Experimental Report

Proposal: **5-32-770** **Council:** 4/2012

Title: Polarized SANS investigation of magnetic nanowires

This proposal is a new proposal

Researh Area: Physics

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Samples: Co
Al203

Instrument	Req. Days	All. Days	From	To
D22	10	6	08/07/2013	11/07/2013
			11/07/2013	12/07/2013

Abstract:

In this experiment, we intend to investigate magnetic nanowires through Polarized SANS measurements. The main aim is to determine the magnetic form factors of these elongated objects and the mechanisms which govern the magnetization reversal process. This experiment should allow to confirm previous measurements performed at LLB which indicated that stray fields cannot be neglicted in SANS measurements as it is usually done : Surprisingly, a magnetic contrast was observed at lower Q-values than expected (Q < 0.4nm-1) and was maximal around 0.1 nm-1. We estimate that these results provide a strong hint that stray fields between elongated nano-objects should be included in the magnetization model whereas it is often neglected in the literature on nano-objects without real theoretical justification. Three kinds of samples will be examined (amorphous Co nanowires, hcp Co nanowires with the axis c along the long axis and hcp Co nanowires with the axis c perpendicular to the long axis). We consider that D33 is optimal for our study and we are asking for 10 days of beam time on D33 (D22 could obviously be a very valuable alternative).

Polarized SANS studies of Ordered Ferromagnetic Metallic Nanowires

This study aims at determining the reversal mechanisms of magnetization inside the magnetic nanowires and the role of pinning centres. We performed polarized SANS experiment at the ILL (D22) on very highly-ordered alumina membranes, filled with either Nickel or Cobalt, with 400nm periodicity and 150nm diameter. The triangular order is extremely high as seen in Figure 1 and we wish to pursue along that route using denser arrays (periodicity 100-150nm) and nanowires with varied diameters (from 20 to 50nm) as to highlight the role played by inter-wire interactions in the magnetization reversal processes.

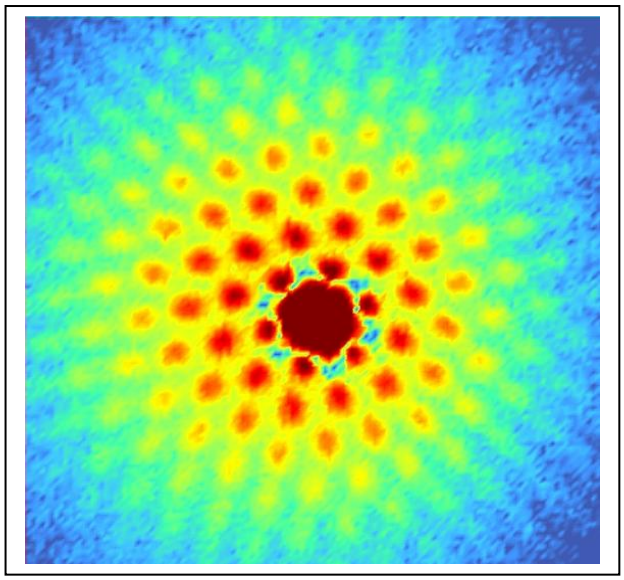

Figure 1: SANS intensities obtained on Co filled nanowires (D22, ILL) at λ=17 Å for a detector distance equal to 17m

Some beam time was lost because of the difficult access to the cryomagnet during operation (sample change, 4He transfer). However, we had enough time to investigate Polarized SANS of Co and Ni nanowires at large Q (λ=9 Å, detector distance=8m). Here, we just show preliminary results for Co nanowires.

