Polarized Neutron- and Synchrotron Mossbauer diffuse scattering in studying of interface magnetism

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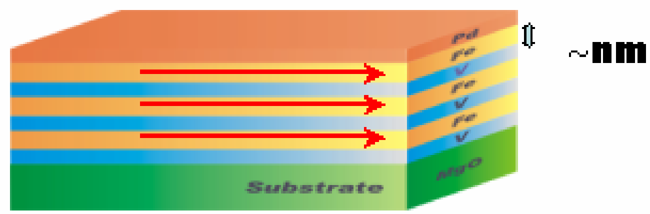
Outline

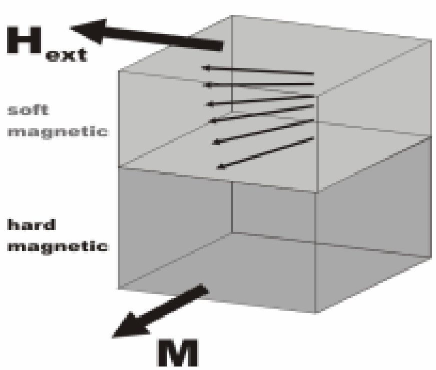
- I. Introduction
    1. Magnetic multilayers
    2. Reflectometry
    3. Domains in multilayers
- II. Open problems
- III. Results, future purposes

