Polarized Neutron Reflectometry at the Spallation Neutron Source

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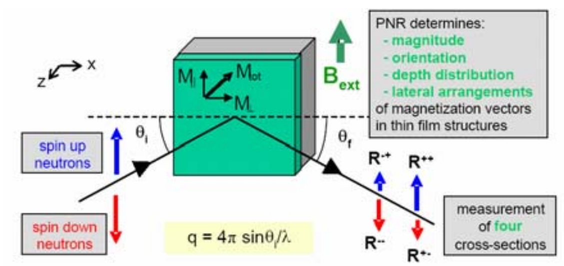
Statement of Research Problem

$Fe_{70}Co_{30}$/Pd multilayers may exhibit higher saturation magnetizations than $Fe_{70}Co_{30}$ alone.[1] This may be due to the enhancement of Fe atoms in the FCC matrix of Co and Pd, along with an induced moment in the Pd.[2] However, precise measurements of the elemental moments has yet to be realized.[3]

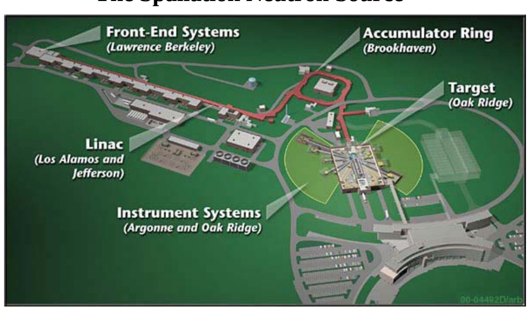
We plan to utilize the Magnetic Reflectometry beamline at the Spallation Neutron Source (SNS), complimented with X-ray Magnetic Circular Dichroism (XMCD) in order to gain insight into the cause of moment enhancement in multilayer structures.

Introduction to Polarized Neutron Reflectometry

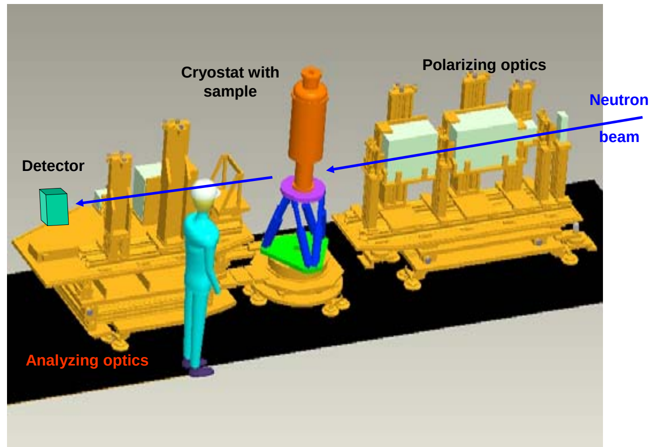
Polarized neutron reflectivity (PNR) has been widely used to determine magnetic and chemical characteristics of thin films and bulk materials. For material science studies, neutrons with wavelengths from 1-3 Å (cold) and 3-30 Å (thermal)[4]. These neutrons allow us to probe numerous magnetic systems, such as dilute magnetic semiconductors, superconductors, interfacial coupling, and multilayers.[5]



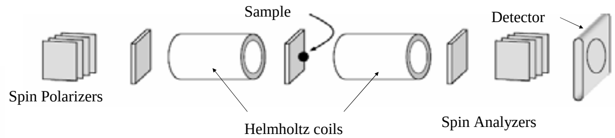
The Spallation Neutron Source



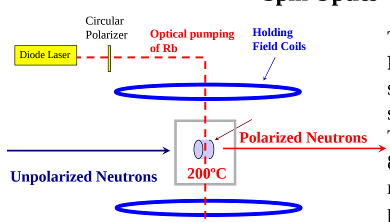
Spallation Neutron Source: Beamline 4A



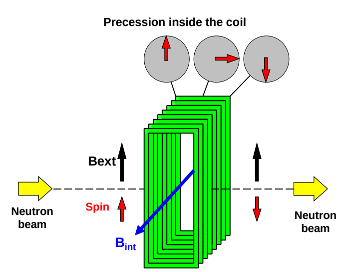
Typical Sample Set-up



Spin Optics



There are two ^{3}**He Spin Filters** (one prior to the sample, one after the sample) on the beamline. These have an efficiency of 80 % for spin selection of neutrons. The basic principle is the transfer of spin from polarized ^{3}He to the incident neutrons. The ^{3}He is polarized via collision with optically pumped Rb atoms.



The two **Mezei spin flippers** (one prior to the sample, one after the sample) utilize Larmor precession of the neutron. As a result, the neutrons' spin rotates to the preferred orientation.[4]

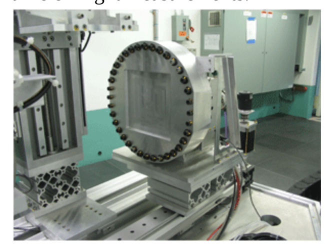
Detectors

Since neutrons are neutral, they cannot be directly "seen." An intermediary interaction is necessary. For the "cold" neutrons used at the SNS Magnetic Reflectometer, ^{3}He gas is used. For each neutron, the following reaction takes place:

$$n + {}^3He \rightarrow {}^3H + {}^1H + 0.764\ MeV$$

The secondary particles are "seen" by charge-coupled devices (CCD's).

Arrays of individual detectors allow spatial resolution and time of flight measurements.



Specifications:
Type: ^{3}He Proportional Counter
Size: 400 cm^2
Resolution: 1 mm^2
Sensitivity: 30 meV
Rate: 100 ns for 100 pixels

Future Work

The Spallation Neutron Source was completed in June 2006. At the present time, the individual beamline stations are preparing for their general users.

For us, the samples of $Fe_{70}Co_{30}$/Pd need to be made and sent to SNS for testing. This is scheduled for 4-6 NOV 2006.

We are slotted to be the **first general user** of the SNS.

References

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