Measurement of the Nuclear Spin-Lattice Relaxation of ^{90}Nb on Low-Field Sites in Fe ◇

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Utilizing the nuclear reaction ^{89}Y(α,3n), radioactive ^{90}Nb ($T_{1/2}$ = 14 h) was recoil-implanted into thin Fe foils. The magnetic hyperfine interaction

$$\nu_{\rm M} = |\, g\mu_N B_{\rm HF}/h\,| , \qquad (1)$$

where g is the nuclear g-factor and $B_{\rm HF}$ is the magnetic hyperfine field, was measured with nuclear magnetic resonance on oriented nuclei (NMR-ON) in an external magnetic field $B_{\rm ext}$ = 1 kG. The result is shown in Fig. 1.

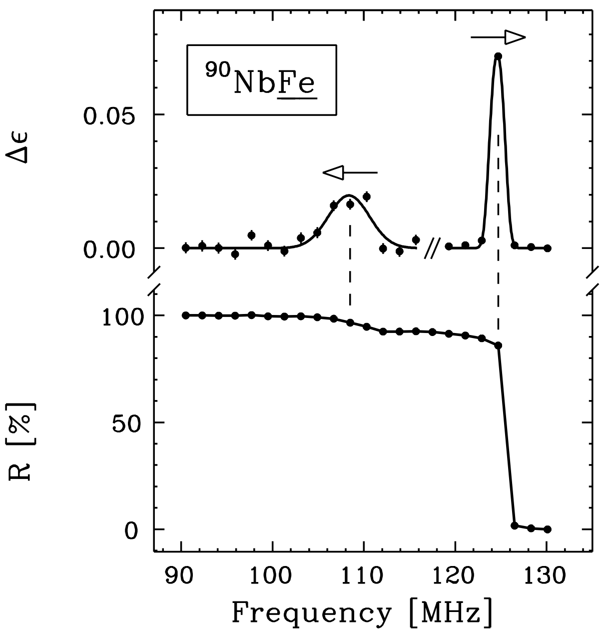

Fig. 1: NMR-ON measurememt on ^{90}NbFe for $B_{\rm ext}$ = 1 kG. Top: Destruction of the γ anisotropy ϵ as function of the frequency of the applied rf-field. Bottom: Integrated resonance effect $\int_{130}^{\nu} \Delta\epsilon(\nu')d\nu'/\epsilon$, where ϵ is the measured γ anisotropy. The integrated resonance effect of 100(1)% indicates that all Nb nuclei which are oriented and hence contribute to the γ-anisotropy have been resonated.

The resonance signal consists of two dominant contributions: About 90% is concentrated around 125 MHz, which is attributed to Nb nuclei on substitutional ("S") sites with a more or less undisturbed surrounding. About 10% of the NMR-ON signal appears in a broad resonance centered at $\sim$ 108 MHz, the details of the lattice ("N") site being unknown. For both sites the nuclear spin-lattice relaxation (NSLR) rate $R_{\rm K}$ was measured by observing the time-dependent recovery of the γ anisotropy ϵ after resonant destruction of the low-temperature orientation of the nuclear spin system. Spectra are shown in Fig. 2.

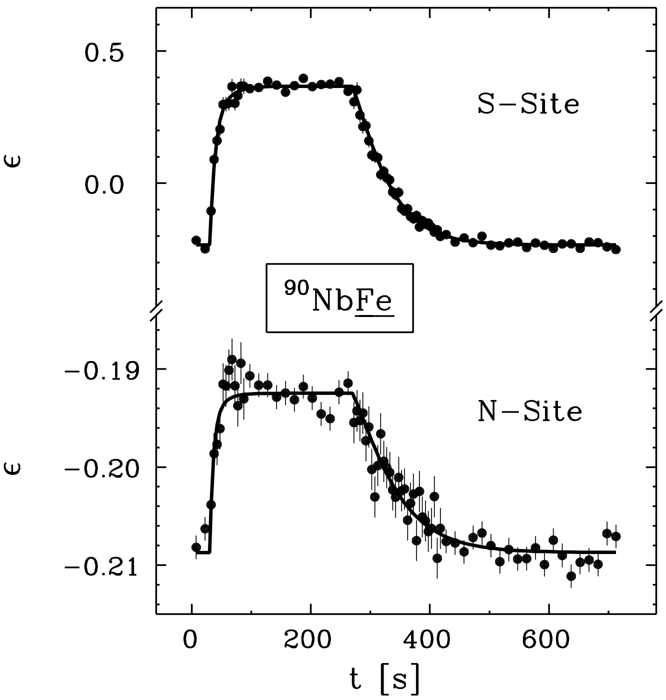

Fig. 2: NSLR measurement on ^{90}NbFe for $B_{\rm ext}$ = 1 kG.

The results are compiled in Table 1.

$B_{\rm ext}$ [kG]	$R_{\rm K}^{\rm (N)}$ [1/Ks]	$R_{\rm K}^{\rm (S)}$ [1/Ks]	$R_{\rm K}^{\rm (N)}/R_{\rm K}^{\rm (S)}$
1	0.618(37)	0.611(8)	1.01(6)
6	0.163(15)	0.179(2)	0.91(8)
average			0.97(5)

Table 1: Spin-lattice relaxation rate $R_{\rm K} = 1/C_{\rm K}$ of ^{90}NbFe on N- and S-sites.

Summarizing, the ratio of the Korringa constants $C_{\rm K} = 1/R_{\rm K}$ for the spin-lattice relaxation on N- and S-sites is found to be $C_{\rm K}^{\rm (N)}/C_{\rm K}^{\rm (S)}$ = 1.03(5), in contrast to the ratio of hyperfine fields at N- and S-sites, $(B_{\rm HF}^{\rm (N)}/B_{\rm HF}^{\rm (S)})^2$ = 0.74, Thus it is evident that the NSLR rate does not scale with $\nu_{\rm M}^2$, but is essentially the same for both sites. This can be interpreted as follows: Whereas the magnetic hyperfine field is a local property — it depends on the local *integral* spin density at the impurity site —, the NSLR is independent on local variations of the integral spin density. The NSLR depends on the electron density of states at the Fermi energy, which seems to be more independent on local variations.
A full description of this work is given in [1].

References

[1] G. Seewald, B. Hinfurtner, E. Hagn, E. Zech, Phys.Lett.A **236** (1997) 167

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