Commissioning of a Cryostat and a Successful Measurement of Resonant Magnetic Specular Reflections from a Multilayer at BL39XU

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The 12 beam shifts in late April 1999 were dedicated to the commissioning of a Cryogenics CS-201G cryostat, provided by the 1998 Beam Station *Kohdoka* Program, and to the first successful measurement of resonant x-ray magnetic specular-reflection profiles from a multilayer at low temperatures at the BL39XU. The station was equipped with a cryostat mounted on a large electromagnet on a Huber two-circle goniometer. This is a good instrument for magnetic absorption and diffraction spectroscopy measurements, but not for magnetic scattering which scans the ***q*** vector. To make standard magnetic scattering experiments feasible at BL39XU, we proposed to mount another cryostat on the Huber 424-511.1 four-circle goniometer, installed on the big arm of the two-circle Huber for polarization analysis purposes. Our proposal included placing a permanent magnet inside the cryostat to apply a field on the sample at low temperatures. The circularly polarized primary X-ray beam passed through the air gap of the electromagnet and was directly guided to the 424-511.1, on which the CS-201G was mounted in a horizontal position. The proposal was accepted and the cryostat delivered in March 1999.

Prior to the experiment, we incorporated a control code for the diamond phase plate in the BL39XU SPEC system.

We measured superlattice Bragg reflections from an $[Fe(3.5\ nm)/Gd(5.4\ nm)]_{15}$ multilayer by flipping the helicity of a circularly polarized X-ray beam of energy tuned close to the Gd L_3 edge. An in-plane field of 2.4 kOe was applied on the Fe/Gd sample in the $\phi = 0^\circ$ geometry, where the field was parallel to the plane of scattering. Dropping down to 140 K from RT took ~3 hours. This time can be shortened by using a turbo-molecular pump in place of the rotary pump used. We first placed a broad receiving slit in front of an NaI detector and made θ-2θ scans during which the helicity of the probing beam was flipped. The difference intensity, $I(+)$-$I(-)$, showed positive and negative peaks at the q's for the second and third Bragg reflections, and is in agreement with our previous measurement [1]. The peak signs were reversed, with the peak heights conserved, by rotating the whole cryostat by 180° on the Huber ϕ axis. This confirms a proper charge-magnetic interference scattering measurement. The receiving slit was then narrowed to 0.25 mm to measure the four Bragg peaks, which showed relative peak heights in good agreement with the previous measurements. We also observed finite difference Braggs peaks in the $\phi = 90^\circ$ geometry. The lowest temperature tested was 15 K, at which the signs of the second, third and fourth difference Bragg peaks were opposite to those at 140 K, while the $\phi = 90^\circ$ peaks kept the same signs as at 140 K. This is a new finding, which can be the first observation of the surface-twisted state predicted for the Fe/Gd multilayer.

An extension of the detector arm of the Huber 424-511.1 will improve the signal-to-noise ratio and make the BL39XU an excellent station for X-ray magnetic scattering experiments with a highly intense circularly polarized beam.

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References

[1] N. Ishimatsu *et al.*, Phys. Rev. **B 60** (1999) 9596.