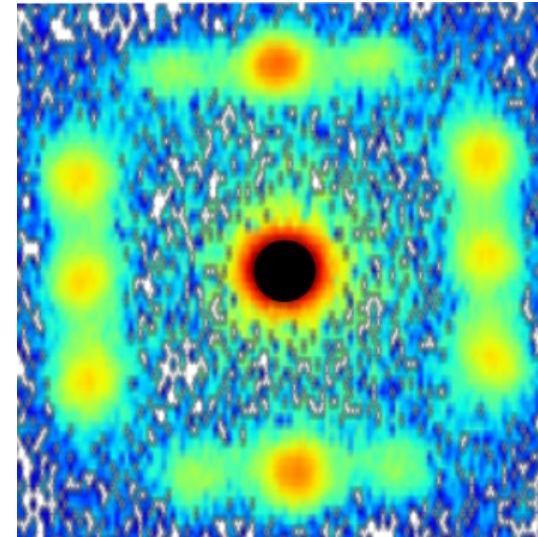
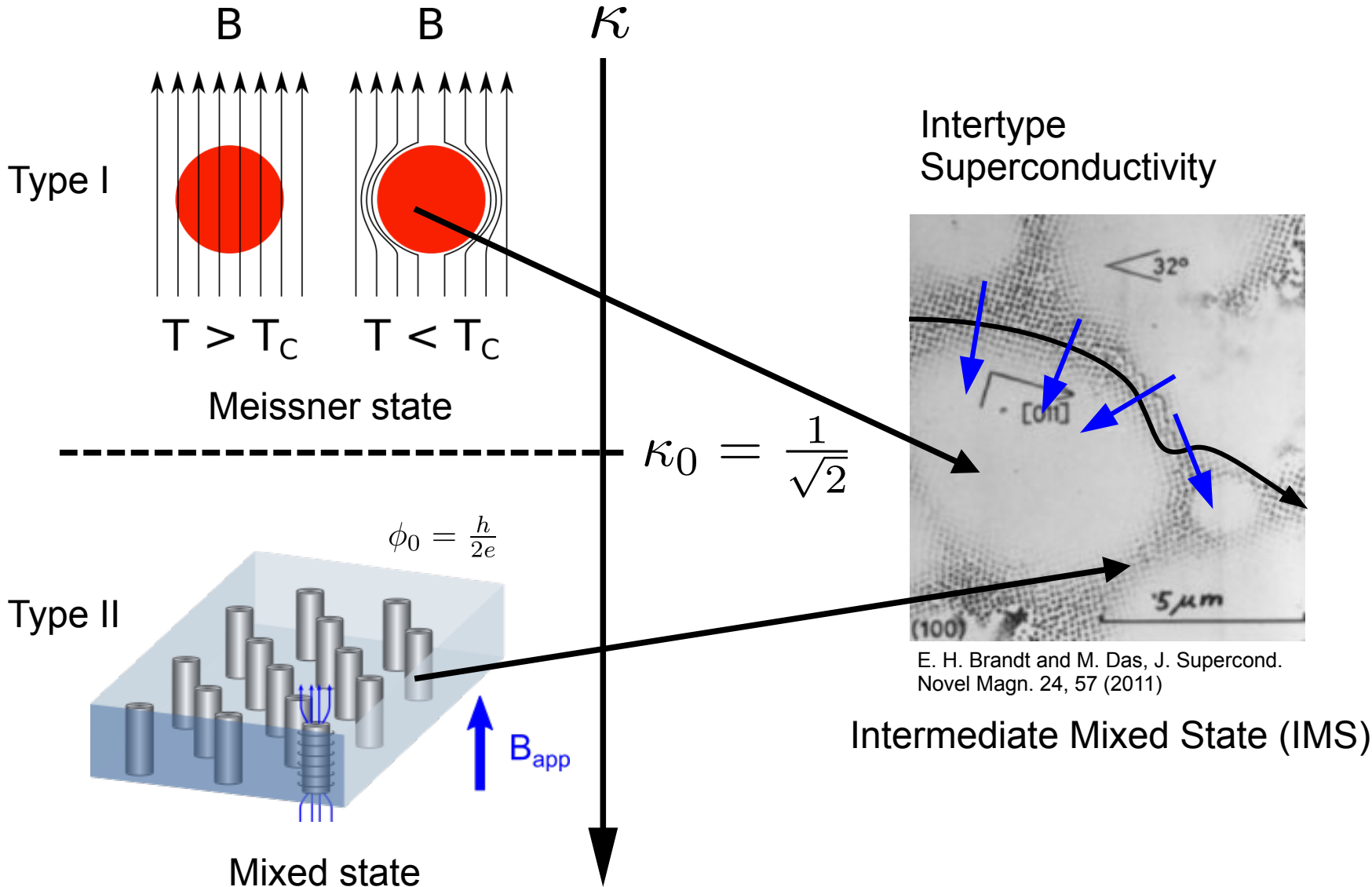


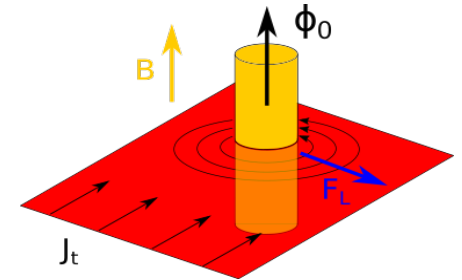
Vortex Matter Transport Phenomena of the Intermediate Mixed State

Xaver Simon Brems
ESS/ILL user meeting 2022
7 October 2022
Lund, Sweden





Apply current ?



