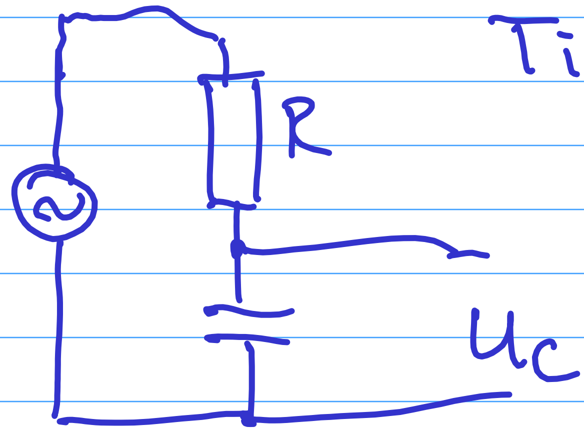
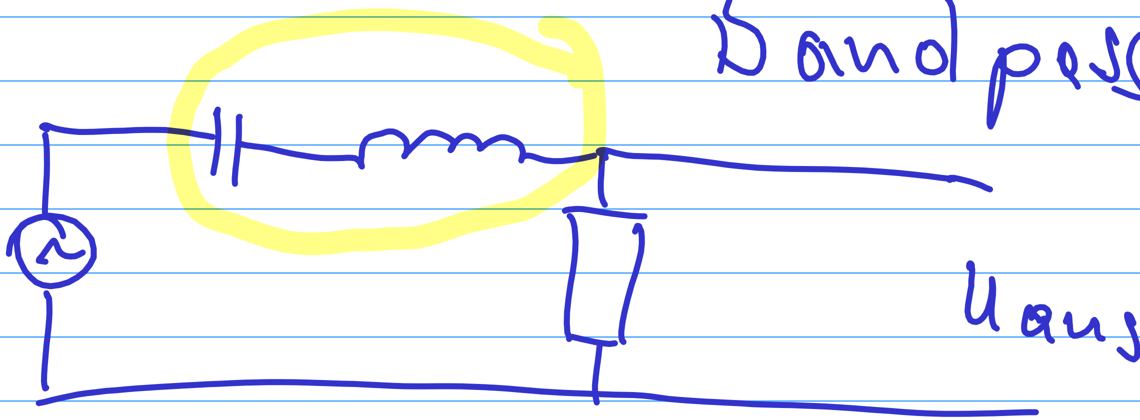
Passive Filter

Impedanzen sind frequenzabh.

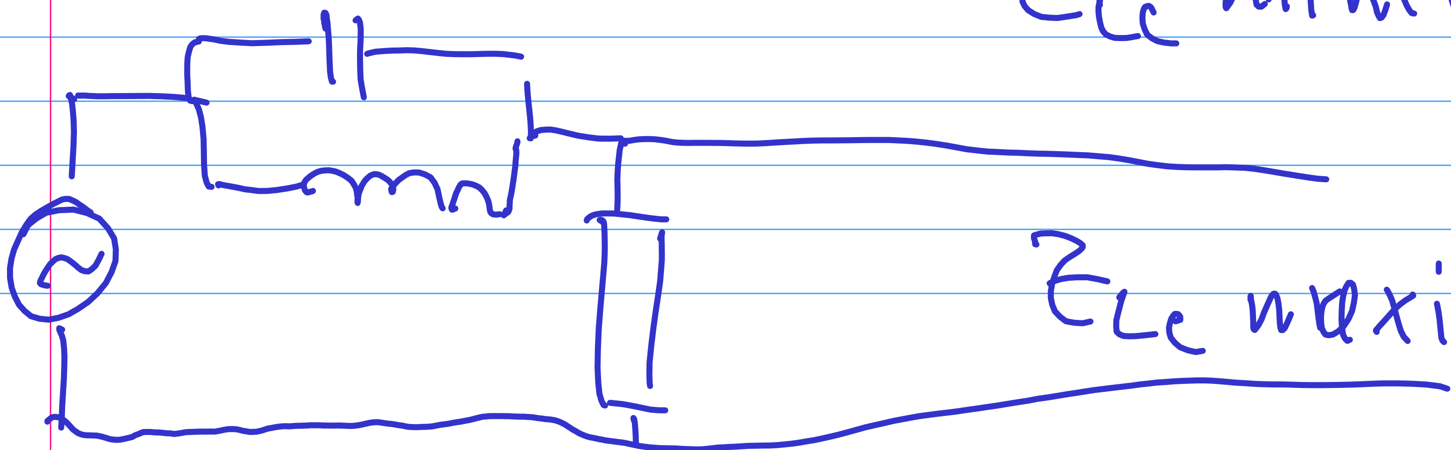
Tiefpass



Bandpass

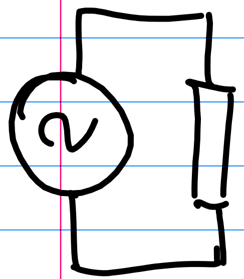


Z_{LC} minimal bei ω_0



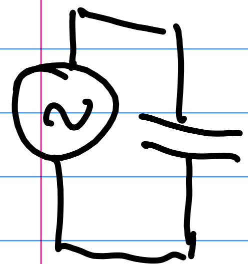
Z_{LC} maximal bei ω_0

Wirk- und Scheinleistung



1. Halbwelle: Strom "hin" → R warm
2. Halbwelle: Strom "rück" → R warm

$P = U I$ Wirkleistung



1. Halbwelle: C laden → Energie gespei.
2. Halbwelle: C entladen → Energie abgabe

→ vor und nach T kein Unterschied

→ keine Wirkleistung

Zeitmittel über T

1) Widerstand

instantane Leistung $P(t) = R \cdot I(t)^2$

$I = I_0 \sin(\omega t)$

$\Rightarrow P = I_0^2 \sin^2(\omega t)\, R$

Zeitmittel: $\overline{P} = \frac{1}{T} \int_0^T dt\, P(t) = \frac{1}{T} \int_0^T dt\, R I_0^2 \sin^2\left(\frac{2\pi}{T} t\right)$

$= \frac{1}{2} I_0^2 R = \left(\frac{I_0}{\sqrt{2}}\right)^2 R = I_{eff}^2 R$

$\frac{I_0}{\sqrt{2}} = I_{eff}$ Effektivwert

Phasendifferenz φ zw. U und I

$$U = U_0 \cos(\omega t) \qquad I = I_0 \cos(\omega t + \varphi)$$

$$\overline{P} = \frac{1}{T}\int_0^T dt\, P(t) = \frac{U_0 I_0}{T}\int_0^T dt \cos(\omega t)\cos(\omega t + \varphi)$$

$$= \frac{U_0 I_0}{T}\Big[\underbrace{\int_0^T dt \cos^2(\omega t)\cos\varphi}_{\frac{T}{2}\cos\varphi} - \underbrace{\int_0^T dt \cos(\omega t)\sin(\omega t)\sin\varphi}_{0}\Big]$$

$$= \frac{U_0}{\sqrt{2}}\frac{I_0}{\sqrt{2}}\cos\varphi = \boxed{U_{eff}\cdot I_{eff}\cdot\cos\varphi = \overline{P}}$$

$\overline{P_C} = \overline{P_L} = 0$

Wirkleistung $P_W = U_{eff} \cdot I_{eff} \cos\varphi$

Blindleistung $P_B = U_{eff} I_{eff} \sin\varphi$

Scheinleistung (Richtleistung) $P_S = U_{eff} I_{eff} = \sqrt{P_W^2 + P_B^2}$

Fragen RLC

Ind.

