}Zr influences the reorientation process. For a negative sign of $\mu(^{89}\mathrm{Zr})$ the γ-anisotropy is enhanced in resonance, whereas it is diminished for a positive sign. Fig. 2 shows the result. The γ-anisotropy is enhanced, i.e. the sign of $\mu(^{89}\mathrm{Zr})$ is negative. For the hyperfine splitting $\nu_{\mathrm{M}}(^{89}\mathrm{Zr}\underline{\mathrm{Fe}}) = 51.57(3)$ MHz is obtained.

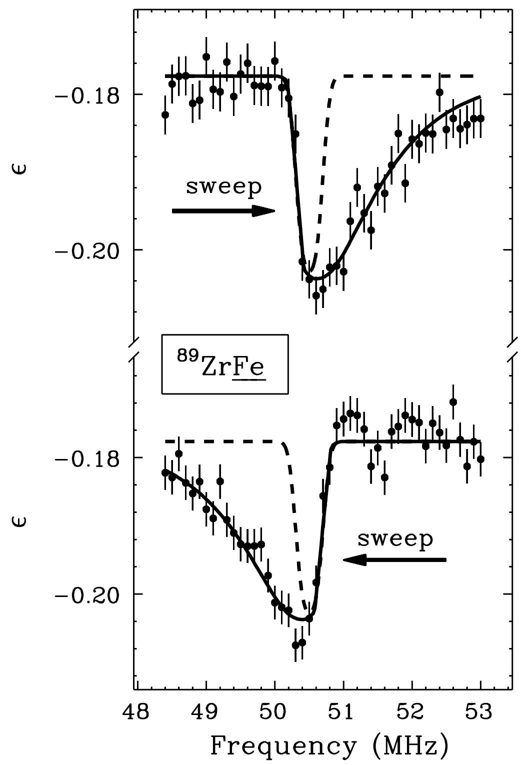

Fig. 2: NMR-ON resonances of $^{89}\mathrm{Zr}\underline{\mathrm{Fe}}$ measured for $B_{\mathrm{ext}} = 6$ kG. The counting time per point was 200 s. Because of the long spin lattice relaxation time of $^{89}\mathrm{Zr}\underline{\mathrm{Fe}}$ ($\approx$ 1 h) the γ-anisotropy is accumulated in sweep-direction. The solid curve is the result of a *least-squares* fit, in which the multi-exponential relaxation has been taken into account. The dashed curve represents the "true" resonance, for which the relaxation effects have been unfolded.

A full description of this work is given in ref. [1].

References

[1] B. Hinfurtner, G. Seewald, E. Hagn and E. Zech, submitted to Nucl. Phys. **A**

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