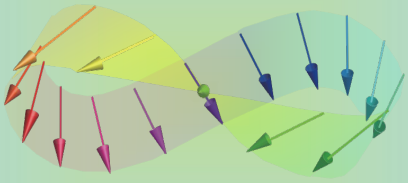
Information Storage and Spintronics
Practical Session 1

~ Vibrating Sample Magnetometer ~



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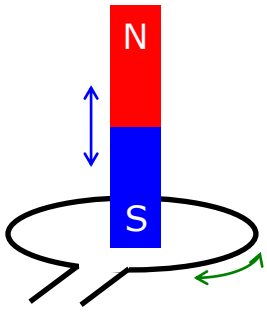
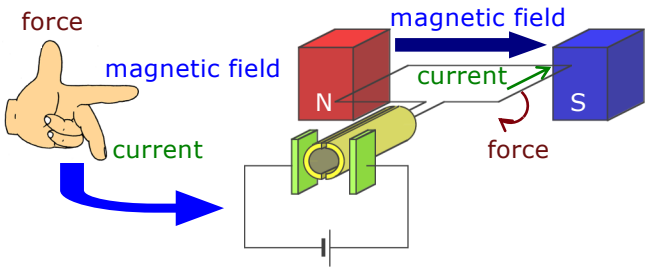
13:00 Wednesday, 12/October/2022

Faraday's Law of Induction

Faraday's law of induction : *





* http://www.wikipedia.org/

Vibrating Sample Magnetometer (VSM)

In 1955, S. Foner invented VSM by vibrating a sample at a constant frequency and amplitude in VSM :

The magnetic flux density changes in the sample under a magnetic field, inducing a voltage in a coil as

$$V_{\text{coil}} = 2\pi f C m A \sin(2\pi f t)$$

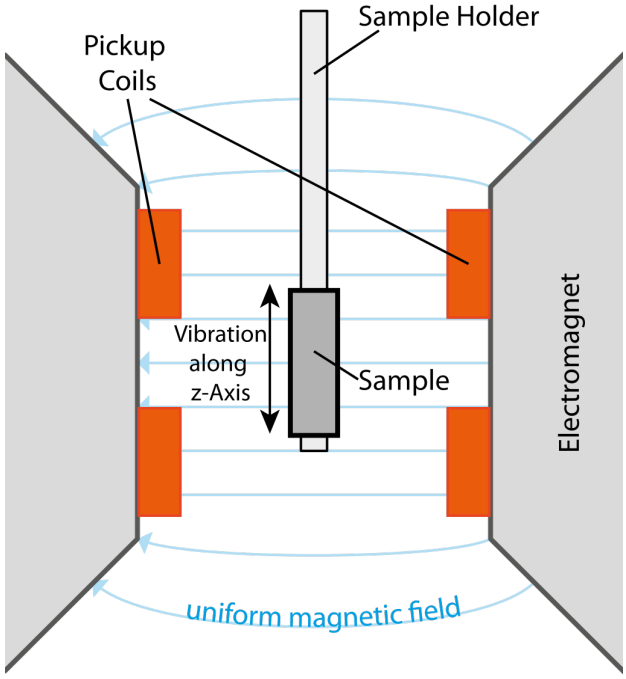
where f : vibrating frequency, C : constant, m : magnetic moment, A : vibrating amplitude and t : time.

By measuring V_{coil}, the magnetic moment of a sample can be determined.

First, a reference sample, such as a Pt foil, is measured for calibration.

A sample under investigation is then measured.

Demagnetisation correction is then applied for the magnetisation curve. See the Lakeshore manual for details.

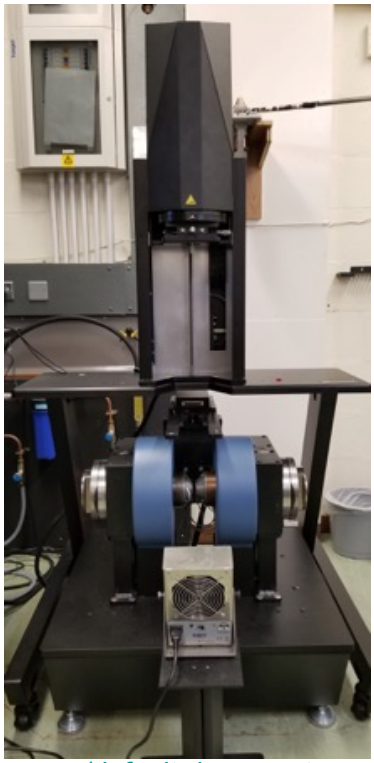


* http://www.wikipedia.org/

VSM Setup

Lakeshore Series 8600 VSM :

