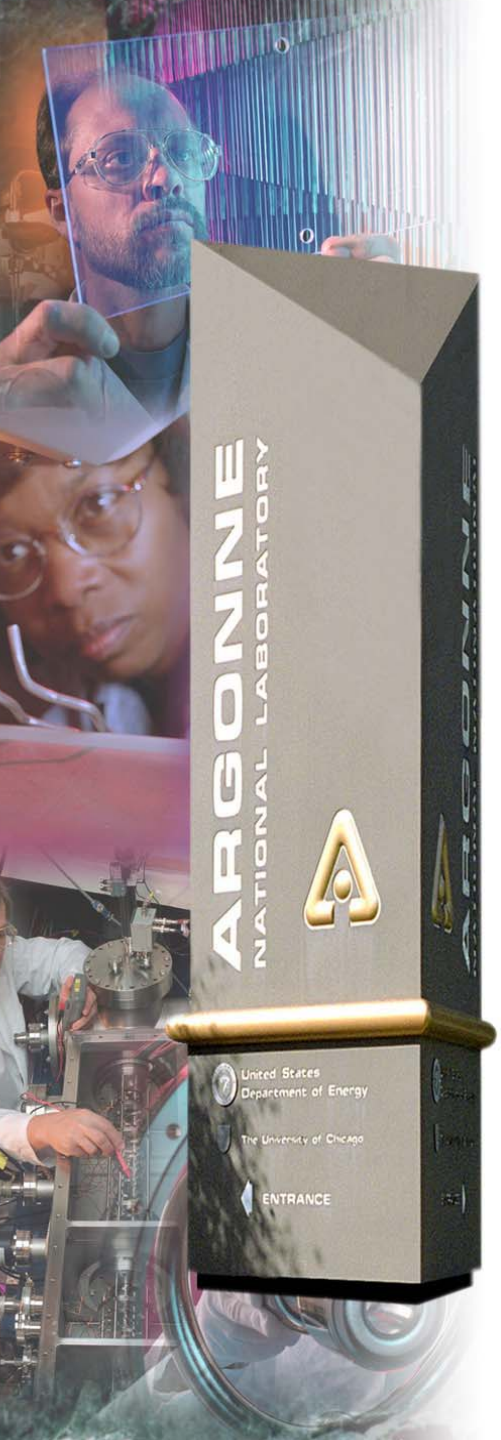

Probing Magnetic Nanostructures by Polarized Neutron Scattering

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Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

Polarized Neutron Scattering

Polarized Neutron Reflectometry

- Study depth-dependent magnetic structure of “nanolayered” films
  - Exchange bias
  - Exchange coupling
  - Interface phenomena

Off-specular scattering

- Study lateral magnetic nanostructures
  - Magnetic domains
  - Patterned/self-assembled magnetic nanostructures