Three electric vectors

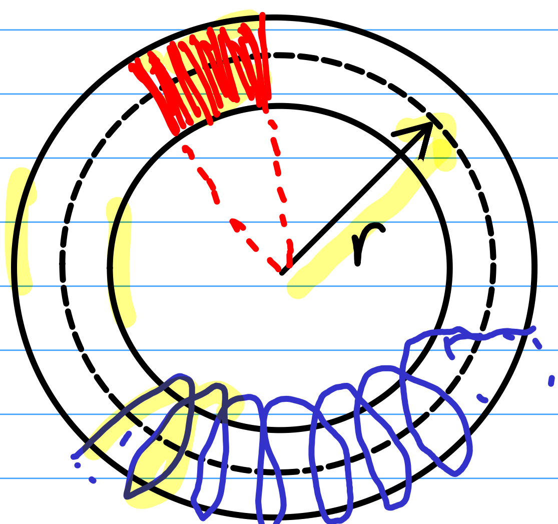
Name	Symbol	Associated with	Boundary Condition
Electric field	**E**	All charges	Tangential component continuous
Electric displacement	**D**	Free charges only	Normal component continuous
Polarization (electric dipole moment per unit volume)	**P**	Polarization charges only	Vanishes in a vacuum

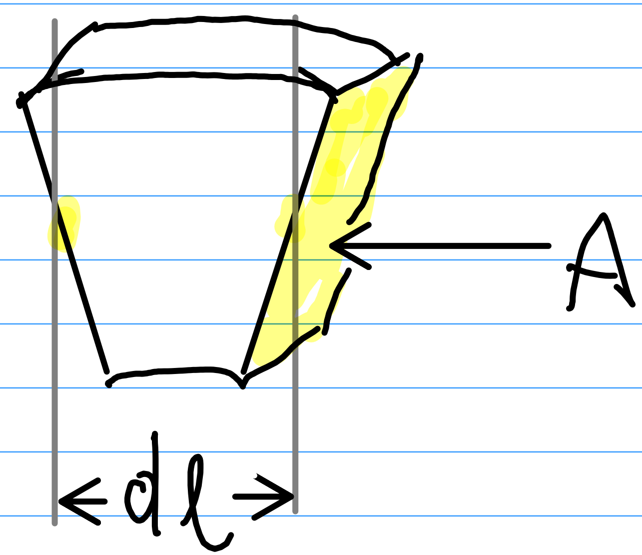
Defining equation for **E**	$\mathbf{F} = q\mathbf{E}$
General relation among the three vectors	$\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P}$
Gauss's law when dielectric media are present	$\oint \mathbf{D} \cdot d\mathbf{S} = q$ (q = free charge only)
Empirical relations for certain dielectric materials*	$\mathbf{D} = \kappa\epsilon_0\mathbf{E}$ $\mathbf{P} = (\kappa - 1)\epsilon_0\mathbf{E}$

ε

Drei magnetische Feldvektoren

$\vec{B}_0 \rightarrow$ Magnetisierung $\vec{M} \rightarrow \vec{H}$





Ampère, Kreis mit Radius r, ohne Fe

$$\int \vec{B}_0 d\vec{l} = B_0 2\pi r = N \mu_0 i_0$$

i_0 ← Spulenstrom

N ← Windungszahl

Mit Fe: $B > B_0$ → hypoth. Strom i_M

$$\oint \vec{B} d\vec{l} = \mu_0 (i_0 + i_M)$$

$$B 2\pi r = \mu_0 N i_0 + \mu_0 N i_M \quad (*)$$

Zu i_M gehört Dipolmoment:

$$\vec{m} = N i_M A$$

Segment mit Länge dl

$$d\vec{\mu} = \vec{M} A\, dl$$

$$= \vec{\mu} \frac{dl}{2\pi r} = \frac{dl}{2\pi r} N i_m A$$

$$\Rightarrow N i_m = M\, 2\pi r \quad ; \quad \text{in } (*) \Rightarrow$$

$$B\, 2\pi r = \mu_0 \underbrace{N i_0} + \mu_0 2\pi r M$$

$$\oint \vec{B}\, d\vec{l} = \underbrace{\mu_0 I}_{\text{"Ampère"}} + \underbrace{\mu_0 \oint \vec{M}\, d\vec{l}}_{\text{"Strom"}} \qquad (**)$$

$$\vec{H} := \left(\vec{B} - \mu_0 \vec{M}\right)\frac{1}{\mu_0} = \frac{1}{\mu_0}\vec{B} - \vec{M}$$

$$\Leftrightarrow \vec{B} = \mu_0\left(\vec{H} + \vec{M}\right) \quad ; \text{ in } (**)$$

$$\Rightarrow \oint \vec{H}\, d\vec{l} = I \quad ; \quad I = \text{freier Strom}$$

Im Vakuum: $H_0 = B_0 / \mu_0$

manche Materialien

$$M = \underbrace{\chi_M}_{\text{magn. Suszeptibilität}} H$$

$$\Rightarrow B = \mu_0 (H + M) = \mu_0 \underbrace{(1 + \chi_M)}_{} H$$

$$= \mu_0 \; \mu_R \; H$$

↑ Permeabilitäts-zahl

"manche"?

diamagnetisch

paramagnetisch

weichmagnetisch

---

nicht: ferromagnetisch

Three magnetic vectors

Name	Symbol	Associated with	Boundary Condition
magnetic field	**B**	All currents	Normal component continuous
magnetizing field	**H**	True currents only	Tangential component continuous†
Magnetization (magnetic dipole moment per unit volume)	**M**	"Magnetization currents" only	Vanishes in a vacuum

Defining equations for **B** $\quad \mathbf{F} = q\mathbf{v} \times \mathbf{B}$

or $\quad = i\mathbf{l} \times \mathbf{B}$

General relation among the three vectors $\quad \mathbf{B} = \mu_0\mathbf{H} + \mu_0\mathbf{M}$

Ampère's law when magnetic materials are present $\quad \oint \mathbf{H}\cdot d\mathbf{l} = i$

(i = true current only)

Empirical relations for certain magnetic materials** $\quad \mathbf{B} = \kappa_m\mu_0\mathbf{H}$

$$\mathbf{M} = \underbrace{(\kappa_m - 1)}_{\chi_m}\mathbf{H}$$

Klassen magnetischer Materialien

diamagnetisch – verdrängt aus $\vec{B}$

paramagnetisch – Zug ins Feld

ferromagnetisch – permanentes magn. Moment

Magnetische Suszeptibilitäten

χ_m

He	-9.85×10^{-10}	dia.
H_2O	-9.04×10^{-6}	
Ag	-2.31×10^{-5}	
O_2	$+3.73 \times 10^{-7}$	para..
Al	$+2.2 \times 10^{-5}$	

Beachte: $\mu_r = 1 + \chi_m$

Ursache von Magnetismus?

Elektronen!

