Vibrating Sample Magnetometry

Theoretical principle

Faraday's law of induction

$$V(t) = -\frac{\mathrm{d}\phi_B}{\mathrm{d}t} \tag{1}$$

$$\phi_B = \iint_S \vec{B}(\vec{r}, t) \cdot \mathrm{d}\vec{A} = BS \tag{2}$$

$$\implies V(z, t) = -NS\frac{\mathrm{d}B}{\mathrm{d}z}\frac{\mathrm{d}z}{\mathrm{d}t} \tag{3}$$

Magnetization

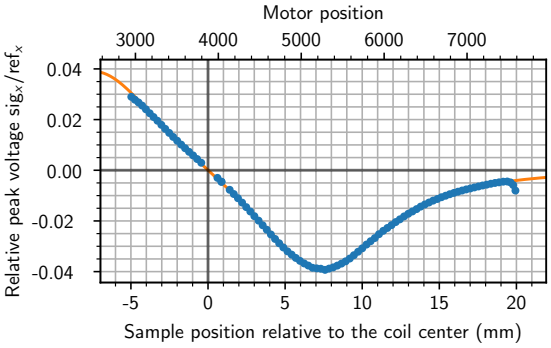
- **Paramagnetism:** Magnetic moment of unpaired electrons
- **Diamagnetism:** Lorentz force on electrons in orbitals

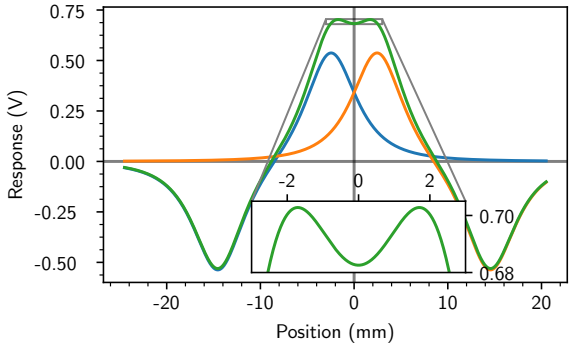
Theoretical principle

Induction on one pickup coil

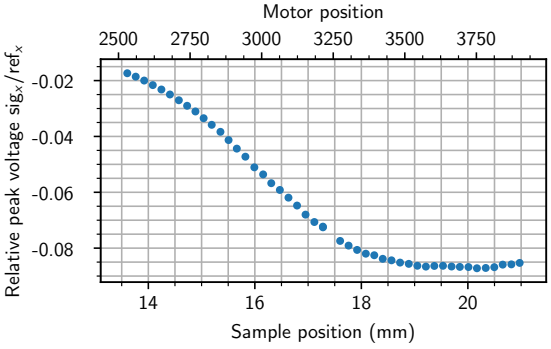
$$V(z) = -NASI\mu_0\frac{f\pi}{\sqrt{2}}\left[\ln\left(r_2+\sqrt{r_2^2+(z-L)^2}\right)-\ln\left(r_1+\sqrt{r_1^2+(z-L)^2}\right)+\right.$$
$$(z-L)^2\left(\frac{1}{r_2\sqrt{r_2^2+(z-L)^2}+r_2^2+(z-L)^2}-\frac{1}{r_1\sqrt{r_1^2+(z-L)^2}+r_1^2+(z-L)^2}\right)+$$
$$\ln\left(r_1+\sqrt{r_1^2+z^2}\right)-\ln\left(r_2+\sqrt{r_2^2+z^2}\right)+$$
$$\left.z^2\left(\frac{1}{r_1\sqrt{r_1^2+z^2}+r_1^2+z^2}-\frac{1}{r_2\sqrt{r_2^2+z^2}+r_2^2+z^2}\right)\right] \tag{4}$$