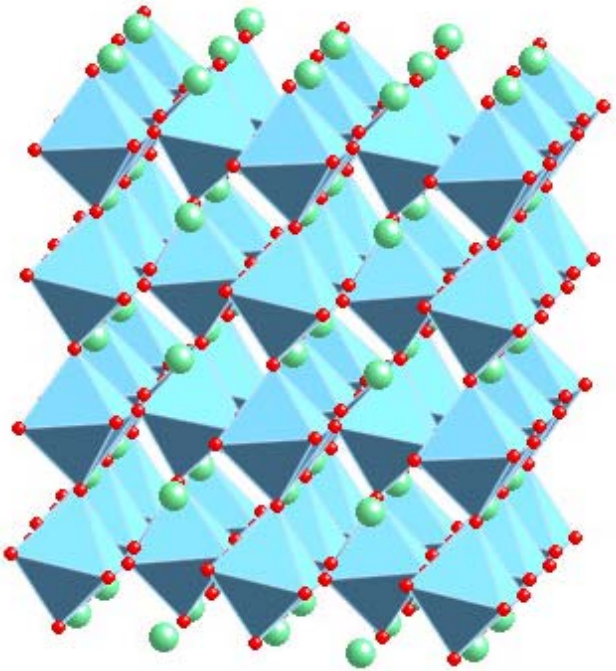
Small Angle Scattering

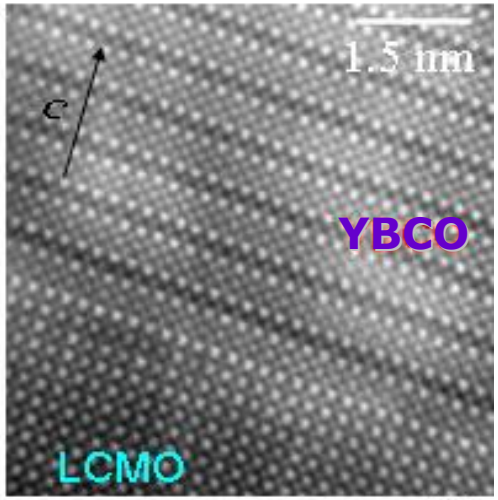
- Study nanoparticles

Interactions in F/S/F heterostructures

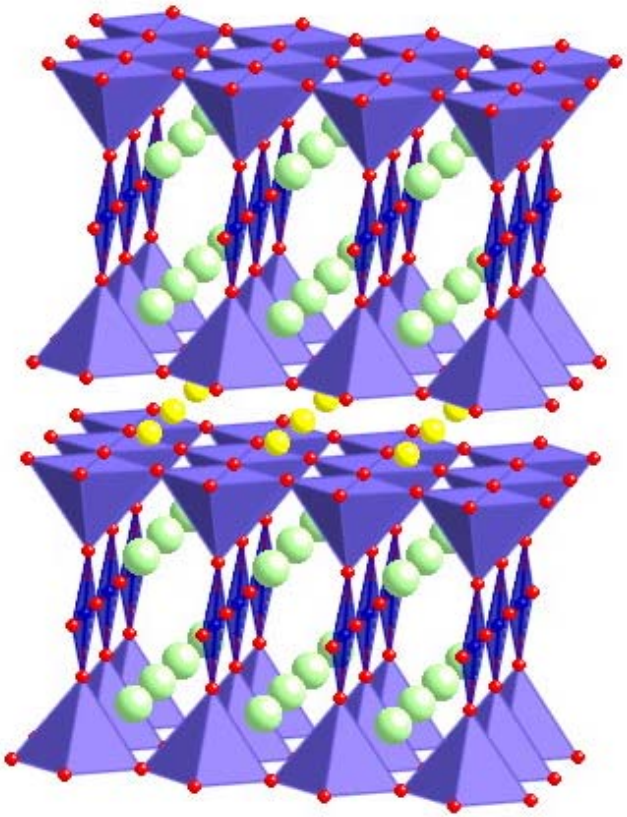
Interplay between

Ferromagnetism & Superconductivity





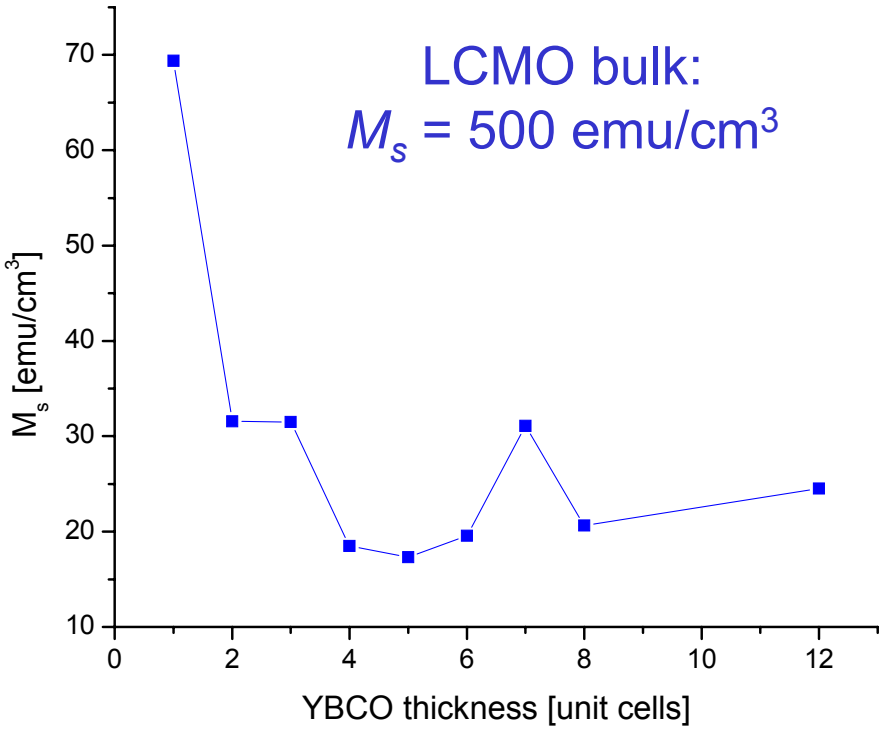
Z-contrast STEM, M. Valera (ORNL)