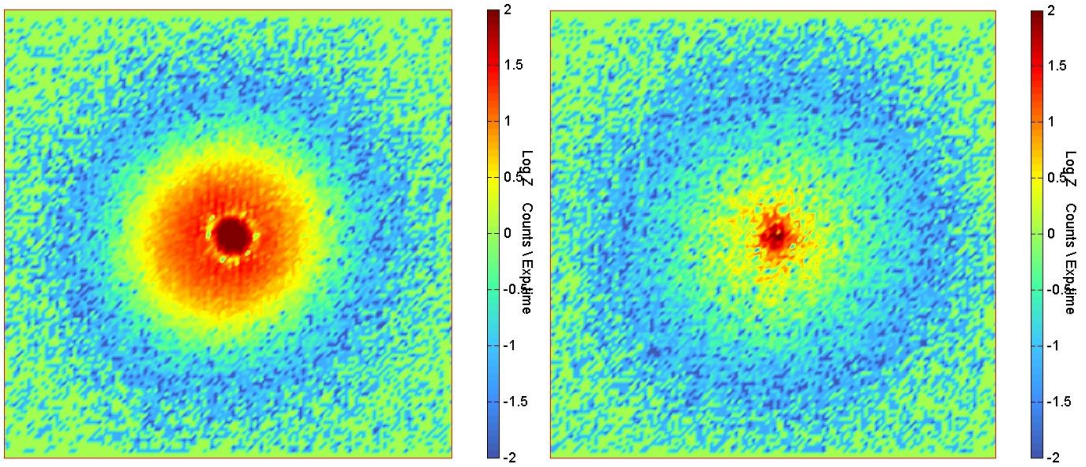

Figure 2: Difference between the intensities of neutrons initially polarized DOWN and UP (DOWN-UP) obtained on Co filled nanowires for $\mu_0 H$*=1.5T (left) and 0T (right).* ***Note that the magnetic field is applied along the nanowire axis.***

Figure 2 shows a significant increase of the magnetic contrast which is extracted from the difference between the intensities of neutrons initially polarized DOWN and UP (DOWN-UP). The Q-dependence of the difference between the intensities of neutrons initially polarized DOWN and UP (DOWN-UP) is displayed on Figure 3. It can be seen that the difference between UP and DOWN intensities reaches a maximum for 0.25T. Efforts will be made to fit such Q-profiles in order to extract magnetic form factors of such nanowires and information about reversal mechanisms in magnetic nanowires.

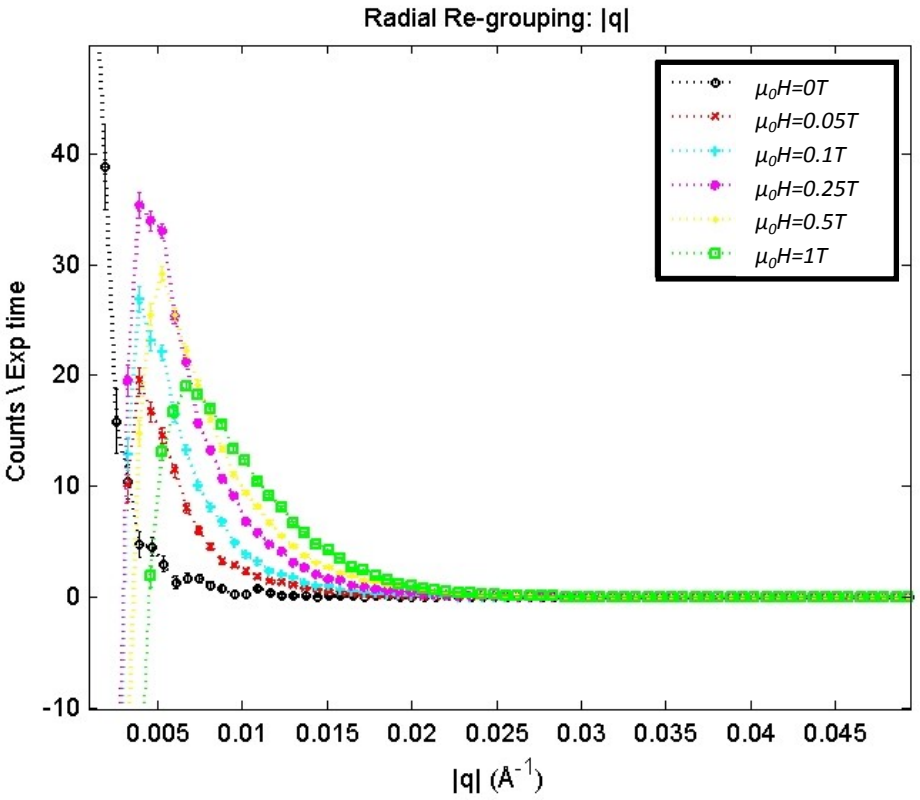

Figure 3: Q-profile of the difference between the intensities of neutrons initially polarized DOWN and UP (DOWN-UP) obtained on Co filled nanowires for different values of the applied magnetic field. ***Note that the magnetic field is applied along the nanowire axis.***

Perspectives:

Technical problems prevented us from fully investigating the samples. However such samples exhibits high scientific interest due to the very long range order of the pores, which leads to Bragg peaks shown in Figure 1.The next experiment will consist in investigating three samples with various inter-wire distances in order to put into evidence the role of dipolar interaction. In order to determine the magnetic reversal mechanisms, measurements will be made for different values of the magnetic field following the hysteresis cycle. Two configurations should be investigated: the magnetic field applied parallel or perpendicularly to the wire axis. If possible, we would like to make a comparison between measurements at room temperature and low temperature.