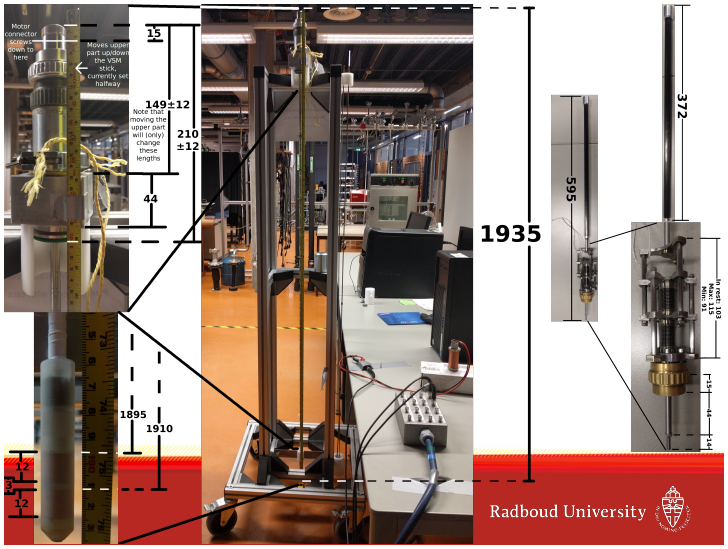
One pickup coil, permanent magnet: 30.9 mg

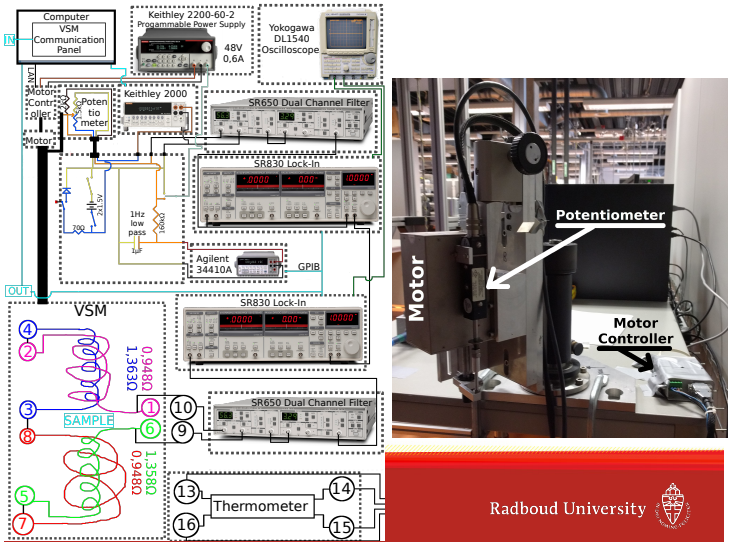




All 4 pickup coils, Nickel: 42.5 mg **at** 2 T **(Room Temperature)**

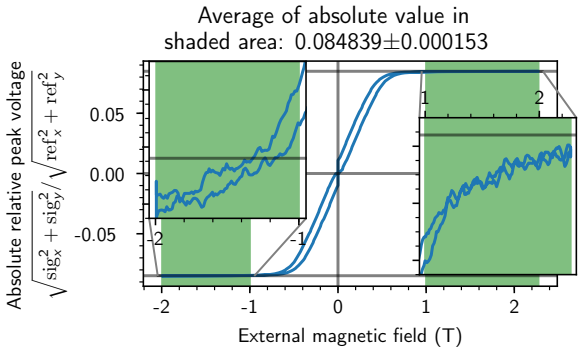




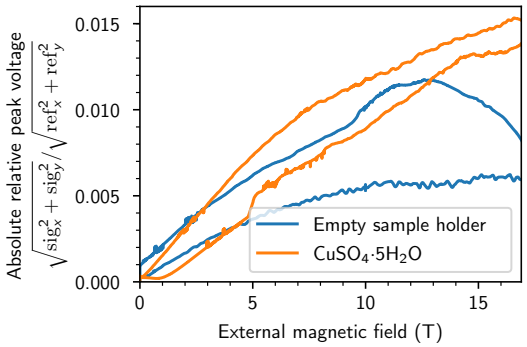


Nickel: 42.5 mg **(Room Temperature)**

$(58.57 \pm 0.03)\,\mathrm{emu/g} \Longrightarrow (2.489 \pm 0.002)\,\mathrm{emu} \Longrightarrow c=(29.34 \pm 0.06)\,\mathrm{emu}$