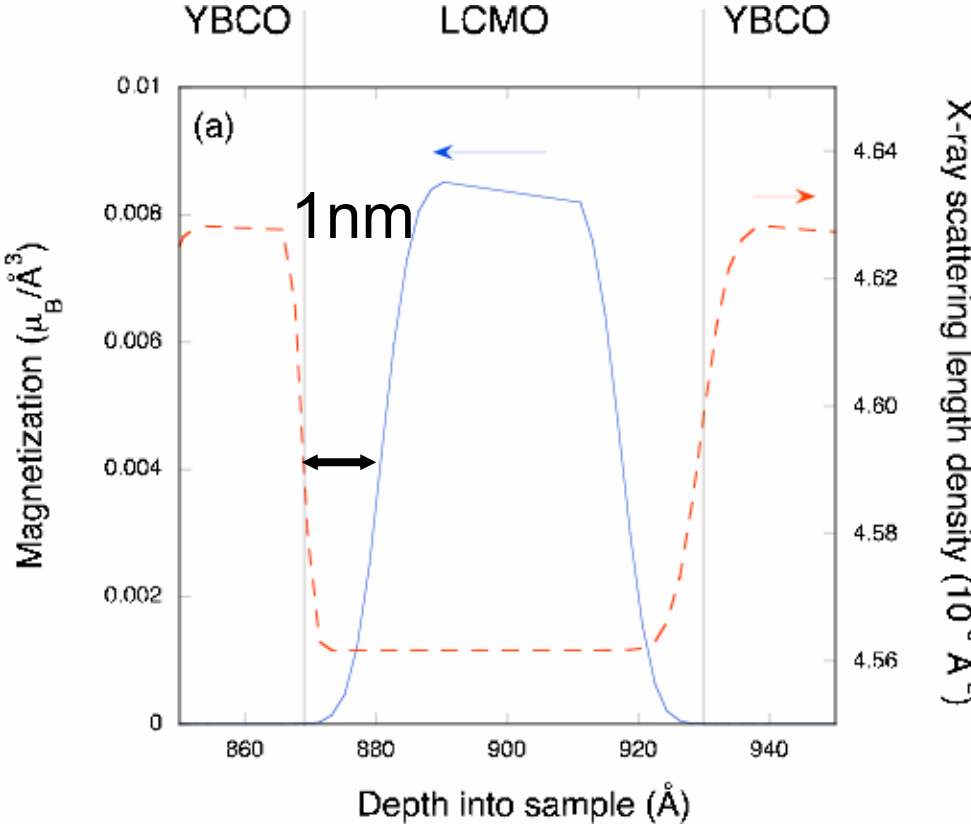


$La_{0.7}Ca_{0.3}MnO_3$ / $YBa_2Cu_3O_{7-\delta}$ superlattices

Reduced Magnetization

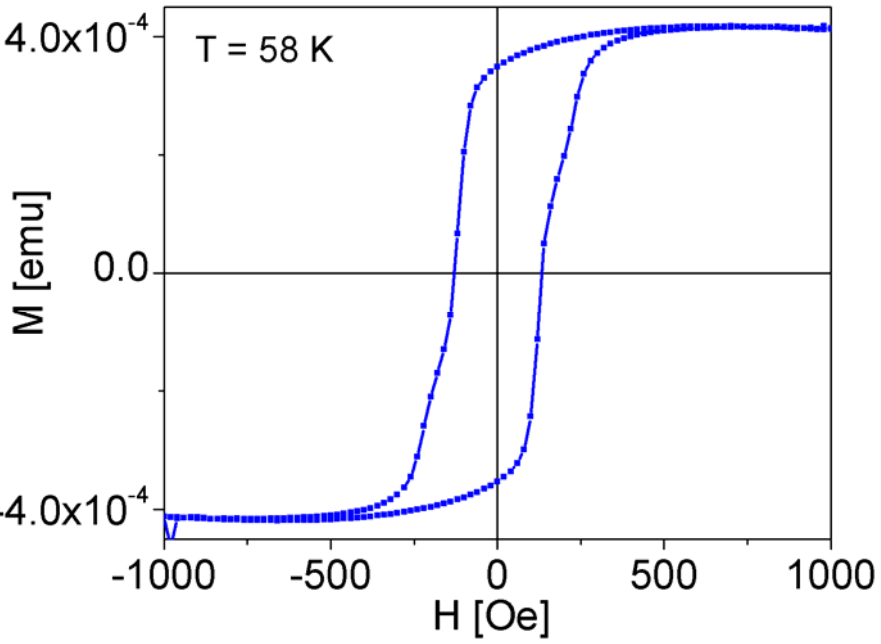
(LCMO 15 u.c./ YBCO N_S u.c.)