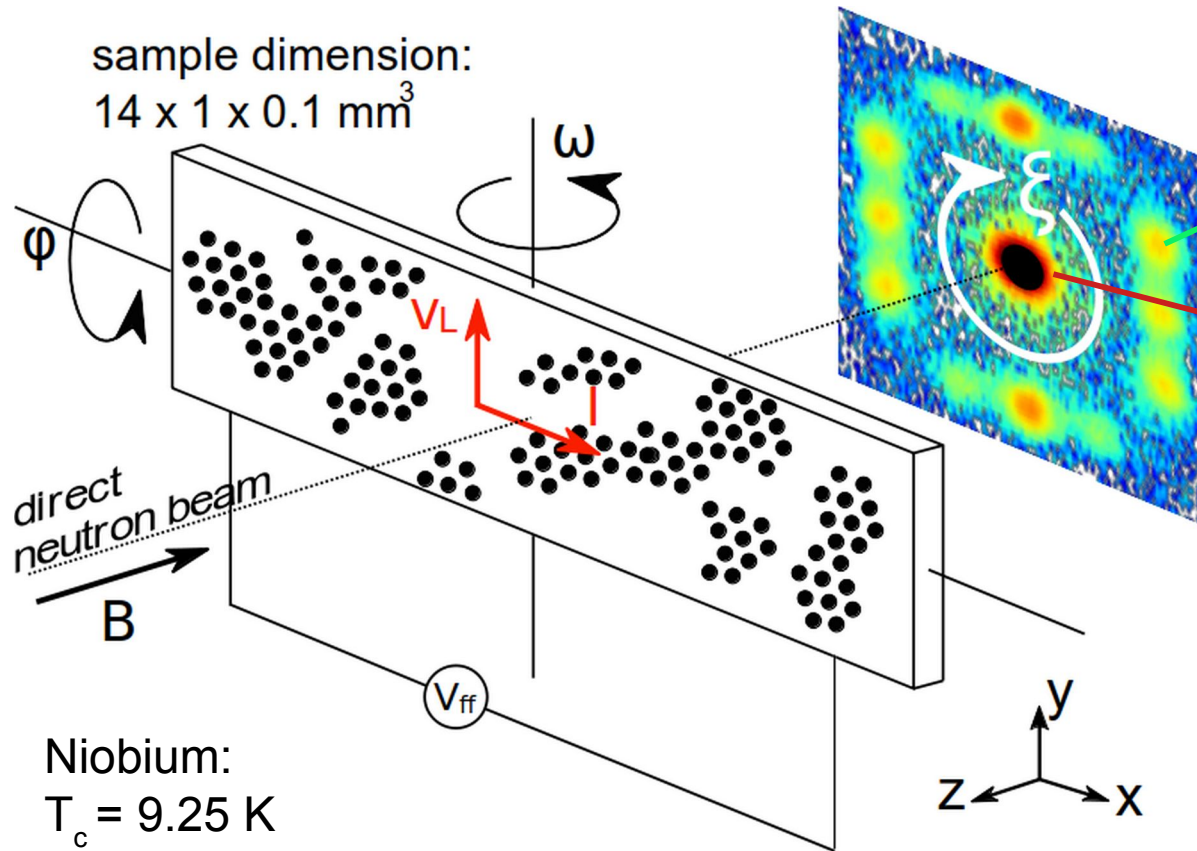
Lorentz force (orthogonal)

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$$

No current where $B = 0$

Results from combined SANS and Transport Measurements Institut Laue-Langevin: D33

'Large' magnetic structures ($100\text{nm} < d < 10\mu\text{m}$) \longrightarrow Small angle neutron scattering ($0.01^\circ < 2\theta < 1^\circ$)