Bahnbewegung $\hat{=}$ Kreisstrom

$\Rightarrow$ magn. Dipol

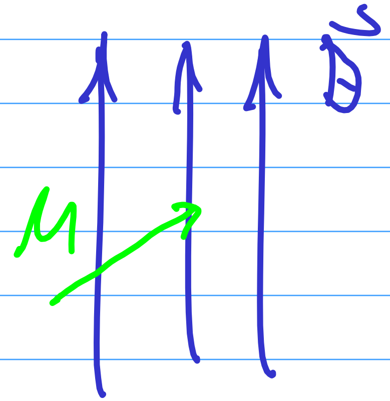
$\mu_{Bahn} = i\,A \qquad A = \pi r^2 \quad (r = \text{Bahnradius})$

$$i = \frac{-e}{2\pi r / v}$$

$$\mu_{Bahn} = -\frac{ev}{2\pi r}\,\pi r^2 = -\frac{1}{2}\,e\,v\,r$$

$$\vec{L} = m\,\vec{r} \times \vec{v} \Rightarrow L = m\,r\,v \Rightarrow \vec{\mu}_{Bahn} = -\frac{1}{2}\frac{e}{m}\vec{L}$$

Diamagnet: Lenz Regel → $\vec{\mu}$ abgestoßen in äußerem $\vec{B}$



Paramagnet:

$$U = -\vec{\mu}\vec{B} \rightsquigarrow \vec{F} = -\vec{\nabla} U$$
$$= \mu \vec{\nabla} B$$

$$\Delta U = \mu B(\cos 180^\circ - \cos 0^\circ)$$
$$= 2\mu B = 10^{-4}\,\mathrm{eV}/T$$

μ ↑ "Bohr Magneton"

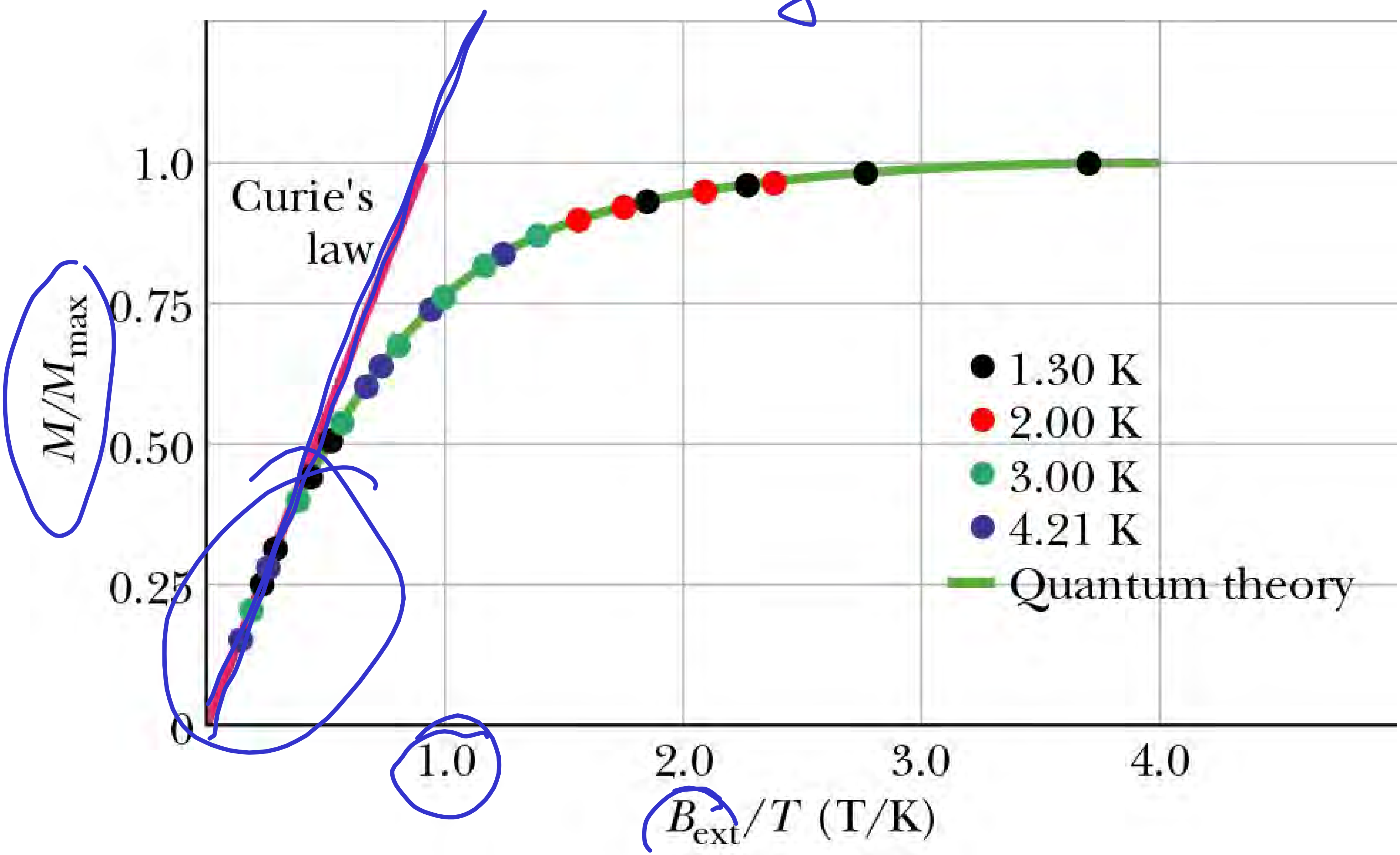
$\approx 300\,K$

$\approx \frac{1}{40}\,\mathrm{eV}$

Eigendrehimpuls: Spin $\vec{S}$

$$\vec{\mu}_{spin} = -\frac{e}{m}\vec{S}$$

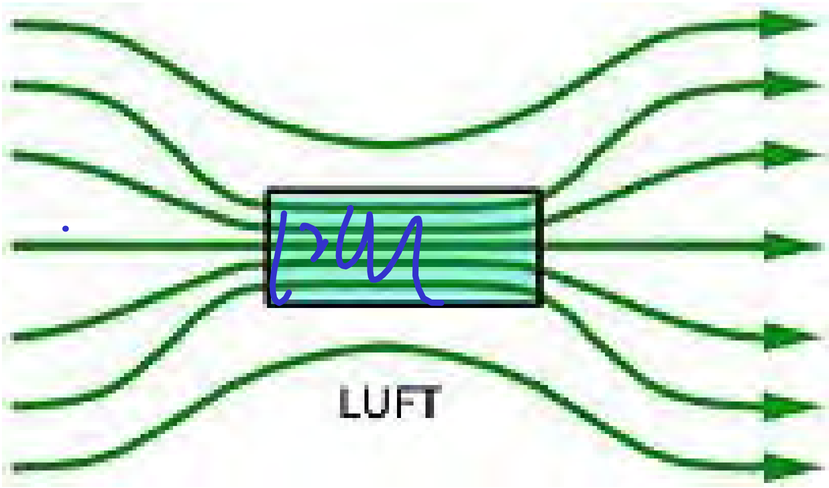
Paramagnet



Halliday, 32-9

Curietemperatur

Three solid steel ball bearings (spheres) easily suspended by miniscule neodymium magnets. The lowest sphere is 3.63cm in diameter (196.1g), and is being held up by a NIB disk magnet 4mm in diameter by 1.5mm thick (0.143g). Such magnets can easily lift thousands of times their own mass.