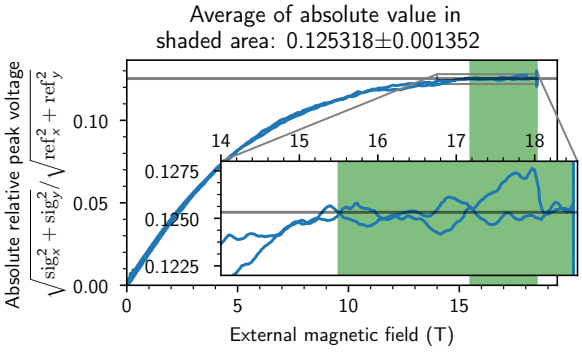


$CuSO_4 \cdot 5\,H_2O$: 143 mg **(Room Temperature)**



$CuSO_4 \cdot 5\,H_2O$: 143 mg **(4 K)**

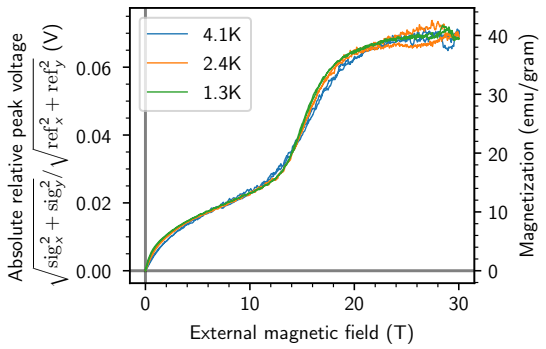
$c=(29.34 \pm 0.06)\,\mathrm{emu} \Longrightarrow (3.67 \pm 0.04)\,\mathrm{emu} \Longrightarrow (25.7 \pm 0.3)\,\mathrm{emu/g}$



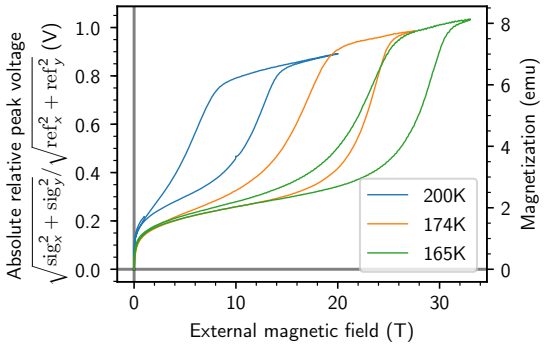
Sanity Check

- Paramagnetic Cu^{2+} ions: Spin 1/2
- $2\sqrt{s\,(s+1)} = \sqrt{3}\;\mu_B$
- $CuSO_4 \cdot 5\,H_2O$: 249.684 u
- $\Longrightarrow$ 39 emu/g
- Diamagnetic contributions of H_2O and SO_4^{2-}

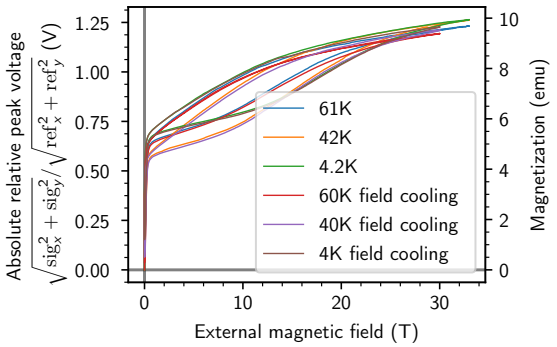
$KEr(MoO_4)_2$: 6.2 mg



$Ni_{38}Mn_{49}Sn_9Fe_4$
Martensite (strained body-centered tetragonal), Austenite (face-centered cubic) phase transition.



$Ni_{37}Mn_{49}Sn_9Fe_5$
Martensite (strained body-centered tetragonal), Austenite (face-centered cubic) phase transition.



More info:
github.com/AndrewAmmerlaan/HFML-VSM_CoilProfilePlotter

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