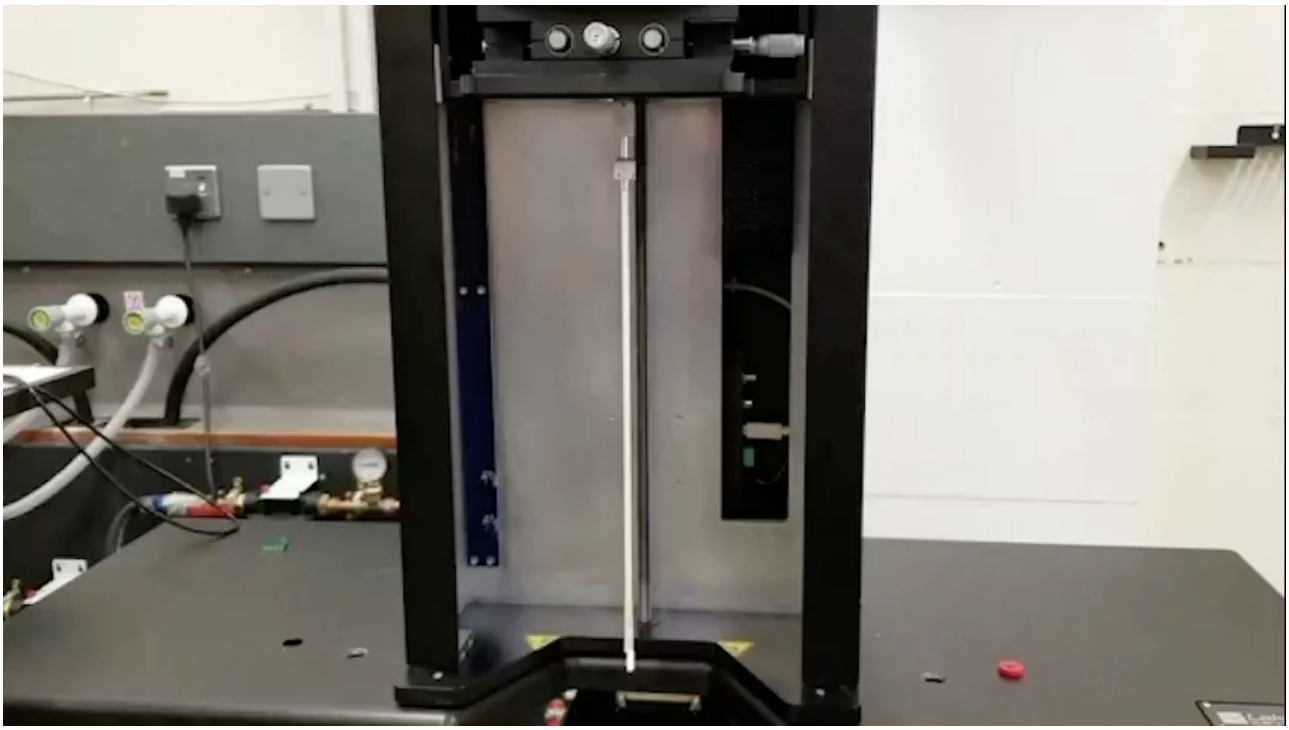
- Magnetic field: < ± 2.76 T
- Field steps: 0.1 mT
- Field accuracy: 1% of reading or ±0.05% of full scale
- Sensitivity: > 15 nemu
- Moment stability: < ± 0.05% of full scale/day for fixed coil geometry at constant field and temperature
- Reproducibility: < ± 0.5% or ±0.1% of full scale, fixed rotation angle and range, with sample replacement
- Accuracy: < ± 1% of reading ±0.2% of full scale with a geometrically identical test sample and calibrant
- Sample rotation steps: 0.1°
- Measurement temperature: 4.2 ~ 450 K
- Temperature steps: 0.001 K
- Temperature stability: < ± 0.2 K
- Sample weight: < 10 g



For further details, see https://www.lakeshore.com/docs/default-source/default-document-library/vsmcatalog8600a4.pdf?sfvrsn=372324de_4