Große Permeabilität:

''Eisen leitet die Feldlinien besser als Luft''

http://www.phyta.net/h-feld4.htm

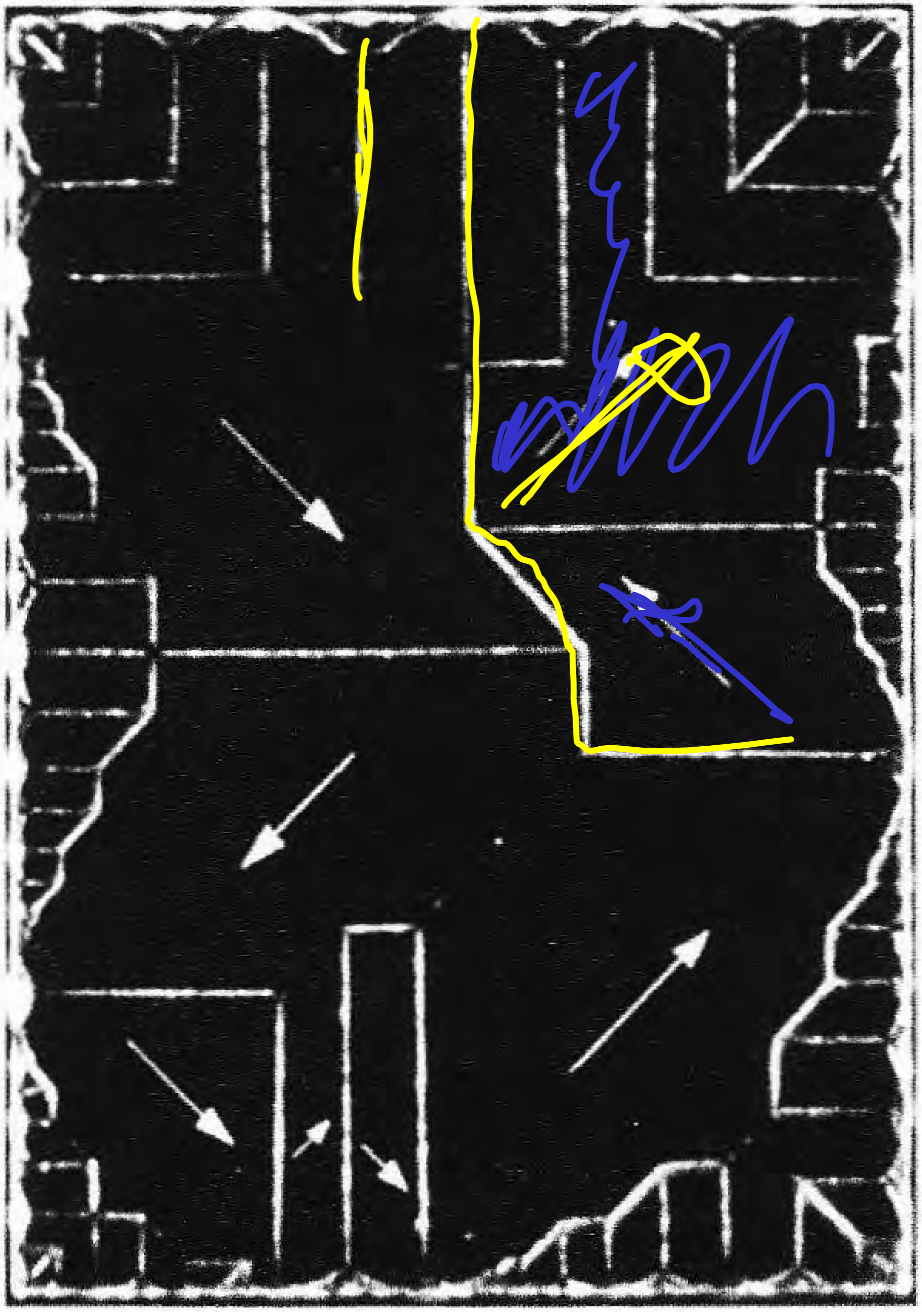
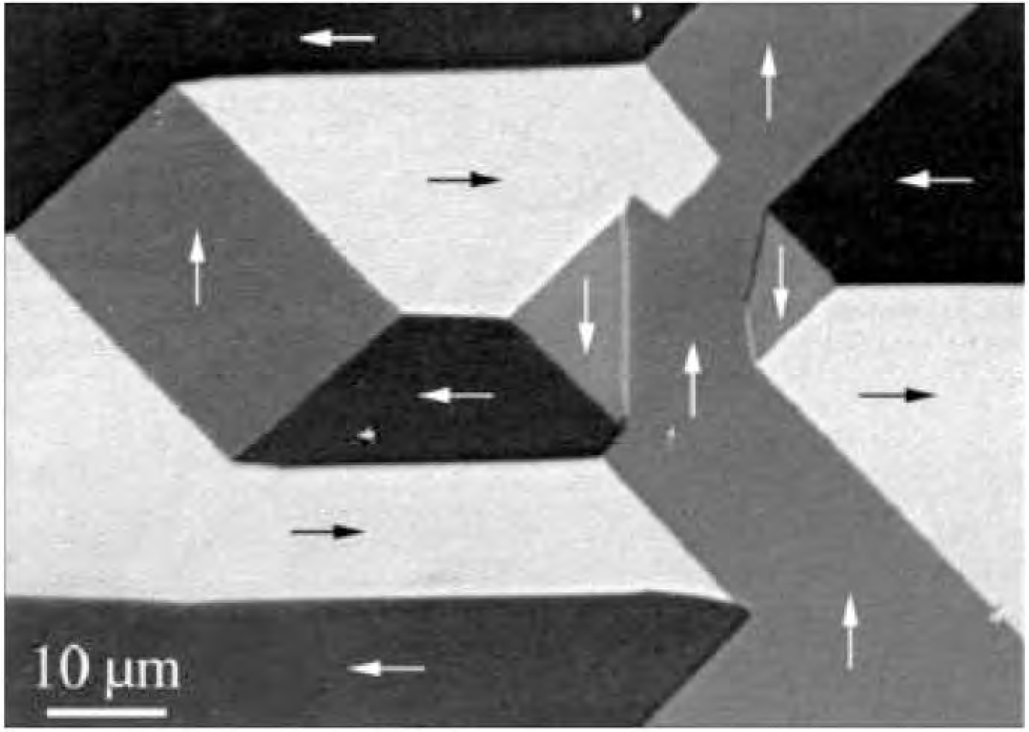


Abb. 32-12
Eine Fotografie der Domänengrenzen an der Oberfläche eines Nickel-Einkristalls. Die eingezeichneten weißen Pfeile zeigen die Orientierungen der magnetischen Dipole in den Domänen und damit die Orientierung der resultierenden magnetischen Dipole der Domänen. Der Kristall als Ganzes ist nicht magnetisiert, wenn die Vektorsumme der magnetischen Dipole aller Domänen null ergibt.