Magnetic multilayers



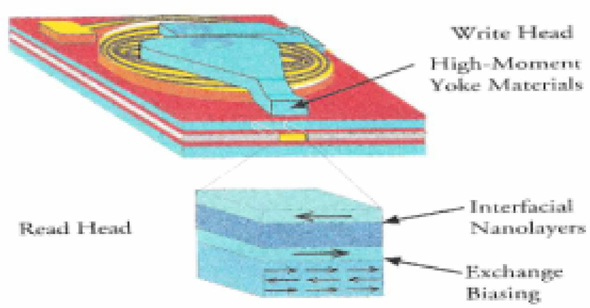
Fundamental Researches

Hard/Soft magnetic bilayers



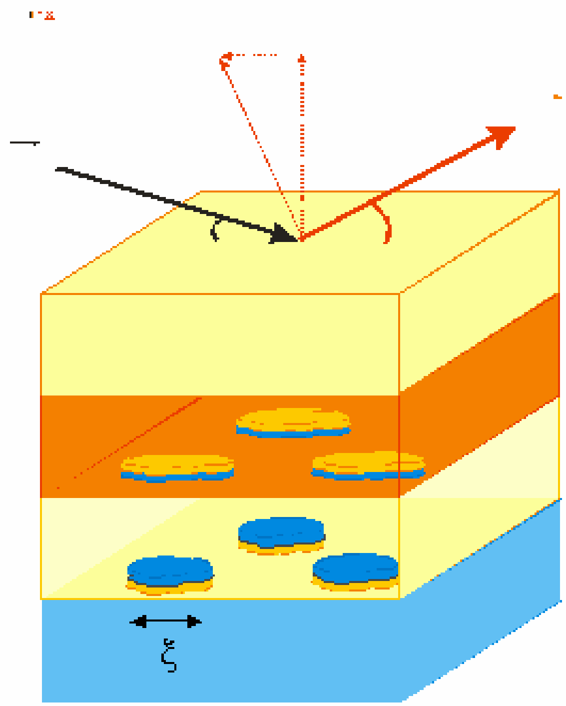
Practical purposes

Magnetic storage devices



J.F. Kortright et al. / JMMM 207 (1999) 7-44

Reflectometry scheme



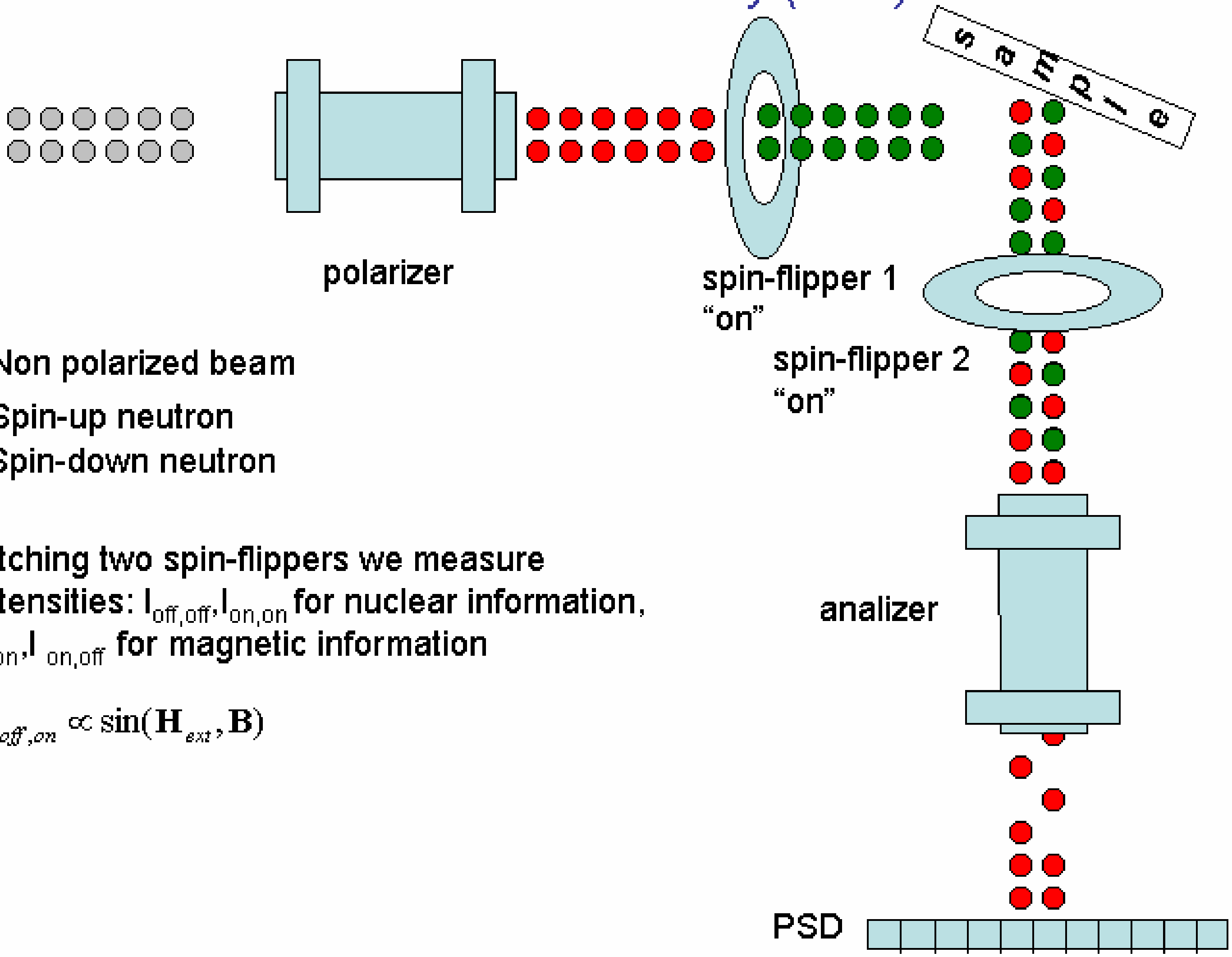
$$\theta \propto 1-10\,\mathrm{mrad}$$

$\theta_f = \theta_i$ specular reflection, radiation feels averaged structure

$\theta_f \neq \theta_i$ off-specular (diffuse) scattering, radiation feels inhomogeneities

$$\xi \propto \frac{2\pi}{\Delta Q_x}$$

Polarized neutron reflectometry (PNR)