Bragg peak scattering from vortex lattice structure

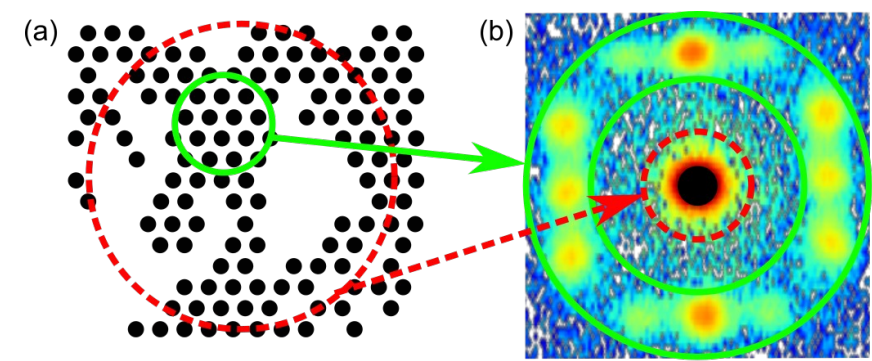
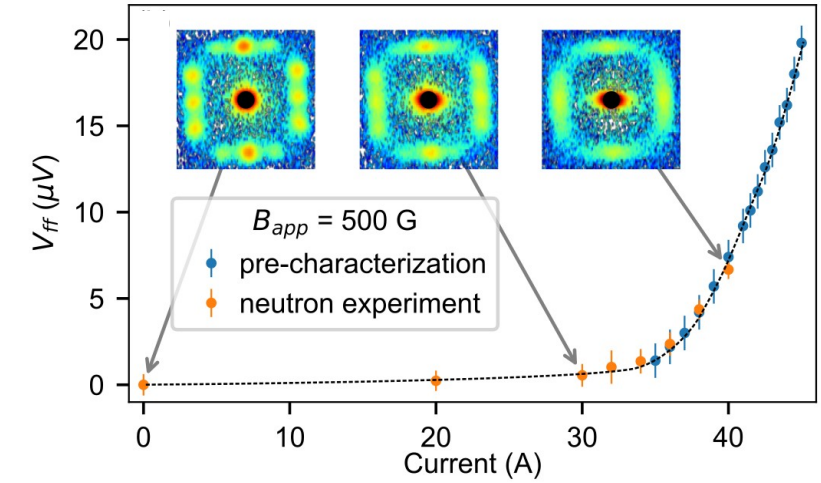
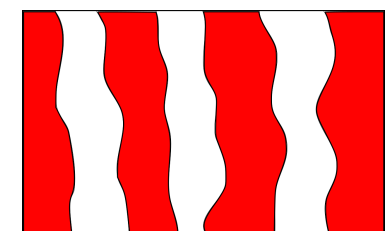
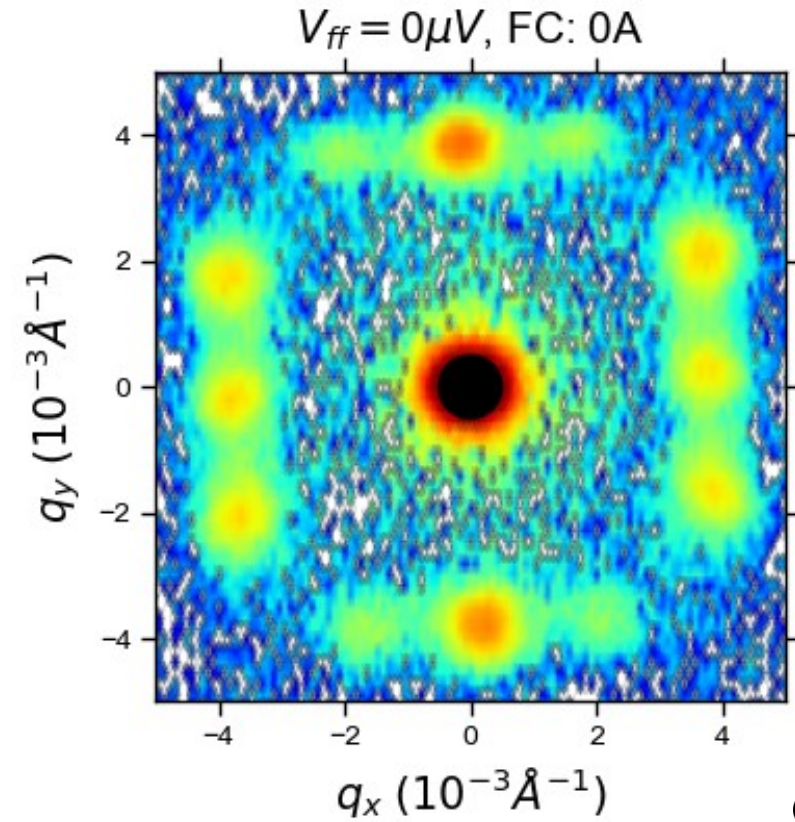
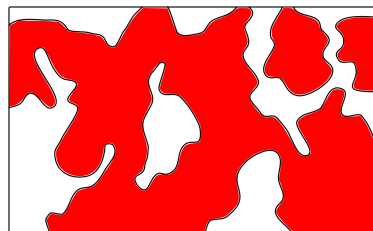
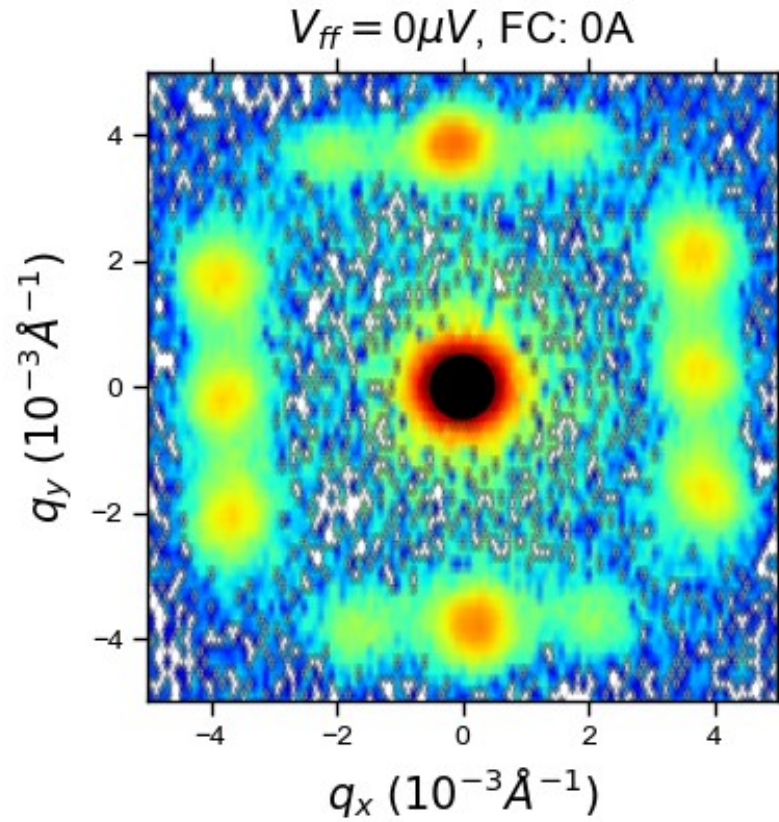
Diffuse power law scattering (IMS domain structure)