Halliday, 32-12

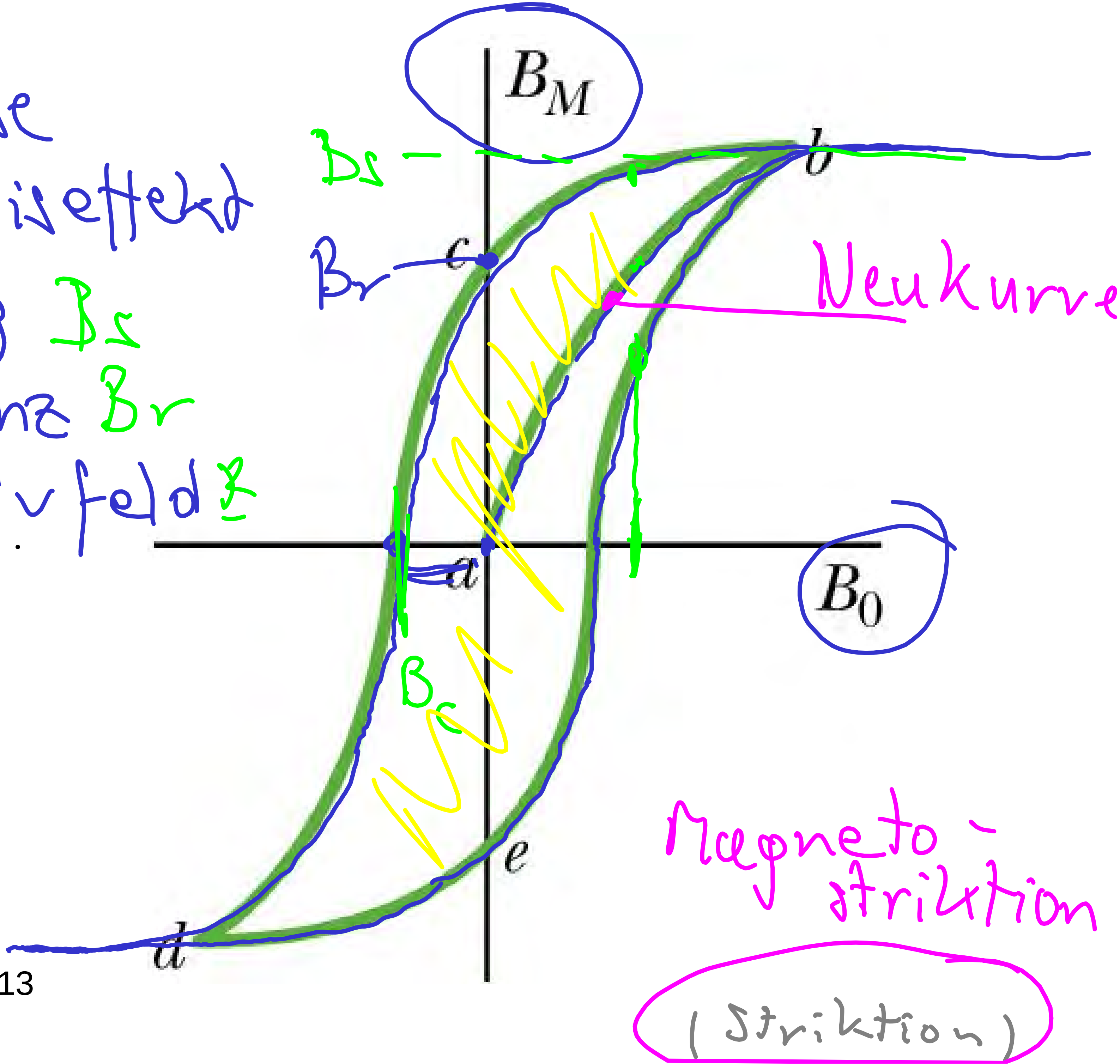
domains on (100)-FeSi sheet



transversal

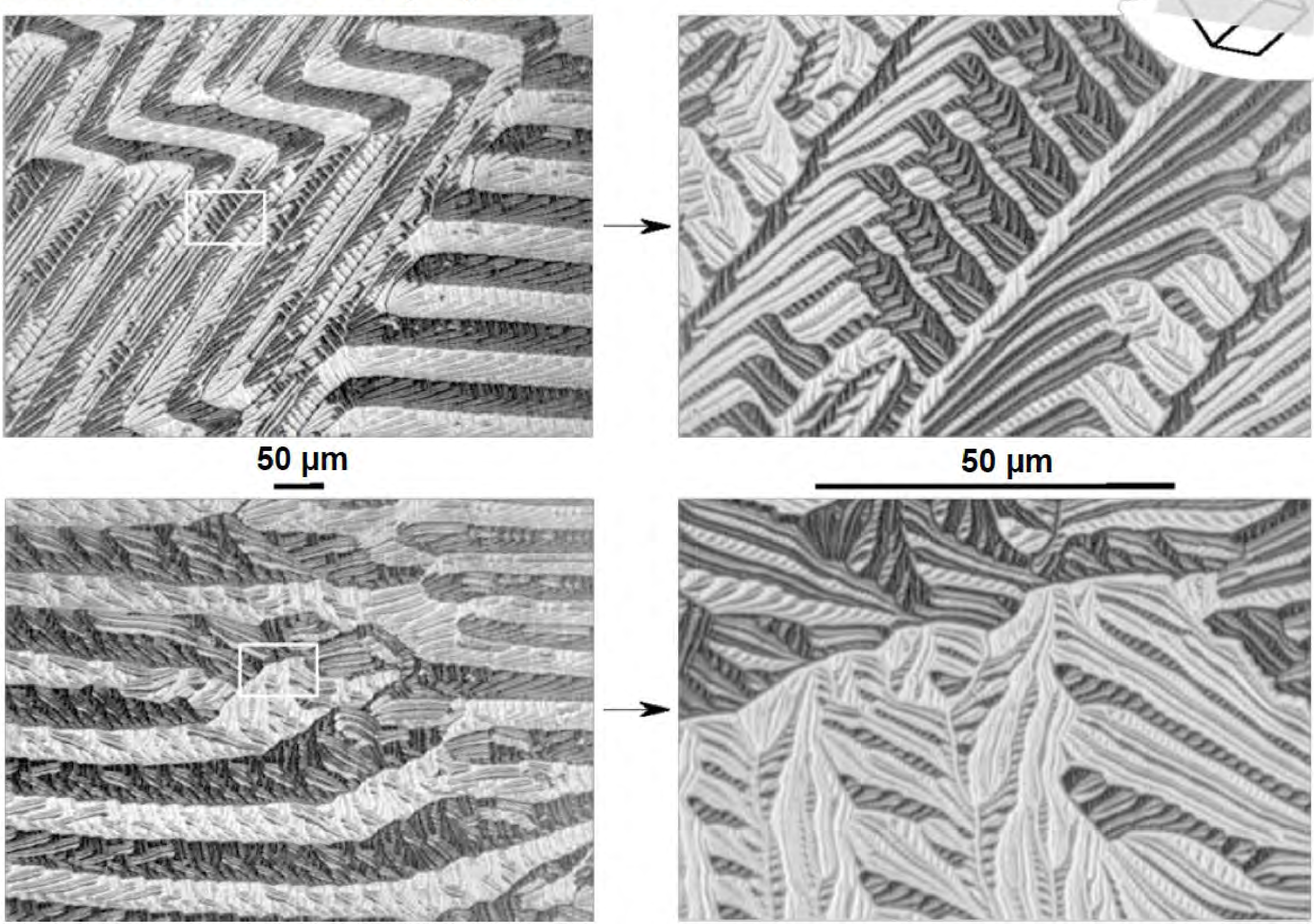
Aus Vortrag „Introduction to Magnetic Imaging“ von Rudolf Schäfer, IFW-Dresden