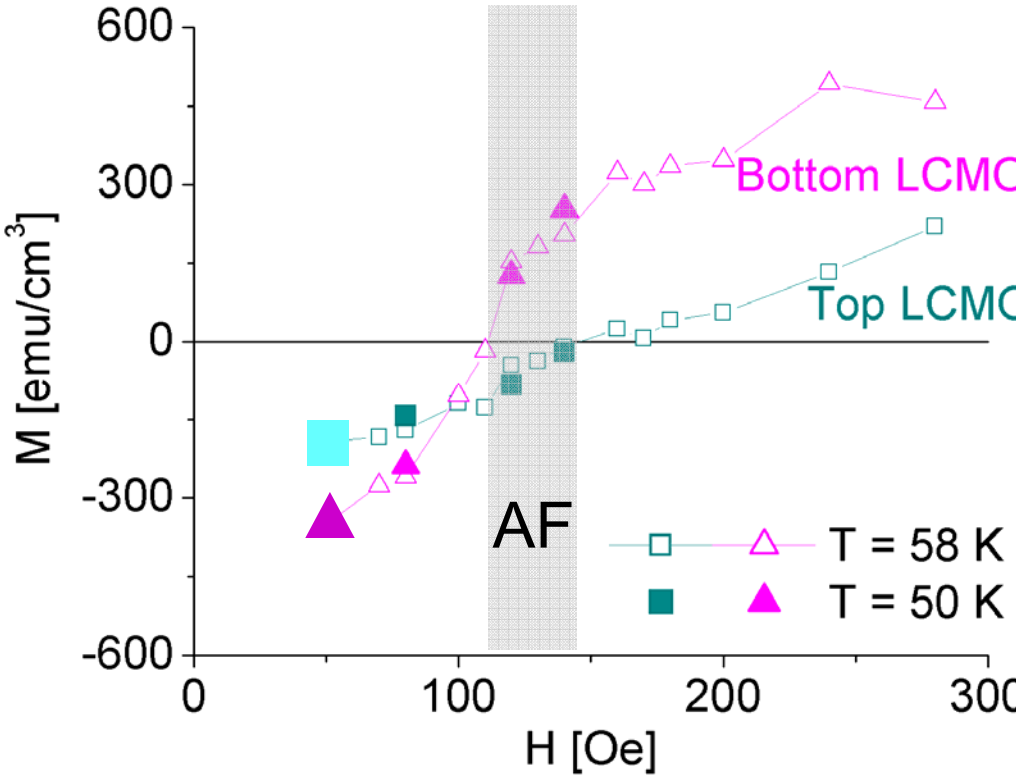




Decrease in M_s due to suppressed M at LCMO interface

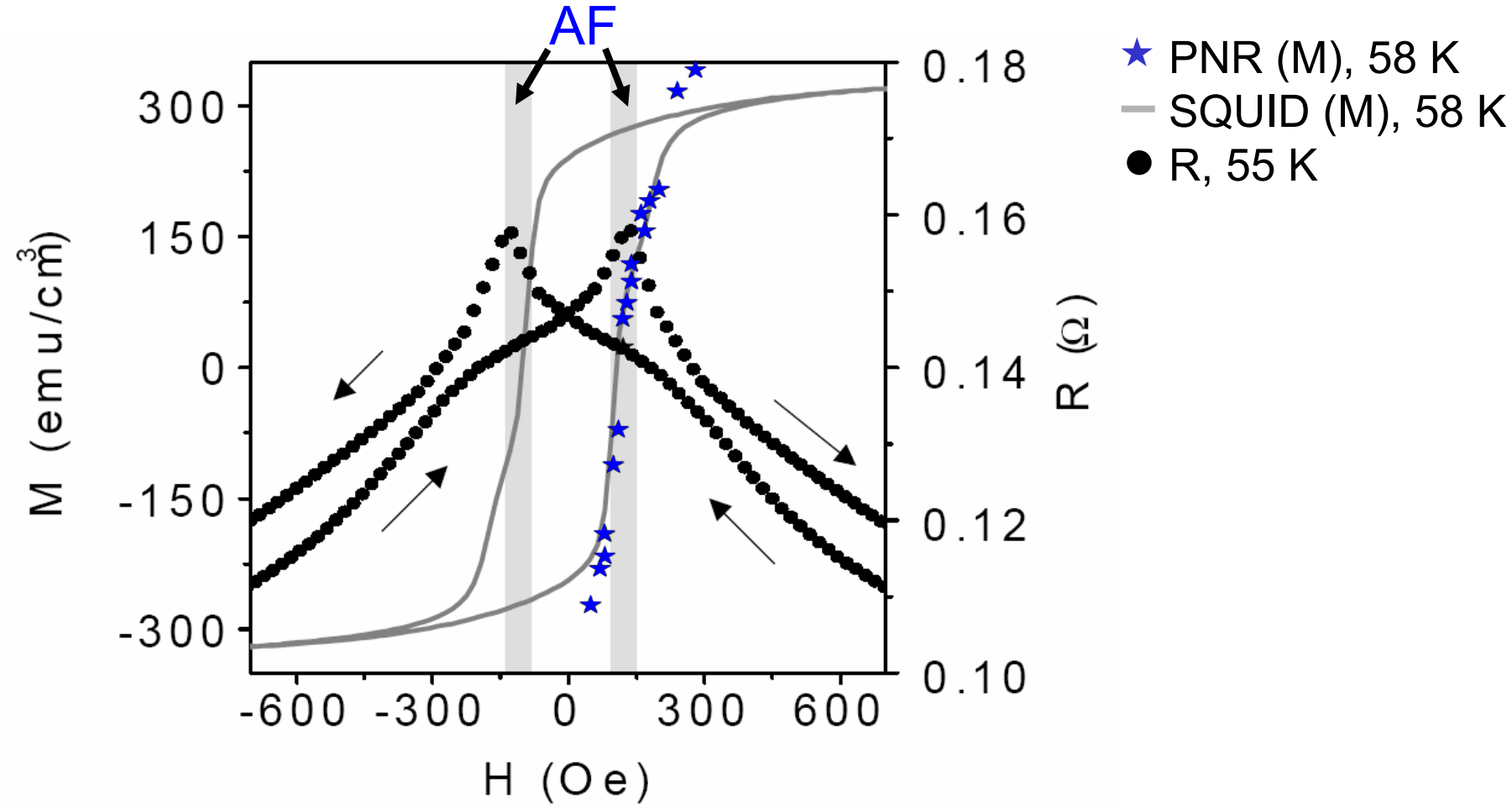
Ferromagnetic/Superconducting Trilayers





Due to difference in switching behavior a field region with **AF alignment** occurs

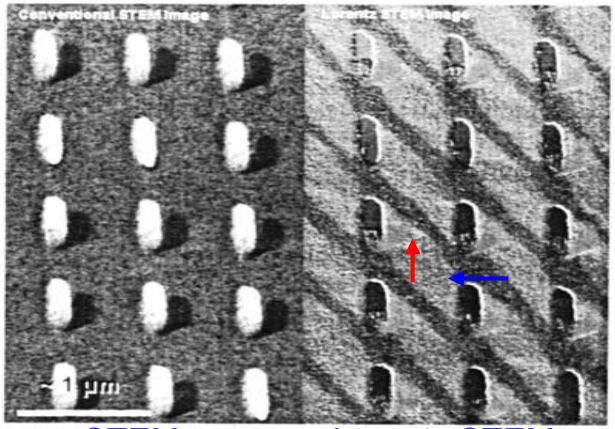
Resistance versus Magnetization



Peak in resistance is coincident with step in the magnetization and with the region **with AF alignment**