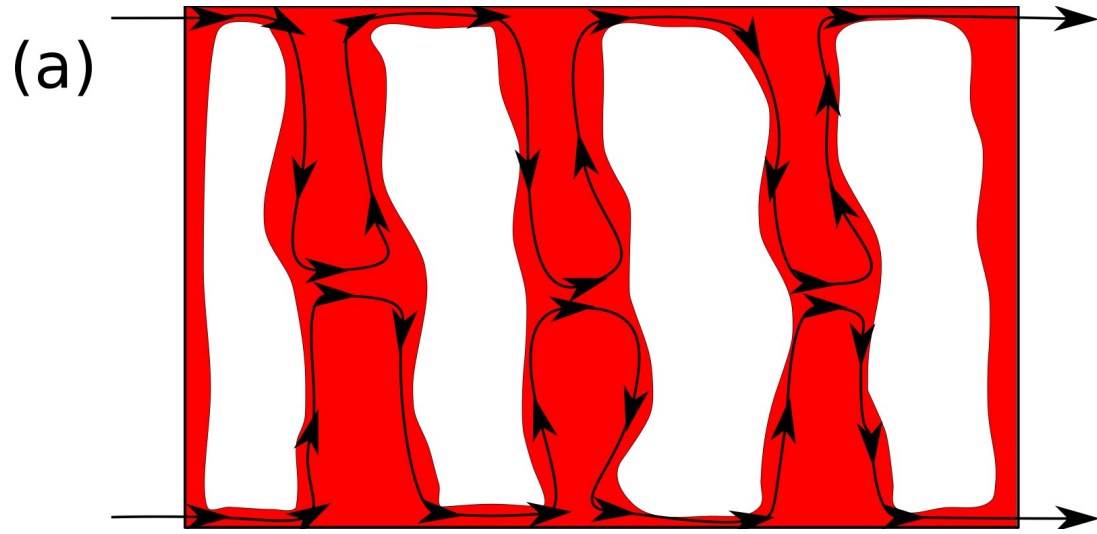
Very challenging experiment:

- Current (up to 50 A)
- Sample in li Helium ($T = 4\text{K}$)
- Magnetic field
- Small sample ($14 \times 1 \times 0.1 \text{ mm}^3$)

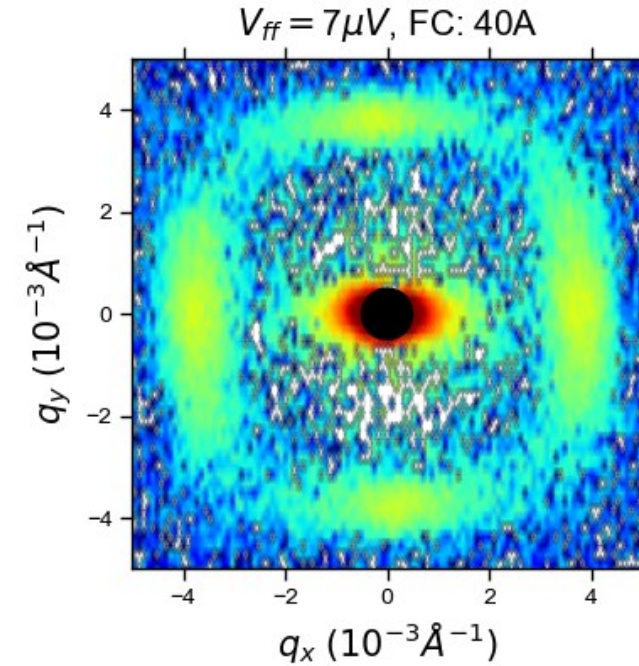
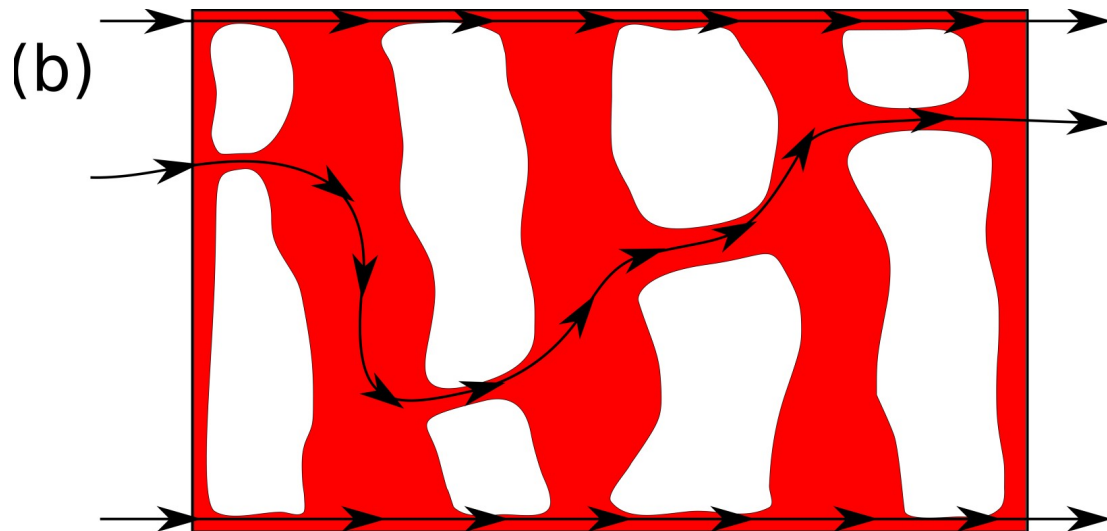
Niobium:
 $T_c = 9.25 \text{ K}$
 $\kappa = 0.78$

Xaver S Brems et al. Supercond. Sci. Technol. 35, 035003 (2022)





