Experimental report number: 28-01-119

The aim of our study of $TmNi_2B_2C$ was to check if Ni contributes to the ordering of Tm by measuring the magnetic form factors around T_C using non-resonant diffraction, and to measure the magnetisation in the superconducting state. For Bragg reflections of the type *hh*0, the magnetic signal is proportional to $(2f_{Tm}+4f_{Ni})$ for h even and to $(2f_{Tm} - 4f_{Ni})$ for h odd. Thus, the individual form factors can be deduced from the data. Cho and coworkers [1] found that the magnetic moment of Tm in the normal state is ~7.5 μ_B. The nickel moment should not exceed that of its free ion value of ~0.6 μ_B and is expected to have a minor contribution to the form factor.

The experiment was performed using the non-resonant monochromatic beam technique. The *c*-axis was oriented in the vertical direction so that the *hh*0 type reflections were in the horizontal plane. The circular polarisation required to allow the magnetic and the charge scattering to interfere, was produced by viewing the incident beam 200 µm above the orbital plane. The charge scattering was minimised by scattering at 90° in the horizontal plane. The sample's magnetisation was reversed using the XMaS 1 Tesla electromagnet in order to produce the necessary difference measurement. The absolute value of the magnetic field was 1 T and applied perpendicular to the *c*-axis. The corresponding superconducting temperature was 8 K [1]. The sample was cooled down with the low temperature displex. The diffracted intensity was recorded with a cyberstar detector, which is linear up to 100,000 cps.

The circularly polarised radiation required to allow the magnetic and the charge scattering to interfere, was produced by looking at the incident beam 100 µm (viewing angle ~2 µrad) above the orbital plane. The charge scattering was minimised by scattering at 90° in the horizontal plane. The sample's magnetisation was reversed using the XMaS 1 Tesla electromagnet in order to produce the necessary difference measurement. The low temperature was reached using the standard displex. Although the aim of the experiment was to measure the flipping ratio in the two geometries described in [2], in order to separate the spin and the orbit form factor, we only measured it with the sample magnetised perpendicular to the incident beam as shown in Figure 1. Indeed, the majority of the beamtime was wasted because the beam was very unstable preventing from measuring any small magnetic signals, which are very sensitive to sudden change in polarisation induced by the movement of the orbit.

In this geometry, the flipping ratio is proportional to the total form factor (equation A.1) by applying the magnetic field perpendicular to the incident beam.

$$R(\alpha = 90°) = -2\tau \ f_p \frac{F_S + F_L}{F_C} \qquad \text{(A.1)}$$

The flipping ratios measured over 12 hours are shown in Figure 2. They were obtained with the magnetic field reversed every minute. The error bars were calculated as the standard deviation of the mean flipping ratio in order to take into account for the beam fluctuations. If the errors had been calculated from the statistical errors, the entire measurements would have taken a few minutes at 10,000 cps. The measurements were badly affected by the movements of the beam, which explains the poor statistics. The measurements were performed both in the normal and superconducting phases. Despite the huge error bars, they seem to suggest that an induced moment persists about T_C. These were the first induced ferromagnetic form factors measured with x-rays in the superconducting state.

References:

[1] B.K. Cho *et al.*, Phys. Rev. B, **52**, 3676 (1995).

[2] L. Bouchenoire *et al.* Experimental report 28-01-074 (2000)

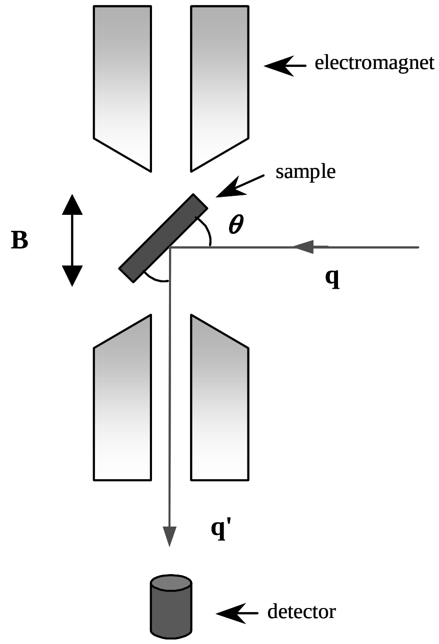

Figure 1: Horizontal 90˚ scattering with the magnetic field applied perpendicular to the incident beam.

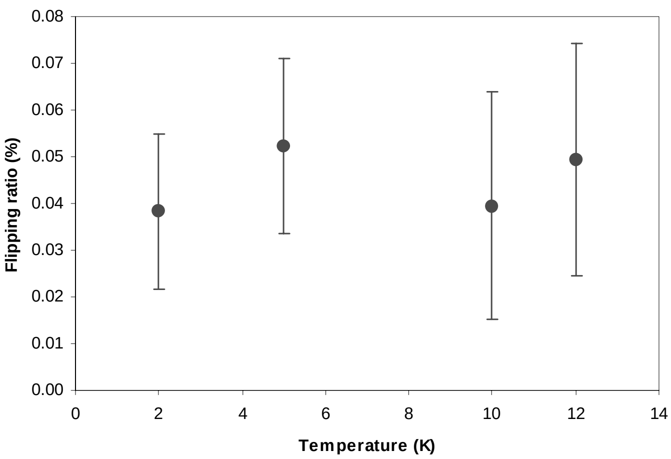

Figure 2: Flipping ratio of the (220) Bragg reflection around T_C with a 1T field applied perpendicular to the *c*-axis.