VSM Measurement 1

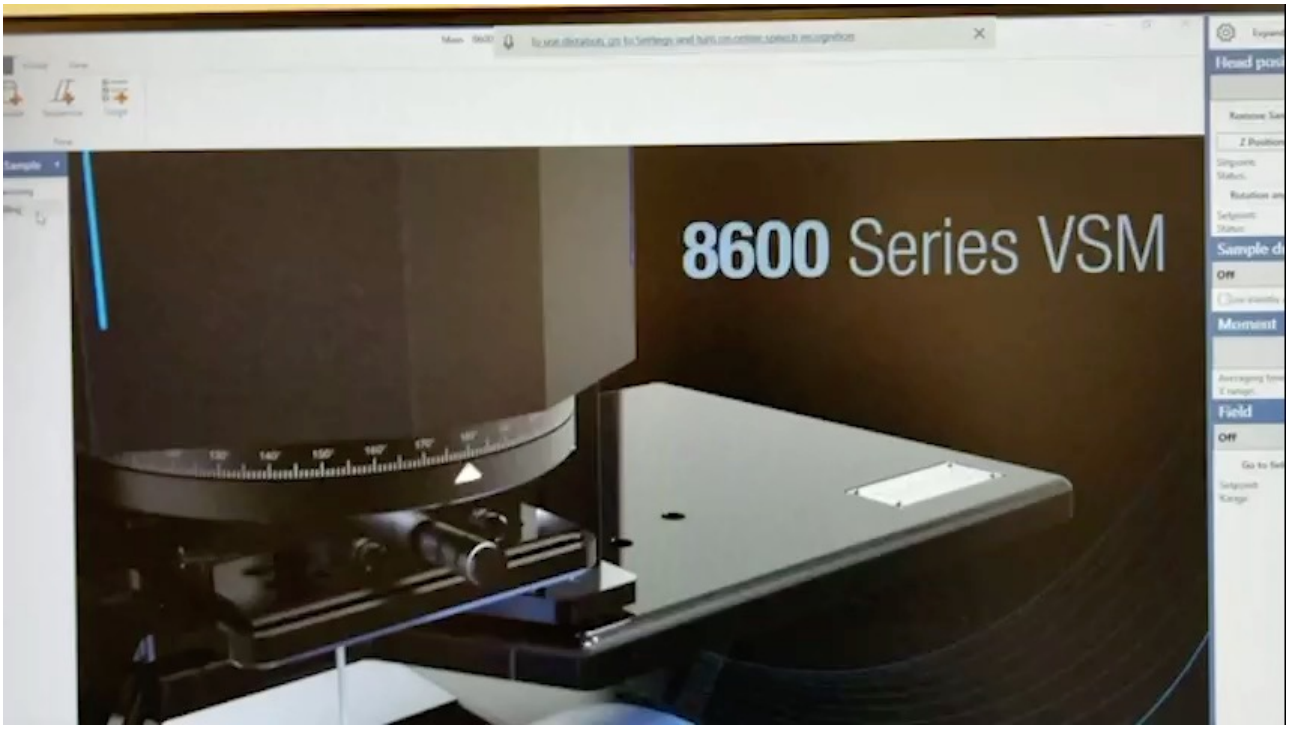
Place a sample on the holder :



Taken by Dr Kelvin Elphick

VSM Measurement 2

Execute a hysteresis loop measurement :

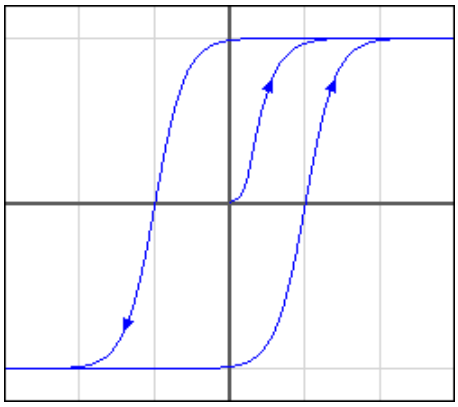


For further details, see https://www.youtube.com/watch?v=tjStr4k5Z6Y

Taken by Dr Kelvin Elphick

VSM Data Analysis

After the demagnetisation correction, the saturation magnetisation of a sample can be estimated in emu (electromagnetic unit).



Saturation magnetisation (M_S)

By taking an optical micrograph(s) of the sample surface, the area of the sample needs to be estimated.

Search the saturation magnetisation of the ferromagnet identified by XRD and obtain the figure in emu/cm^3. See a literature such as https://onlinelibrary.wiley.com/doi/pdf/10.1002/9780470386323.app2

By using the following relationship, estimate the thickness of the total ferromagnetic layers.

$$M_S \text{ in literature } [\text{emu/cm}^3] = \frac{M_S \text{ measured } [\text{emu}]}{\text{area measured } [\text{cm}^2] \times \text{thickness } [\text{cm}]}$$

* http://www.wikipedia.org/