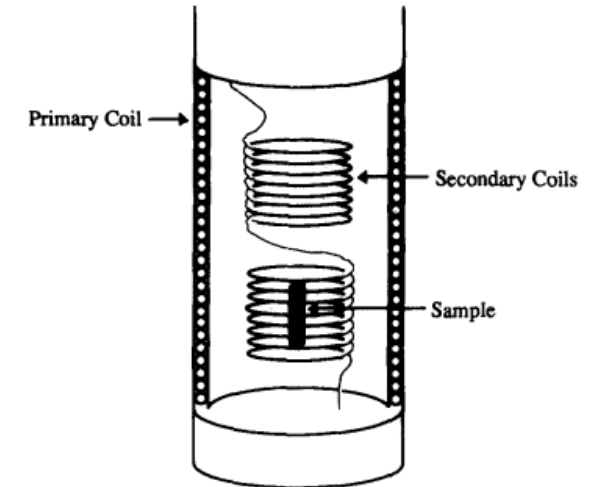
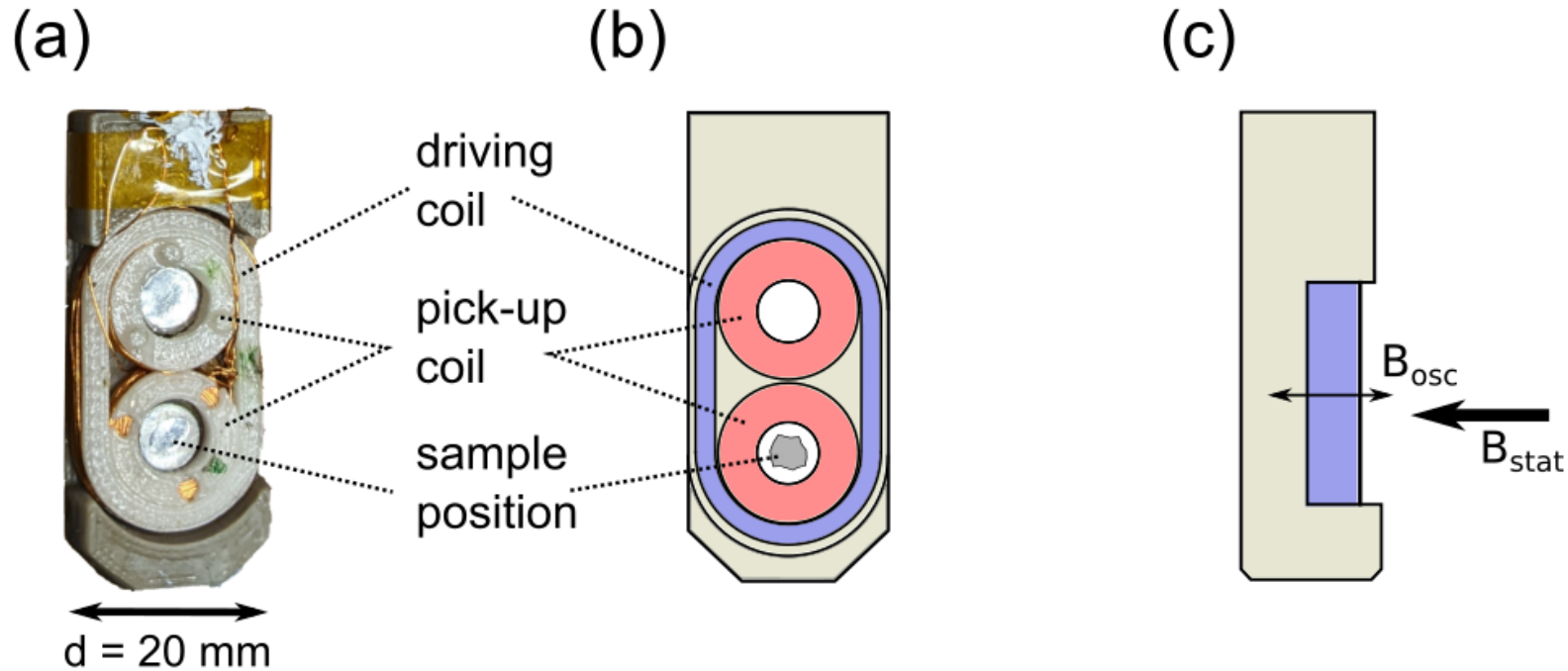
Both scenarios consistent with current measurements