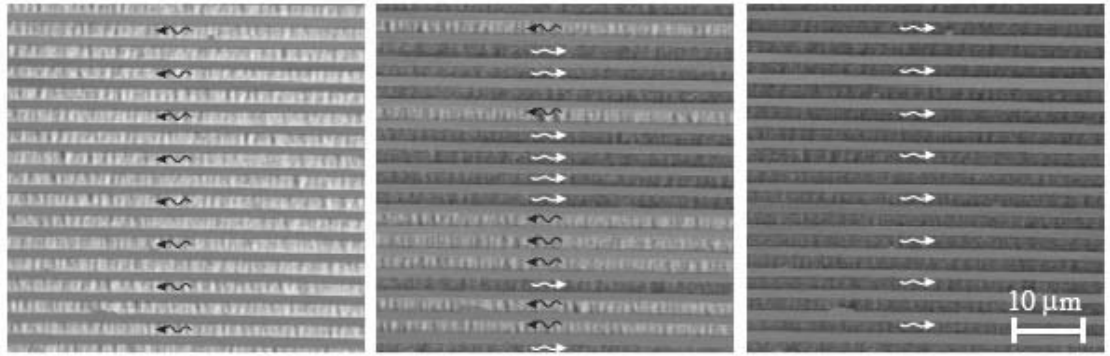
Magnetic domain structure in arrays

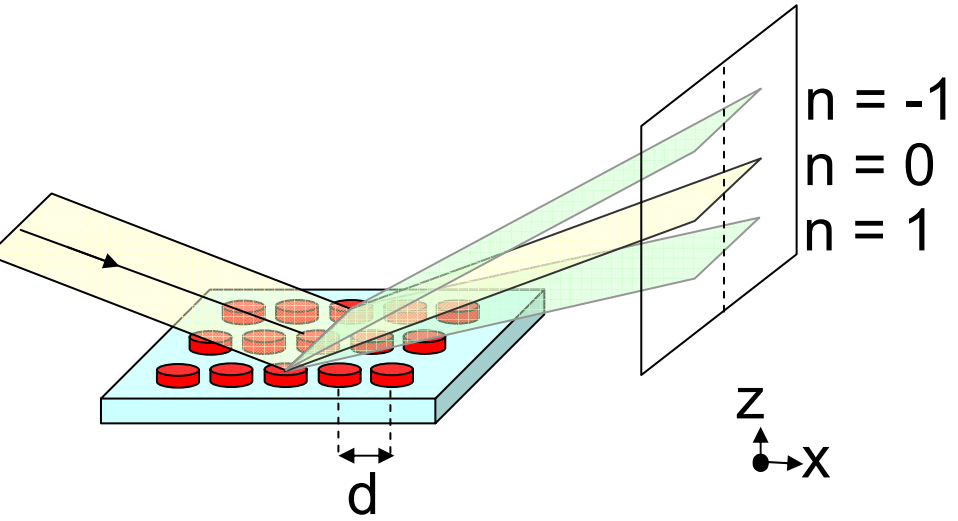
Guedes et al., PRB 62 (2000) 11719



STEM Lorentz STEM

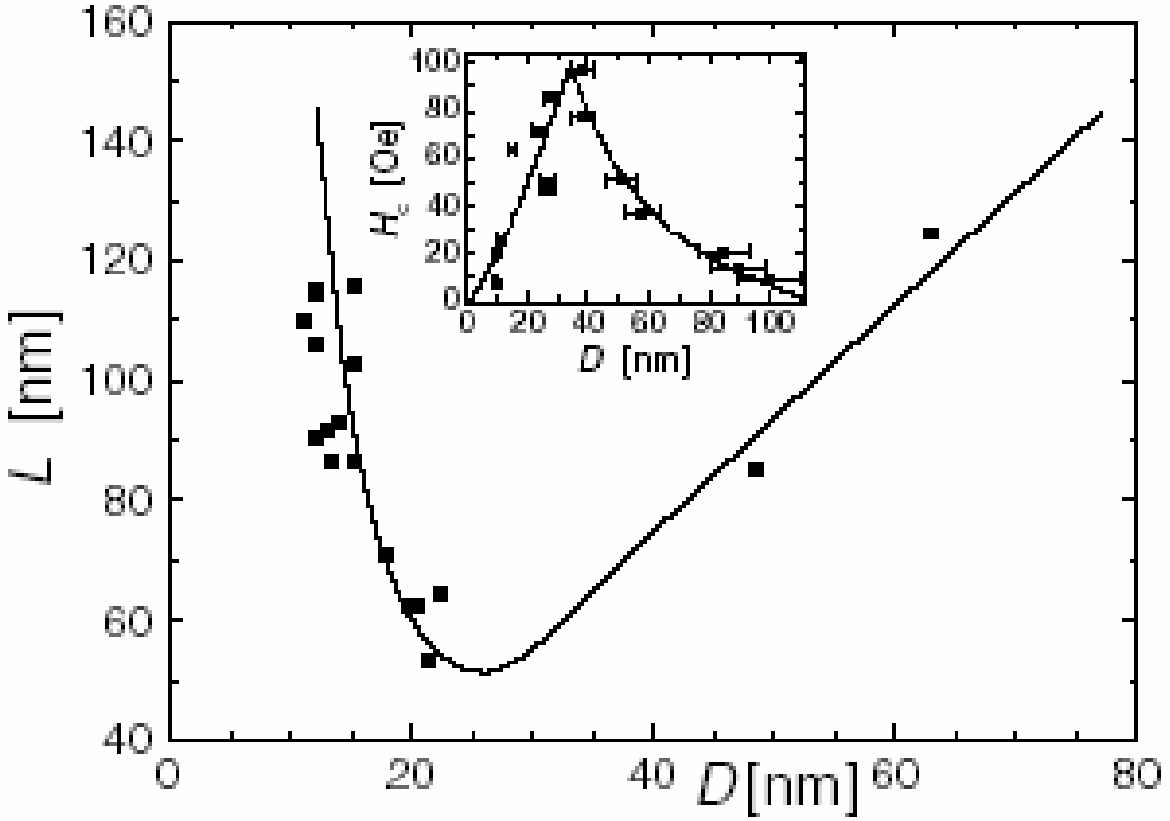
K. Theis-Brohl, Physica B 345 (2004) 161