Hysterese
Gedächtniseffekt
Sättigung B_S
Remanenz B_r
Koerzitivfeld B_c

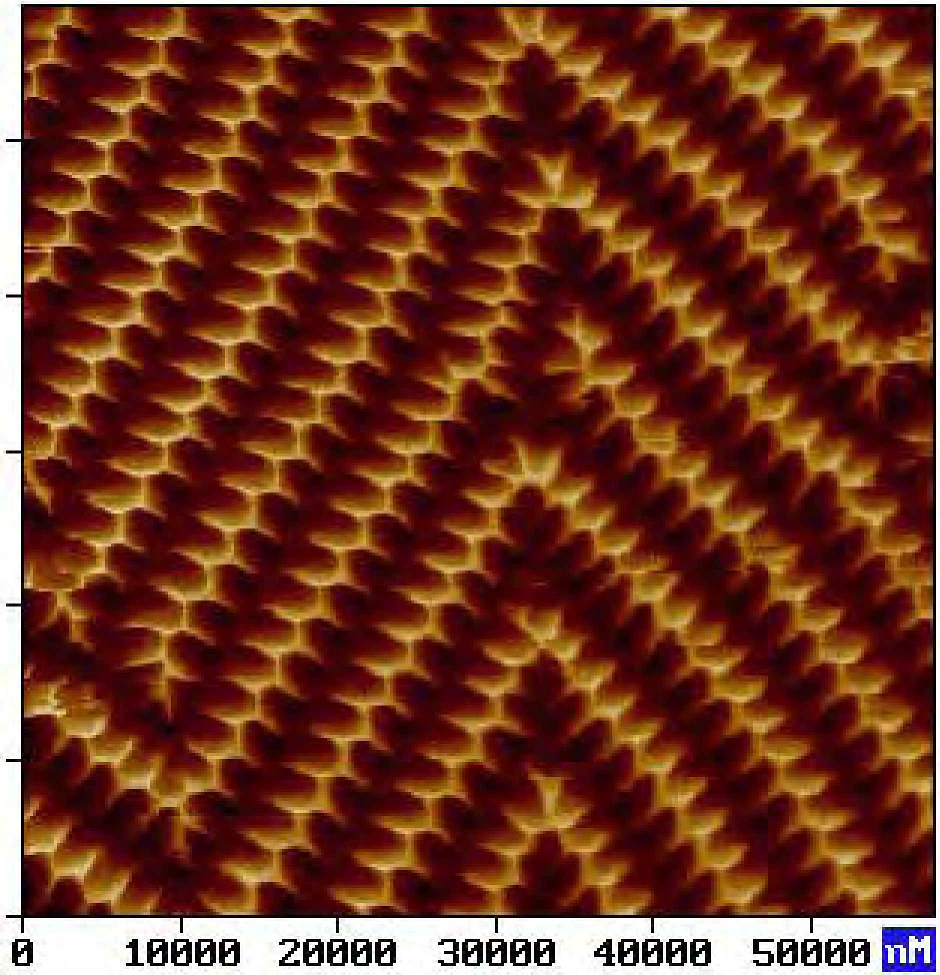


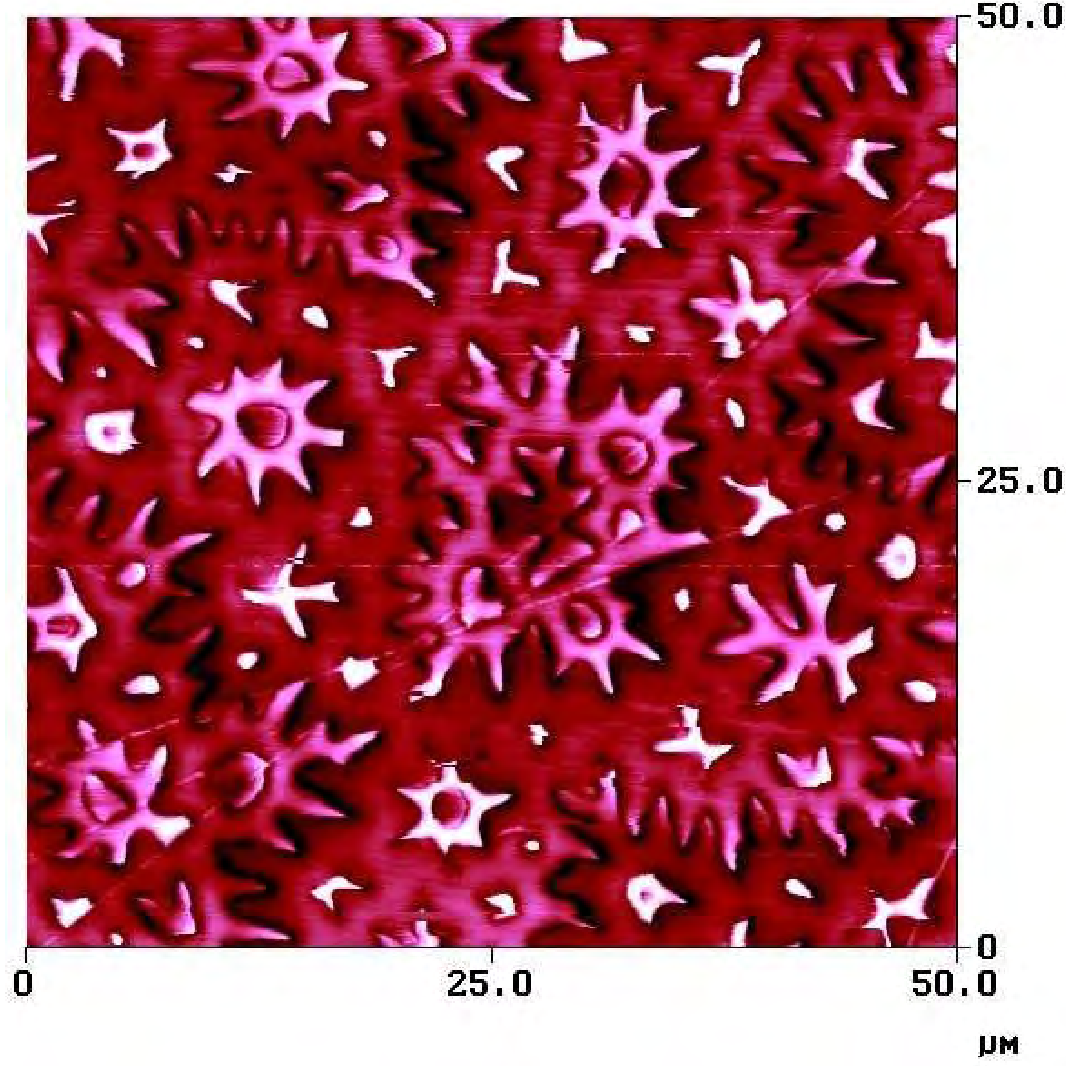
Halliday, 32-13

Branched domains on Fe (111) surface



Aus Vortrag „Introduction to Magnetic Imaging“ von Rudolf Schäfer, IFW-Dresden



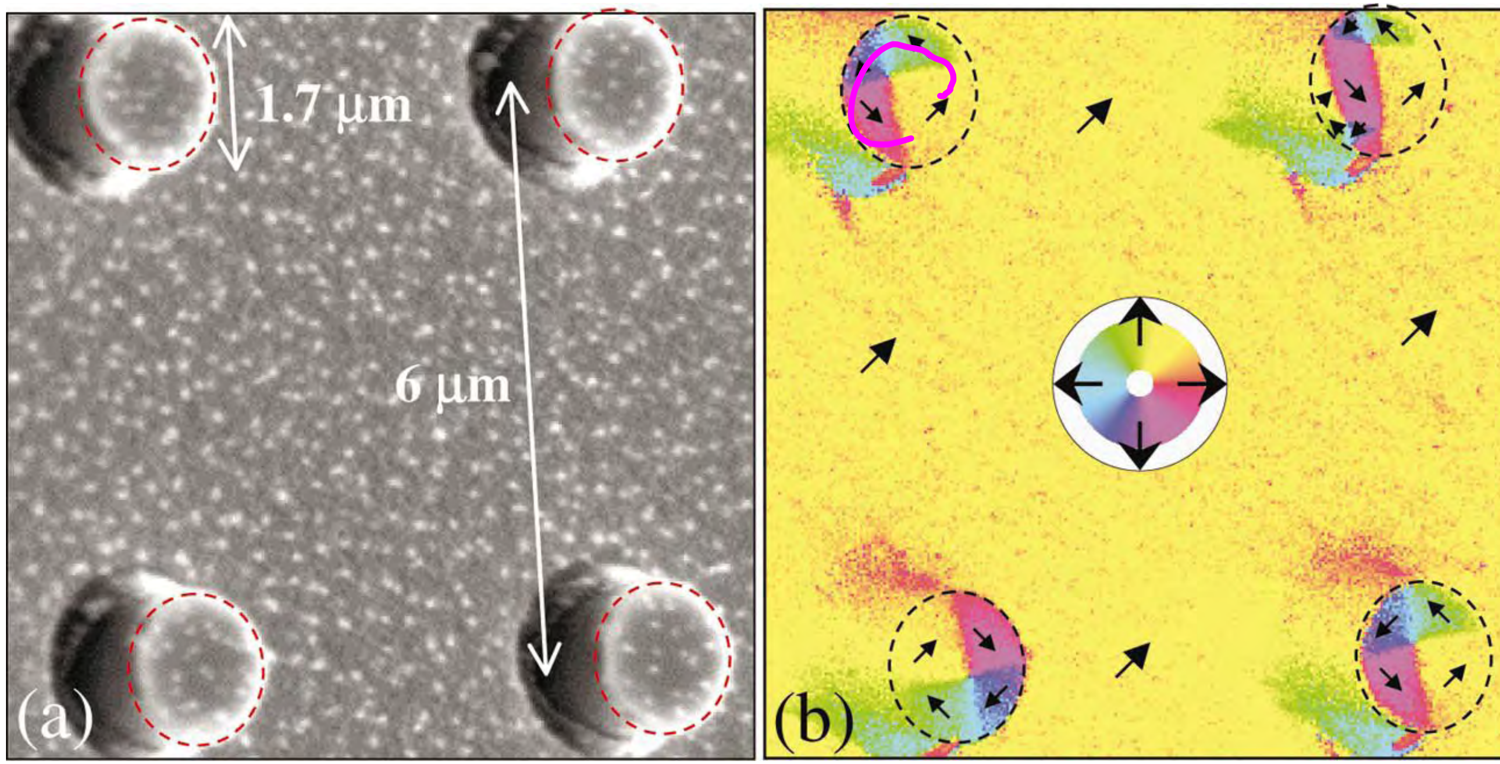


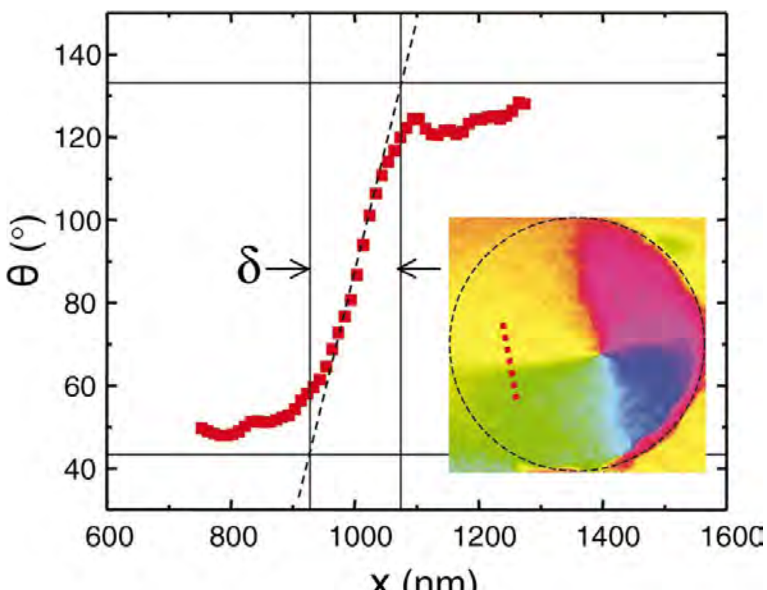
Different complex domain structures of inhomogenious film of Yttrium Iron Garnet (YIG). YIG film has substantial variation of anisotropy field across the film thickness. Mode: Magnetic Force Microscopy (MFM) Image courtesy of A.G. Temiryazev and M.P. Tikhomirova, Institute of Radioengineering & Electronics RAS, Fryazino, Russia.

Magnetic domain structure of a BaFe12O19 single crystal imaged with the Magnetic Force Microscope. (Fraunhofer)

