Experiment number 28-01-801:

The paper written by Hill & Mc Morrow [1] has been successfully used in resonant scattering studies to look at spherical systems. However, it could not account for ″forbidden″ reflections arising from the joint effect of magnetic ordering (magnetisation) and local crystal field (anysotropy). Mirone et al. [2] extended the theory to the non-spherical case. For systems like Ho having a flat spiral structure propagating along the c-axis, a modulation along the (00L) direction with L=2n+1 is predicted. Magnetic reflections are also expected at L= L=2n+1±τ positions. The resonant scattering cross-section can be expressed as follows for the magnetic satellites:

$$F_{E_1E_2}^{res} = 6i\, F_{E_1E_2} \begin{pmatrix} 0 & c^2(\theta)c(\tau.r + 2\phi) \\ c^2(\theta)c(\tau.r + 2\phi) & 0 \end{pmatrix}$$

where F_{E1E2} is the E1-E2 interference scattering term and ϕ is the azymuth angle between the scattering plane & the *x*-axis.

In a previous experiment [3], we measured the Ho(003) and (003±τ) temperature dependence and compared it to the (004) and (004±τ). We found that the magnetic modulation of both the (003) was identical to that for the (004). The experiment was carried out with σ incident polarisation.

The aim of the present experiment was mainly to measure the energy dependence of the (003±τ) in σ→π at the L3 edge (Figure 1). But before doing so, we measured (00L) reflections and satellites at 22K (Figure 2). At this temperature, the magnetic modulation vector, τ, is smaller than 0.2, which enabled us to prove that indeed we were measuring the (003+τ) and (003-τ) and not the (004-4τ) and (002+4τ), respectively. Note that no relative scaling is implied, only the x-axis (L in units of c*) should be taken into consideration. The plot shows that the (001) and (005) and their respective satellites also exist as predicted by Mirone [2]. All these ″forbidden″ reflections are very much weaker than the other (00L±τ) with L even (3 orders of magnitude less intense) and only exist in σ→π. On the other hand, the (003) present in both σ→σ and σ→π is about 8 orders weaker than the (004) Bragg peak.
The energy line shape of the (003±τ) exhibits 2 peaks, one above and one below the white line. We also measured the energy line shape of the (004±τ) for comparison. The low energy peak of the (003±τ) occurs at 8.065keV, i.e. 3 eV below that of the (004±τ). For the latter, the pre-edge peak originates from hybridization between the 5*d* and 4*f* states [4]. The E1 and E2 scattering factors were extracted in a separate work on Ho (00L) reflections with L even [4] and contradicted previous studies which attributed this peak uniquely to quadrupole excitations. For the (003±τ), the two resonant peaks originate from E1-E2 interference. The F_{E1E2} scattering factor could be extracted by also measuring the energy line shape across the Er L3 edge for the (001±τ) and (005±τ) satellite reflections. However, this exercise would be time consuming as for example the (003+τ) is 3 order of magnitude smaller than the (004+τ).

References:

[1] Hill & McMorrow, Acta. Cryst. A **52**, 236 (1996)
[2] A. Mirone *et al.*, Acta Crystallogr Sect A. **63**, 348 (2007)
[3] Experimental report 28-01-757
[4] Bouchenoire *et al.*, submitted to PRL (2007)

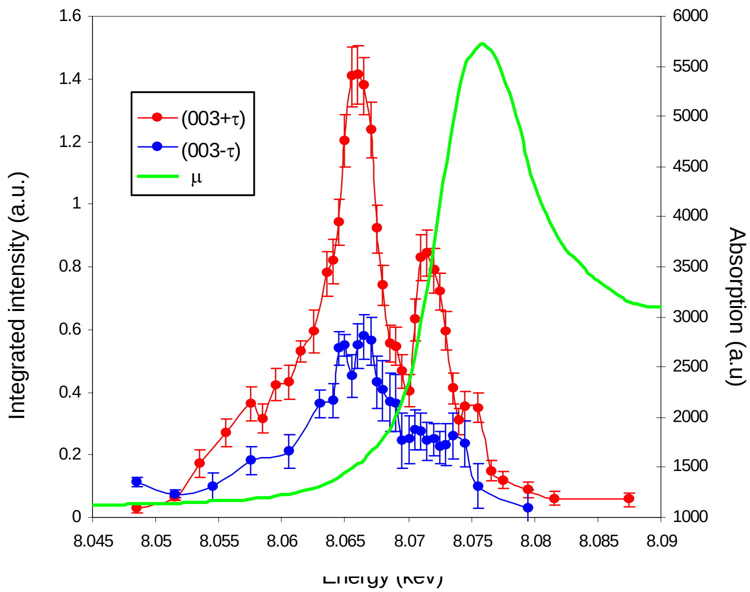

Figure 1 :

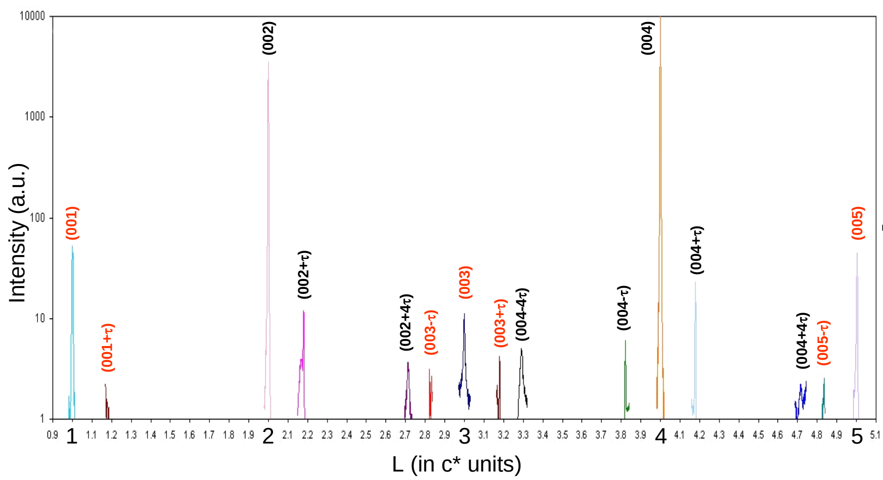

Figure 2 : Ho (00L) reflections measured at 22K