Nanostructured ferromagnets

SANS study of nanostructured Fe, Co, and Ni

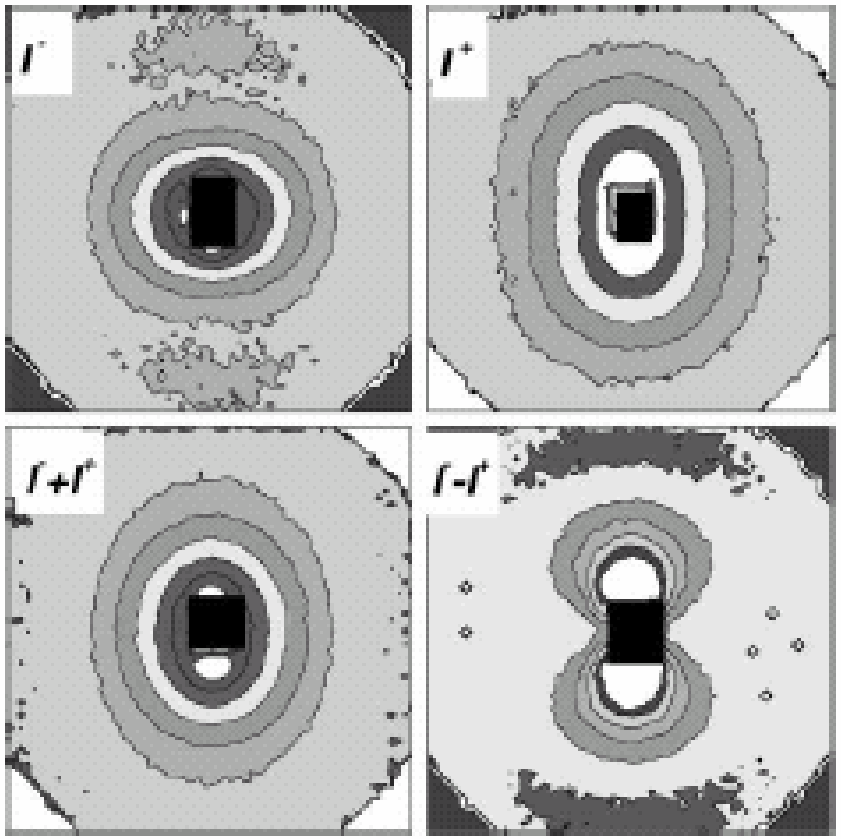


Difference between magnetic (L) and structural (D) correlation length

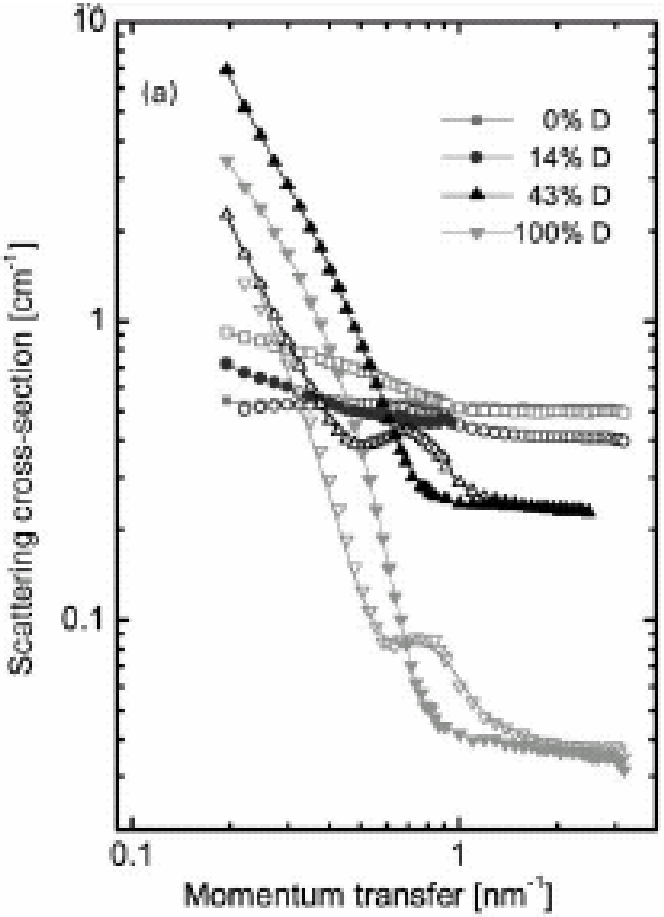
J.F. Löffler, H-B. Braun, W. Wagner, PRL 85 (2000) 1990