Need higher resolution towards lower q

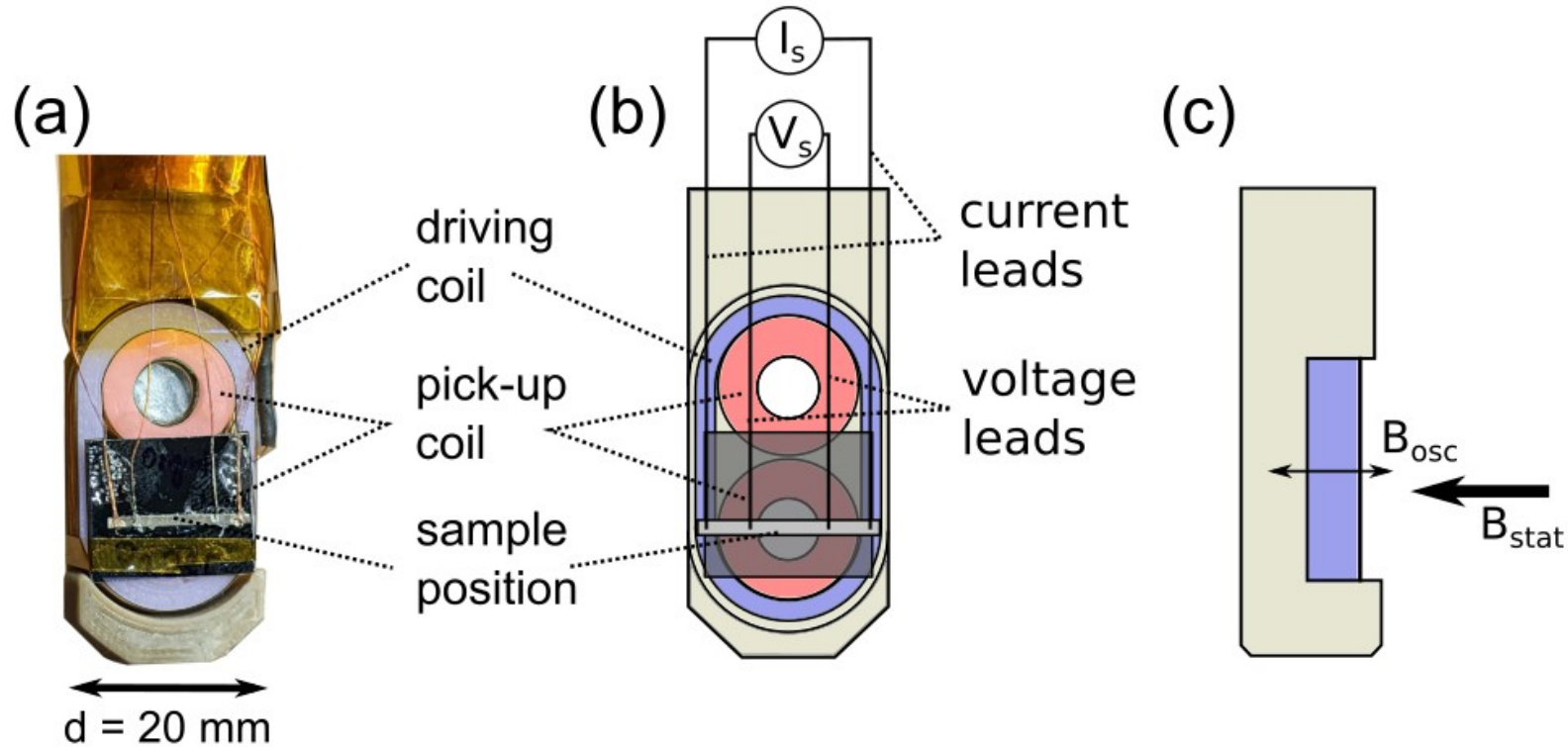
But no neutrons available

Simultaneous AC Susceptibility, Transport and (soon) Neutron Measurements



Nikolo American Journal of Physics 63, 57 (1995)

- + Lock in amplifier
- + Transconductance Amplifier



Simultaneous measurements of transport, ac magnetic susceptibility and neutrons:

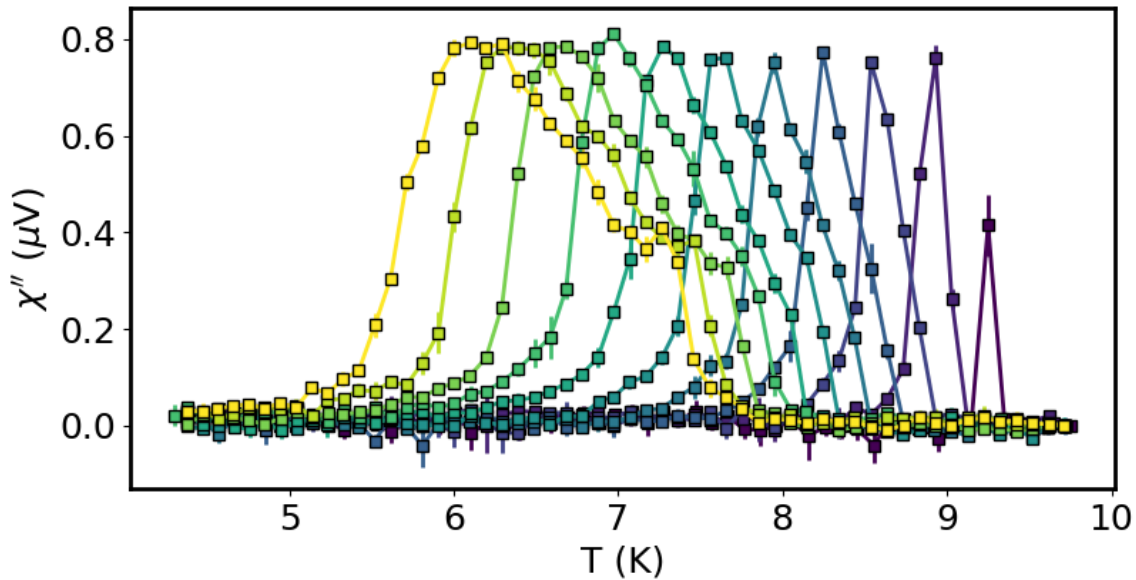
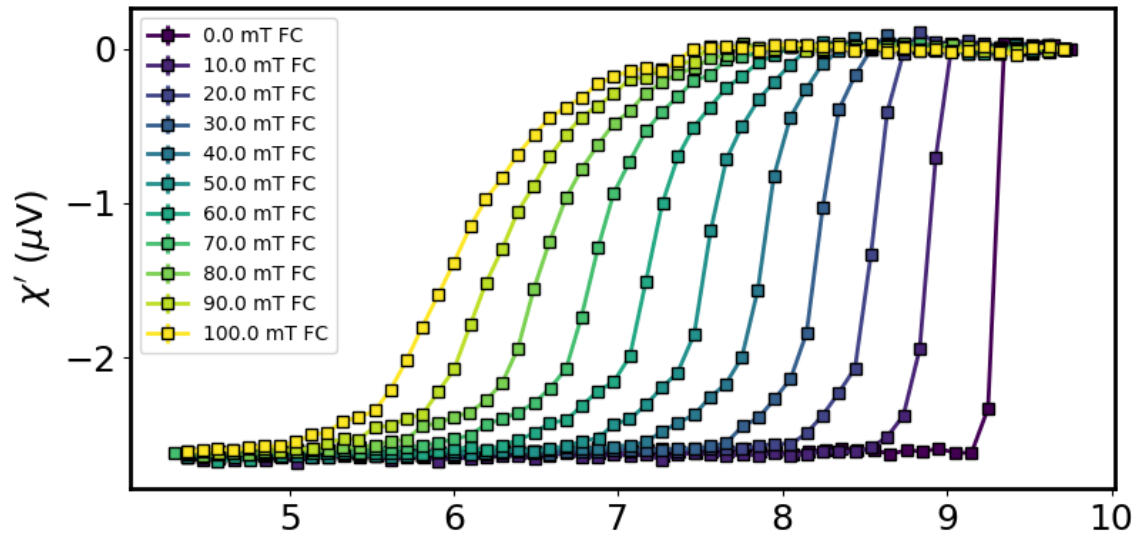
T-scans $\rightarrow T_c(B)$ from changes in:

- χ' (in-phase)
- χ'' (out-of-phase)

I-scans \rightarrow critical depinning current $I_c(B)$ from changes in:

- Voltage
- χ' (in-phase)
- χ'' (out-of-phase)

+ Lock in amplifier
+ Transconductance Amplifier

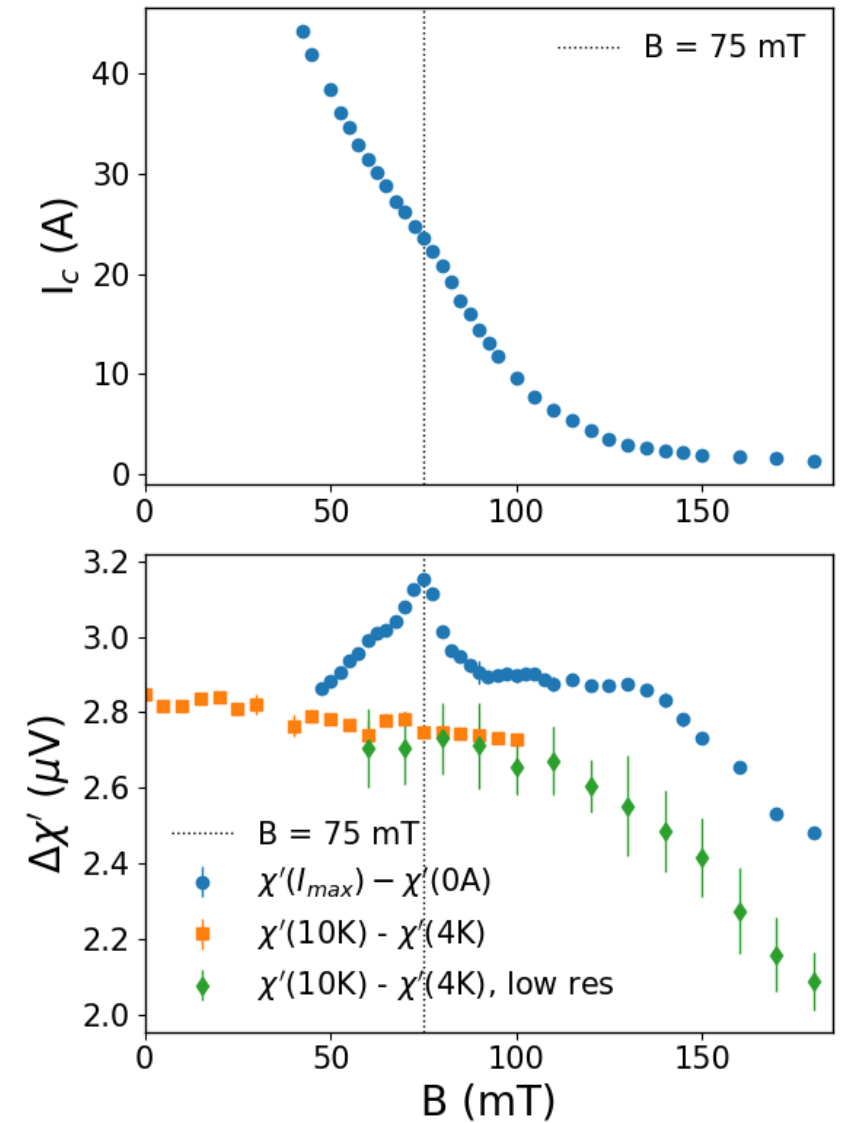
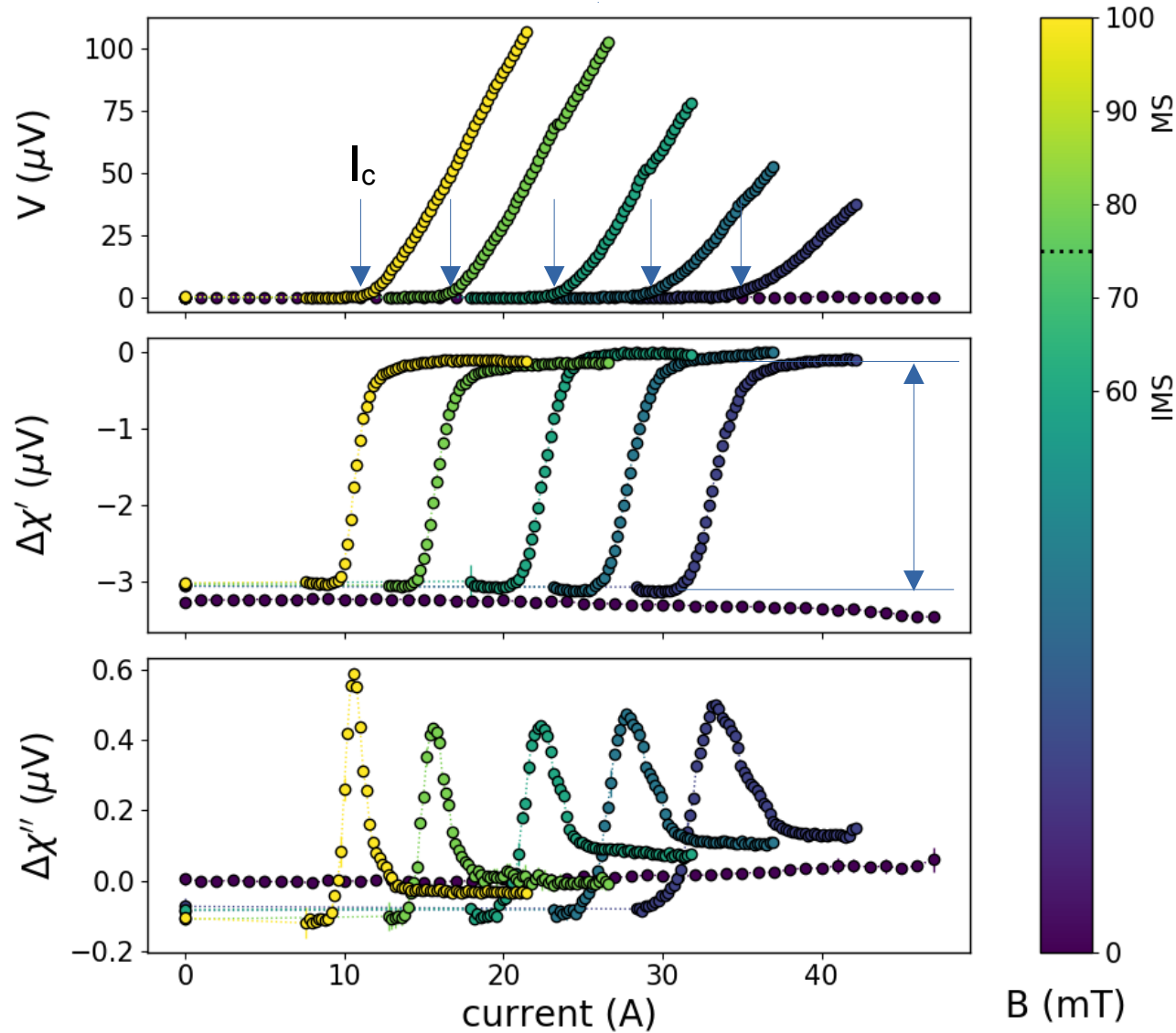