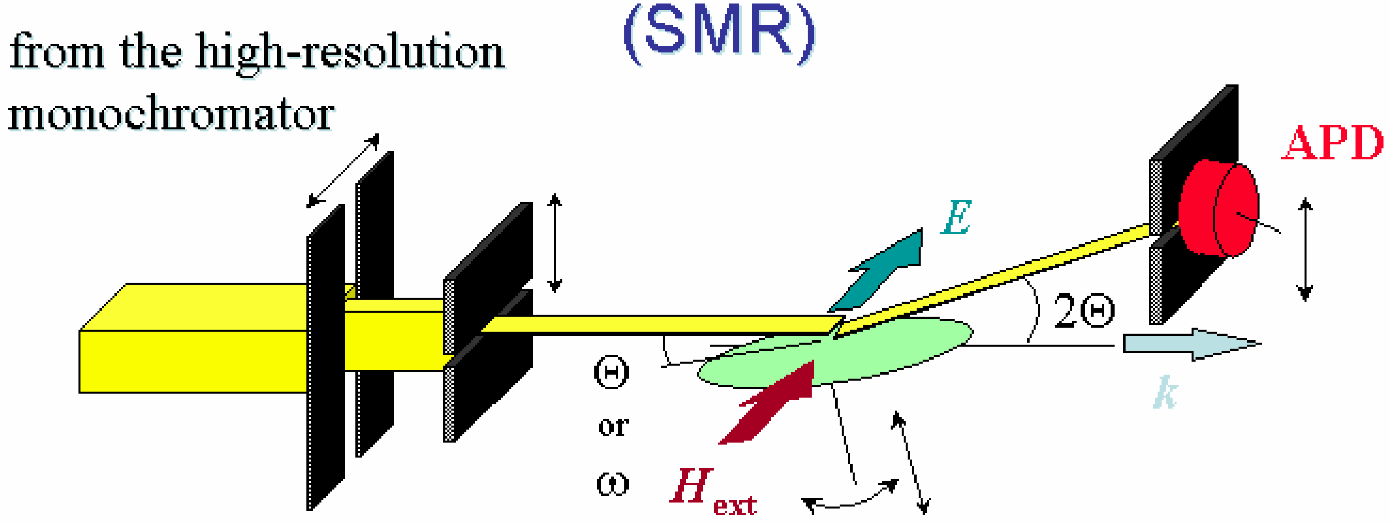


- Non polarized beam
- Spin-up neutron
- Spin-down neutron

Switching two spin-flippers we measure
4 intensities: $I_{off,off}$,$I_{on,on}$ for nuclear information,
$I_{off,on}$,$I_{on,off}$ for magnetic information

$$R_{off,on} \propto \sin(\mathbf{H}_{ext}, \mathbf{B})$$

Synchrotron Mossbauer reflectometry (SMR)

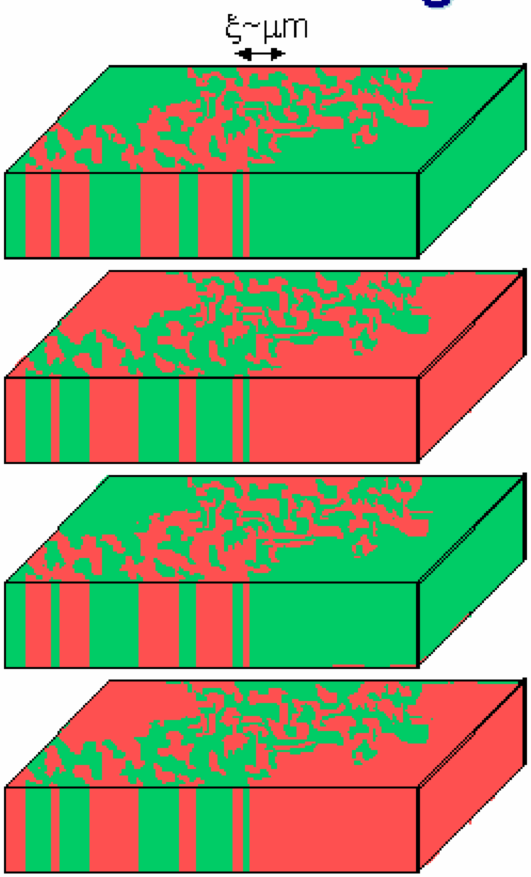


Θ/2Θ-scan

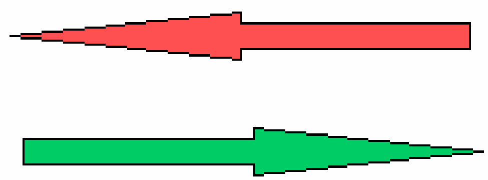
ω-scan

We measure 2 intensities: prompt for nuclear information, delayed for magnetic information

Antiferromagnetic domains in multilayers



Layer magnetisations:



If $H_{ext}<H_{sat}$ $\xi\neq\infty$,

$\xi=\xi(H_{ext})$

Open problems:Theory

Distorted Wave Born Approximation

inhomogeneous wave equation
(both for SMR and PNR)

$$\left[\Delta + k^2 I\right]\Psi_{off}(\mathbf{r}) = -k^2 \sum \left(\chi_l(\mathbf{r}_{\mathrm{II}}) - \overline{\chi}_l\right)\Psi_{coh}(\mathbf{r})$$

The solution:

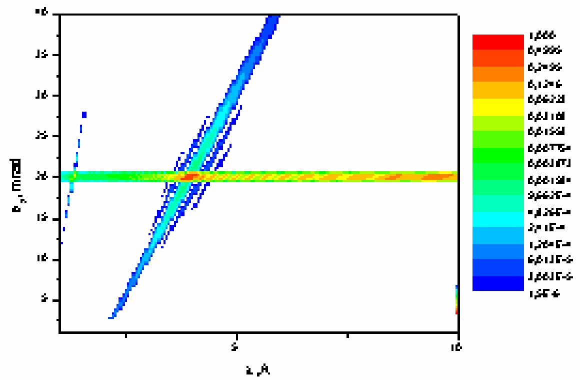
$$I_{off} = \frac{k^4}{4r^2}\sum_l \mathrm{Tr}\left[T_l^+\left(\mathbf{k}'_\perp\right)C_l(\mathbf{K}_{\mathrm{II}})T_l\left(\mathbf{k}'_\perp\right)\rho\right]$$

Submitted to Physical Review B
L. Deak, L. Bottyan, D.L. Nagy,H. Spiering and Yu.N. Khaidukov
DWBA Treatment of O-Specular Synchrotron M□ossbauer
Reectometry