Co Ferrofluids

Polarized SANS



A. Wiedenmann, Physica B 297 (2001) 226



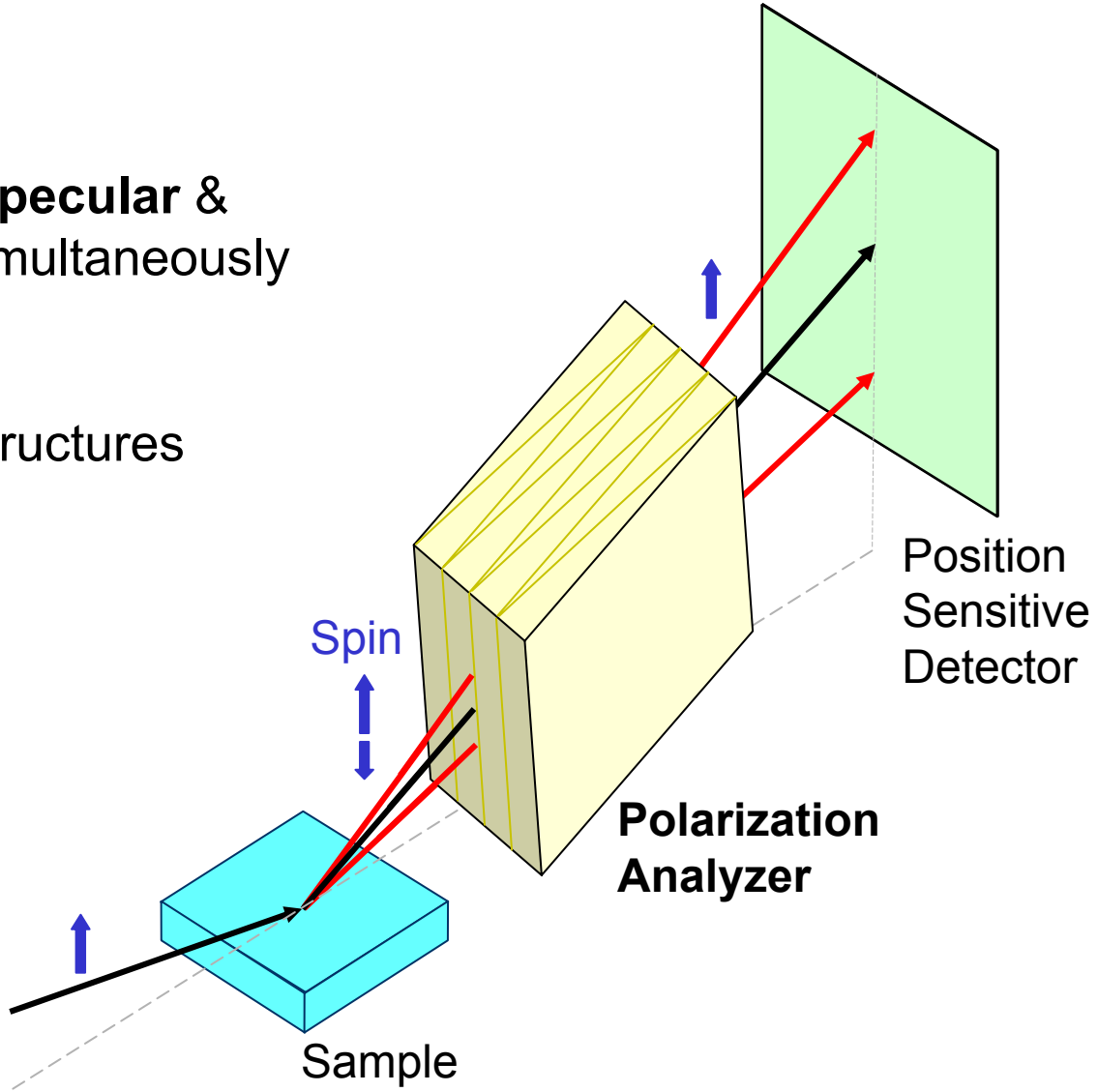
Core: <R'>=3.7 nm

Shell: dR = 2.47 nm

Wide Angle Polarization Analyzer

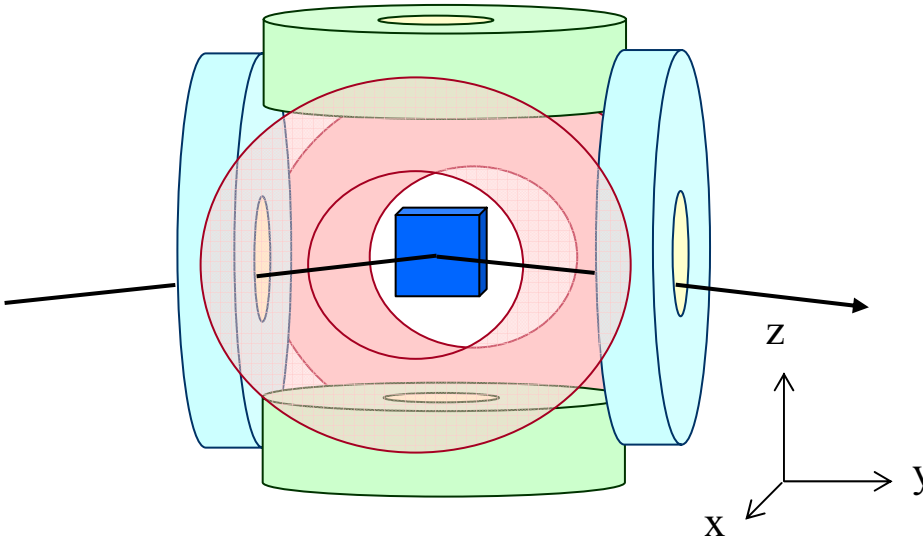
- Analyze polarization of **specular** & **off-specular** scattering simultaneously