Drop in inductive channel (χ'):
Diamagnetic shielding

Peak in resistive channel (χ''):
Vortices penetrate sample

Also possible during neutron
measurements:
AC susceptibility “for free”

Note that the sample is outside the
pickup coil: very sensitive system !



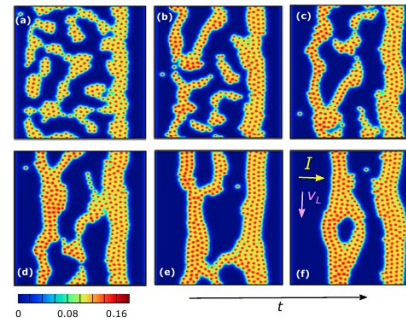
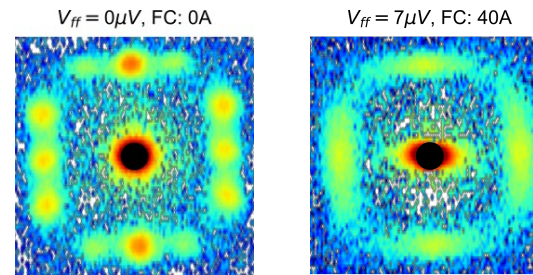
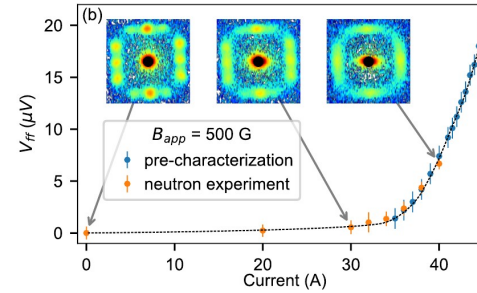
So far:

Vortex Movement in the IMS

Cluster structure is preserved but elongated

Rearrangement to sheet like superstructure (steady state)

Good agreement with simplified numerical simulations

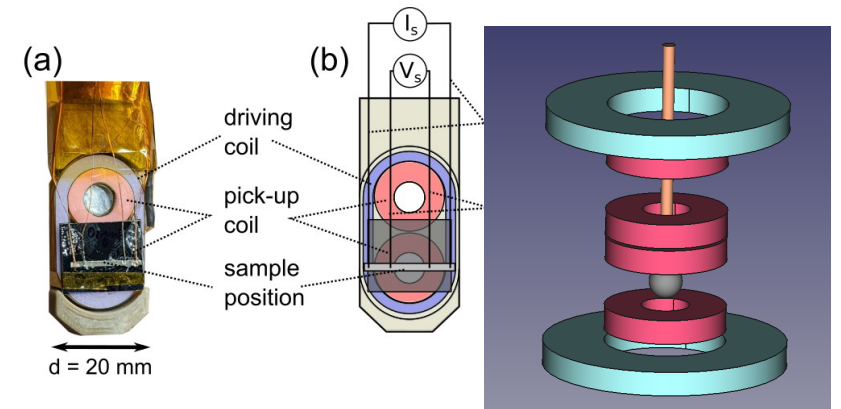


Next:

Where does the current pass?

Influence of different magnetic field strengths?

Neutrons + AC Susceptibility



Prototype optimized for larger rocking / scattering angles

Sebastian Mühlbauer
Robert Cubitt

Alexei Vagov
Arkady Shanenko
Wilmer Córdoba-Camacho
Jose Albino Aguiar

Alexander Backs

Frederic Marchal
Frank Lapeyre
Sebastien Turc
Michel Bonnaud

Christina Cocho Martinez
Abdelali Elaazzouzi

Questions?



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