Co disks

Topograph SEMPA image



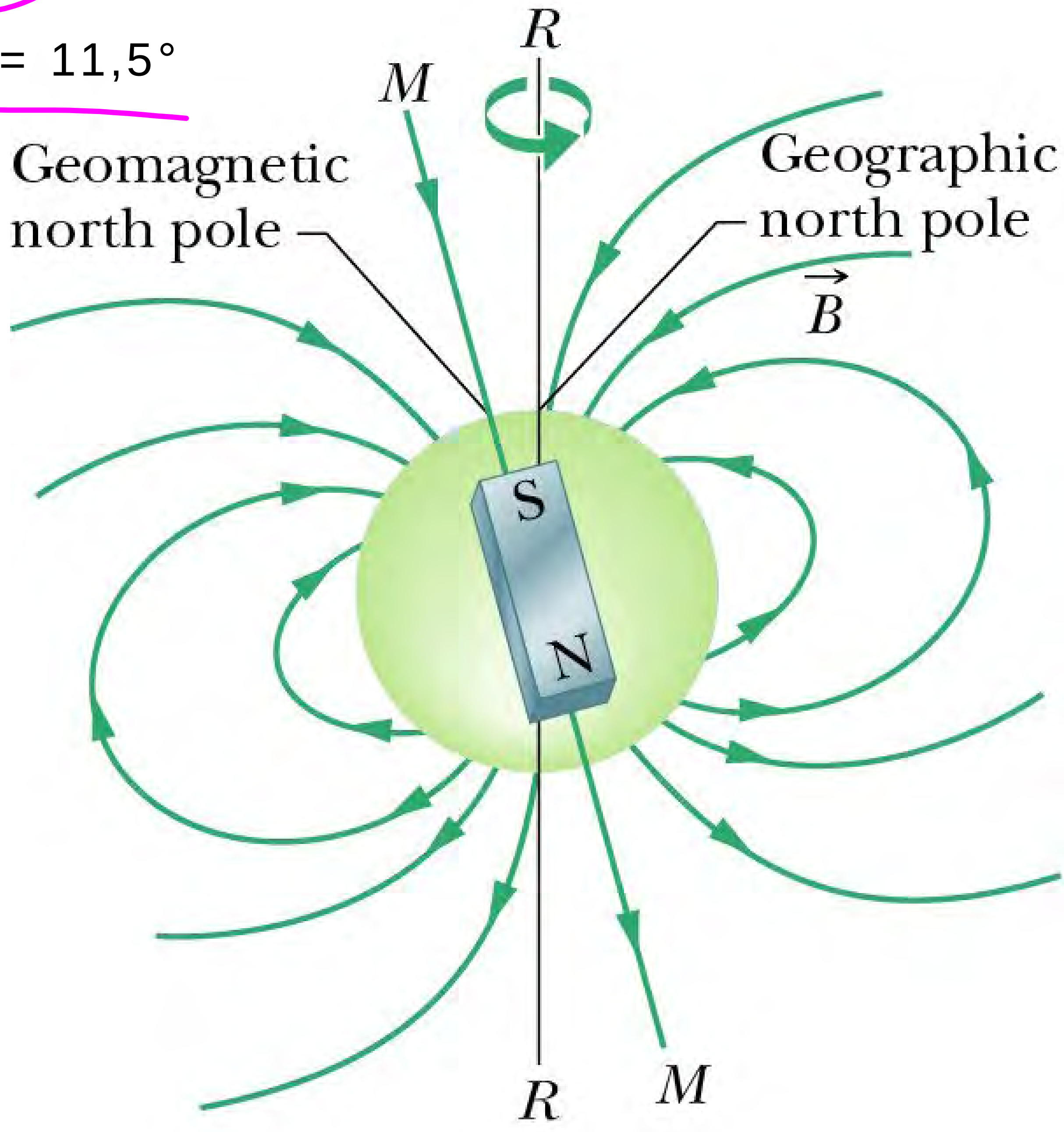


Remanent magnetic states in epitaxial fcc Co small disks

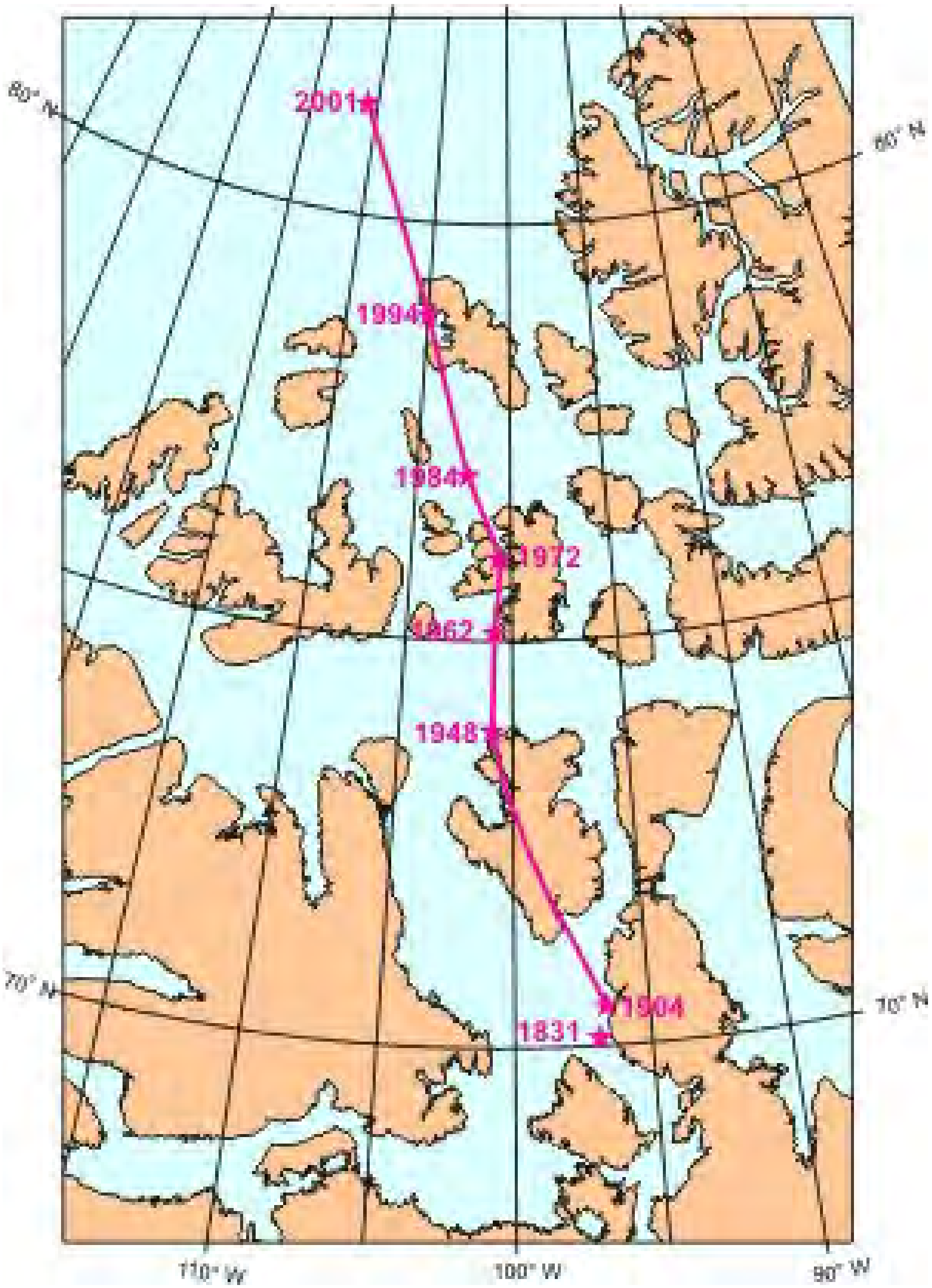
C. A. F. Vaz et al., Phys. Rev. B, **67**, 140405 (2003)

$\mu = 8\cdot10^{22}$ J/T

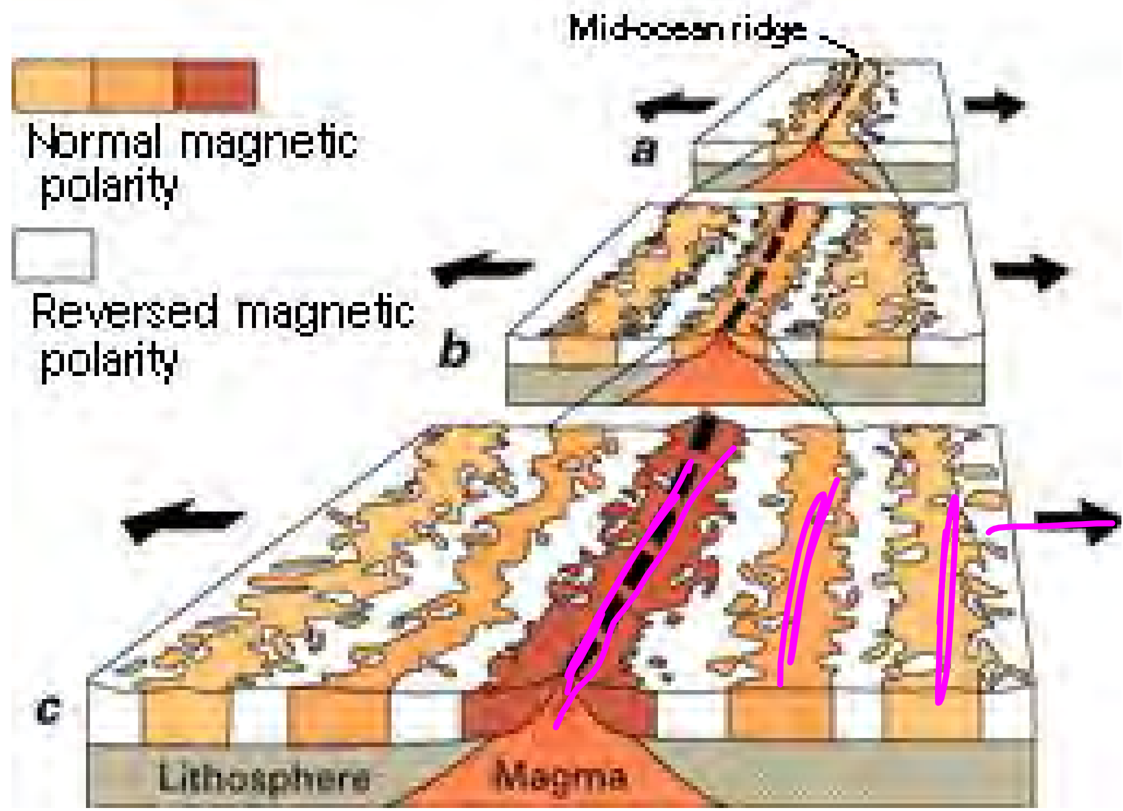
Winkel (M,R) = 11,5°



Halliday, 32-4



The movement of Earth's north magnetic pole across the Canadian arctic, 1831–2001.
Credit: Geological Survey of Canada.



Magnetic stripes around mid-ocean ridges reveal the history of Earth's magnetic field for millions of years. The study of Earth's past magnetism is called paleomagnetism.
Image credit: USGS