- Study lateral magnetic structures
  - Nanoparticles
  - Domains

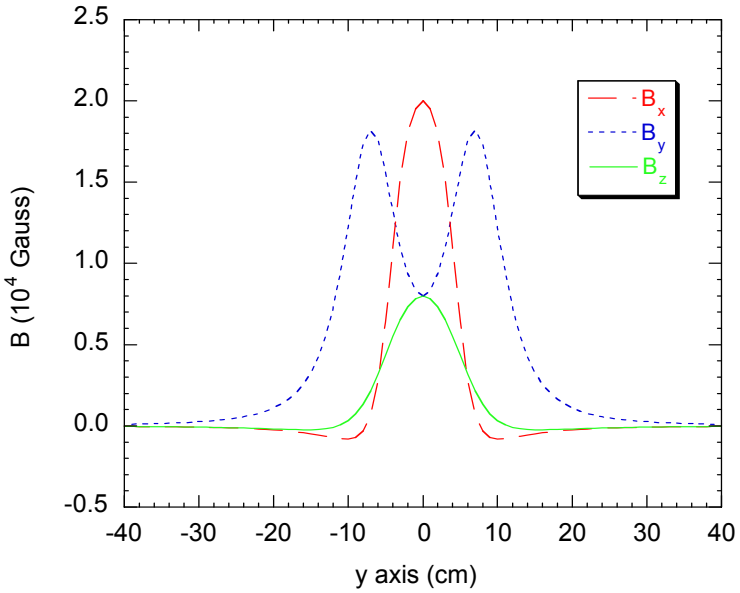


XYZ Magnet

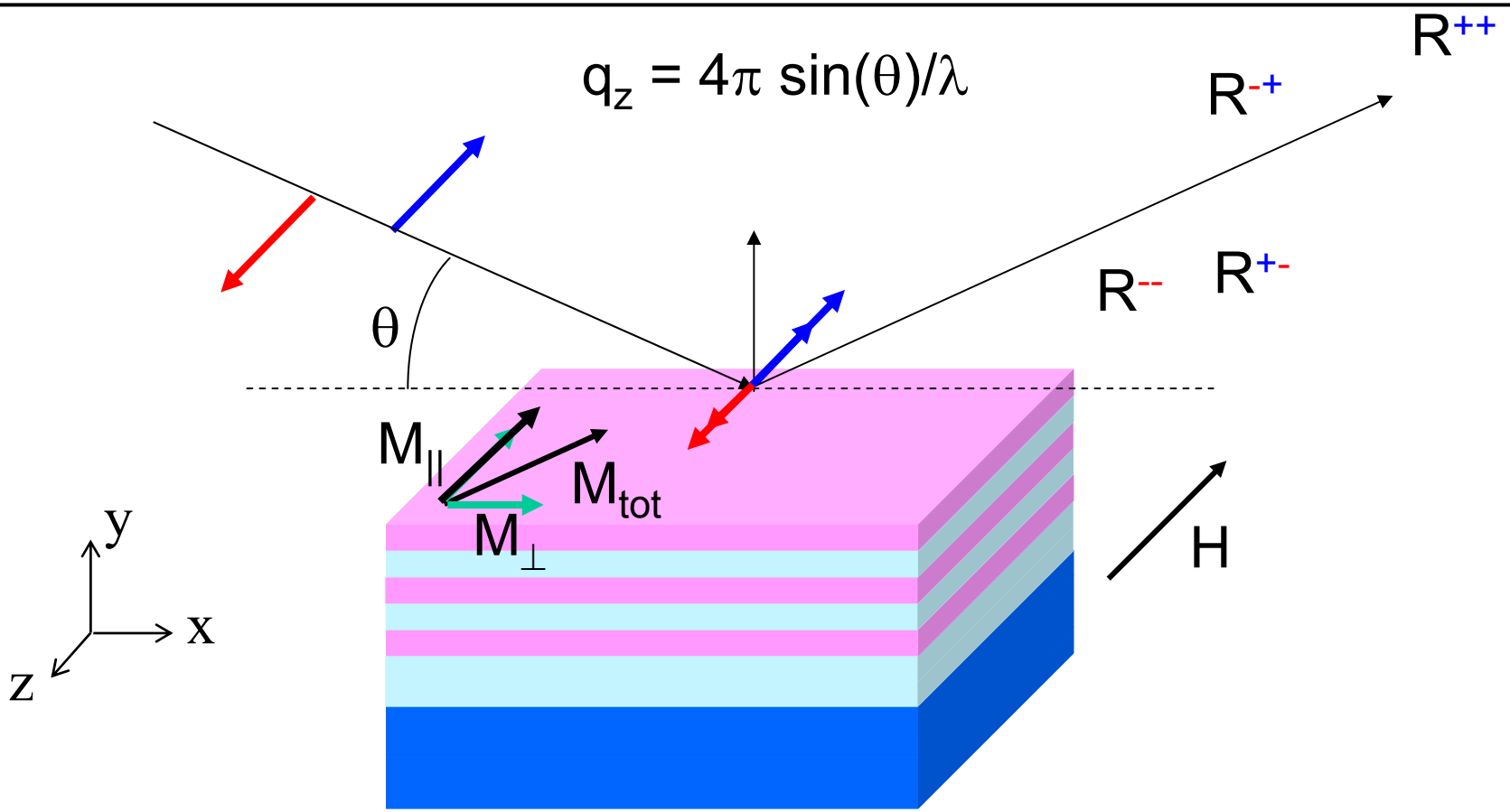
Apply field independent of scattering geometry !



- Magnetic anisotropy
  - Exchange bias: Cooling field vs measuring field
  - Lateral magnetic structures: Shape anisotropy
- Perpendicular fields
  - Measure only chemical profile
  - Out of plane magnetized media



Polarized Neutron Reflectivity



Scattering length density (SLD):

SLD_{nucl} + **SLD_{magn}** => R^{++}

SLD_{nucl} – **SLD_{magn}** => R^{--}