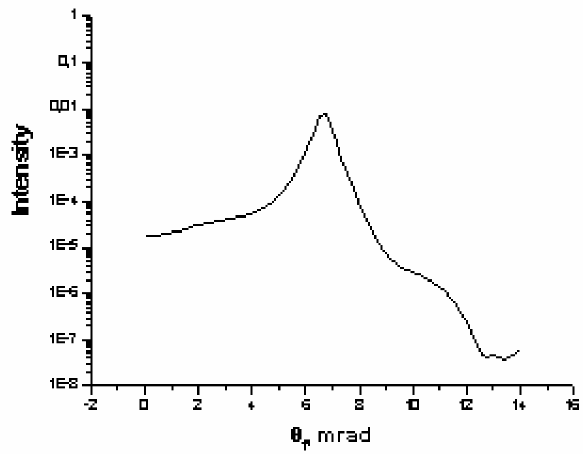
Open problems

Model calculations

System: [^{57}Fe(12.2A)/Cr(26.3A)]x20/MgO, ξ=10mkm



2D PNR



Delayed SMR

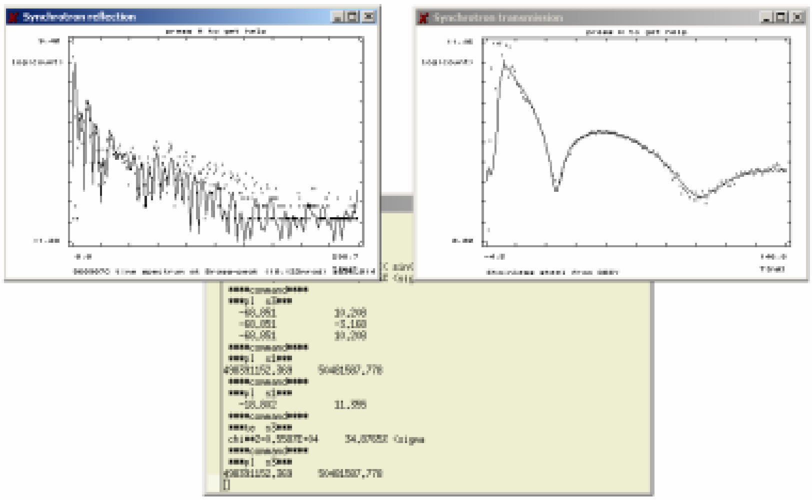
Program for model calculations is ready

Open problems

Program for data evaluation

EFFI (Environment For FItting)

ftp://iacgu7.chemie.uni-mainz.de/pub/effi



Any user can build in "theoretical" modules in EFFI

Present theories:

1. Mossbauer transmission /reemission/reflection
2. Synchrotron reflection /transmission
3. Neutron reflection

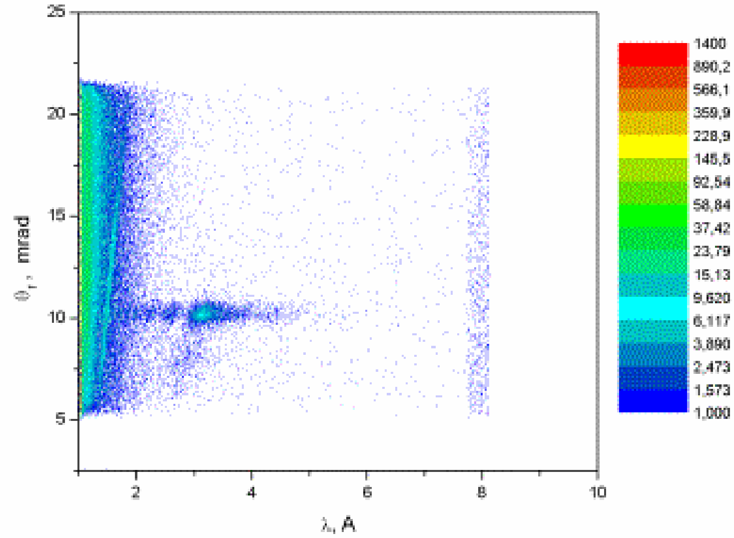
Idea: to insert routines for PNR and SMR diffuse scattering in EFFI

Open problems

Experiments

Neutron experiments in Dubna January 2003

Sample: [^{57}Fe(12.2A)/Cr(26.3A)]x20/MgO
Main goal: To obtain function $\xi=\xi(H_{ext})$



$I_{off,off}$
H=3kOe

Results, future purposes

1. Experiments (done)
2. Theory (done)
3. Implementation in EFFI (in process)
4. Experimental data processing (in process)

Future purposes:

- Theoretical and methodological work (roughness, coherence)
- New experiments related to magnetic multilayers

Collaboration

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