ESRF	Magnetic domain fluctuations observed by coherent x-ray scattering	**Experiment number:** HE-718
Beamline: ID20	**Date of experiment:** from: 03-Nov-99 to: 08-Nov-99	**Date of report:** 20-Feb-2001
Shifts: 18	**Local contact(s):** F. Yakhou	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
F. Yakhou*, F. Livet*, M. de Boissieu*, F. Bley*

Report:

Over the past few years, the availibility of high fluxes of coherent hard x-rays from third generation synchrotron sources has opened up new fields of investigations of disordered systems through the analysis of the random diffraction or "speckle" patterns. In magetic systems, a disorder is induced by the formation of magnetic domains because of crystal symmetry. While magnetic fluctuations have been extensively investigated in the vicinity of critical phase transitions, mainly by neutyron scattering techniques, very little is known on the fluctuations and coarsening of magnetic domains through a first order phase transition.

In a preliminary experiment, we have observed for the first time a static speckle pattern from magnetic domains in the type I antiferromagnetic phase of UAs, at T=100 K [1]. UAs crystallizes in the cubic NaCl structure and at $T_N \approx 123K$ the system undergoes a first order phase transition to a magnetically ordered phase with alternating ferromagnetic sheets stacked along the **c**-axis, and moments along the propagation vector.

In this experiment, we have investigated the temperature dependence of the speckle patterns from both the (001) magnetic reflection and the (002) charge peak throughout the phase transition.

A coherent bean was obtained by properly collimating the beam from a double Si(111) monochromator. The transverse coherence length could be matched to the 20 μm collimating pinhole by controlling the aperture of a set of secondary slits placed after the optics.

The energy was tuned to the Uranium M_{IV} absorption edge at 3.73 keV to take advantage of the huge resonant enhancement of the magnetic scattering amplitude. Special care was taken to lessen the number and thickness of windows along the x-ray path, which resulted in a $\approx 10^9$ ph/s integrated coherent flux at the sample and a 2000 cts/s peak intensity on the magnetic reflection at T=100 K (60 cts/s were achieved in the previous experiment).
The crystal with an (001) cleaved surface was put in a ^{4}He cryostat in horizontal scattering geometry, with incident π polarisation. Both a NaI scintillator and a direct illumination 384x576 22 μm chip CCD camera were used for optimisation and speckle recording respectively.
The speckle patterns were recorded as a sequence of 200 frames of 5 seconds each at different temperatures across the transition. At 122.69 K, the integrated magnetic intensity starts decreasing and within 0.01 K (122.7 K) reaches the background level. At the same time the mean apparent coherence of 10 subsequent frames summed up decreases, indicating that the disorder (domain) configuration is changing within the illuminated volume. The same measurements were performed on the charge speckle pattern, with no observable changes at the transition. The sample movements due to the thermal expansion of the sample stick are less than 10 μm/K and cannot account for the observed decrease of the coherence.
Given the scattering geometry, the magnetic scattering is sensitive only to those domains with moments perpendicular to the surface (**c**-domains). The speckle pattern may then arise either from phase-antiphase domains or from randomly distributed **c**-domains amongst non visible **a**- and **b**-domains, but it is clearly of magnetic origin. The decrease in coherence would then be the first direct observation of domain fluctuations and coarsening through a first order magnetic phase transition.

[1] F.Yakhou et al., ESRF Newsletter **32** 12-13 (1999)

These results have been accepted for publication in Journal of Magnetism and Magnetic Materials (proceedings for the ICM 2000 satellite meeting: Workshop on Applications of Synchrotron Light to Magnetic Materials in Campinas)