ESRF

Experiment title: Investigation of the High Energy Cross-section for Magnetic Compton Scattering	Experiment number: HC-289
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Report:

The first objective of this experiment was to study the cross-section for magnetic Compton scattering at high energies. The cross-section has been developed in the approximation that $E_i << mc^2$ [Grotch et al. Phys. Rev. A27, 243, 1983, Lovesey Rep. Prog. Phys. ,257, 1993 and references therein] and also by Lipps and Tolhoek [Physics, 20, 85, 395] over a large range of energies but for a free electron. Each of these treatments consist of an interference term between charge and magnetic scattering amplitudes, a pure charge term and a pure magnetic term which is negligible at low energies but whose contribution is unsure at higher energies. The interference term which is measurable allows the separation of the charge amplitude from the magnetic scattering amplitude. The second objective of the study was to determine an optimum energy for performing magnetic Compton experiments as the magnetic effect is typically very small, but according to Lipps and Tolhoek the interference term increases linearly with the magnitude of the scattering vector which also increases with incident energy. So higher incident energies lead to larger magnetic effects (typical effects have been of the order of <1%), as well as improved resolution for the experiment which is dominated by the energy resolution of the solid state detector.

Circularly polarised radiation was extracted from the asymmetric Wiggler using the ‘inclined view’ method, with the sample situated 2mm above the orbital plane at 70m from the source. The x-rays were monochromatised using the crystal cut 331 reflection of a Si 220 bent crystal in Laue geometry. The Bragg angle was tuned to give incident energies of

84.4keV, 167.2 keV and 256. OkeV. The sample, which was chosen to be a Fe [1 11] crystal due to its large magnetic effect relative to other ferromagnets and its well known magnetic Compton lineshape, was clipped between the pole pieces of an electromagnet and arranged in a transmission scattering geometry so that the magnetic field and the scattering vector were collinear. The magnetic Compton profiles were obtained by taking the difference between the spectra acquired with the magnetic field in alternate directions. Figure 1 shows the magnetic Compton profiles at each of the incident energies used. Each profile has been normalised to an area of $2.07\mu_B$ from -8 to +8a.u. The lineshapes are identical implying that even at higher energies there is still no contribution from the pure magnetic term. The magnetic effect increased with increasing energy, proportionally to the magnitude of **K** the scattering vector, giving an increase in the size of the effect of almost a factor of 3 at 256keV. Another advantage in going to higher energies was the improvement in resolution which was 0.5 la.u., 0.42a.u. and 0.39a.u. for the 84.4keV, 167.2keV and 256.0keV measurements respectively, compared to typical resolution values with this type of set-up of 0.6-0.7a.u. Due to poor statistics for the 256.0keV measurement, the magnetic Compton profile measured with an incident energy of 167.2keV and momentum resolution 0.42a.u. was chosen to compare with the latest theoretical profile, a FLAPW calculation made by Kubo and Asano [Phys. Rev. B. 42 No 74431 1990] and is shown in Figure 2. This is the best momentum resolution measurement of Fe [1 11] made to date and shows clearly features which have not been visible experimentally until now, including a central dip of about 60% of the total height of the profile - beforehand this central feature was smeared out as a result of poor resolution, and shoulders at p_z=0.5a.u. and 4a.u. are clearly visible.

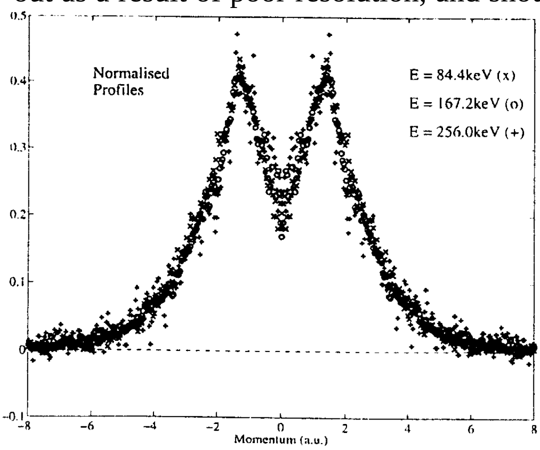

Figure 1

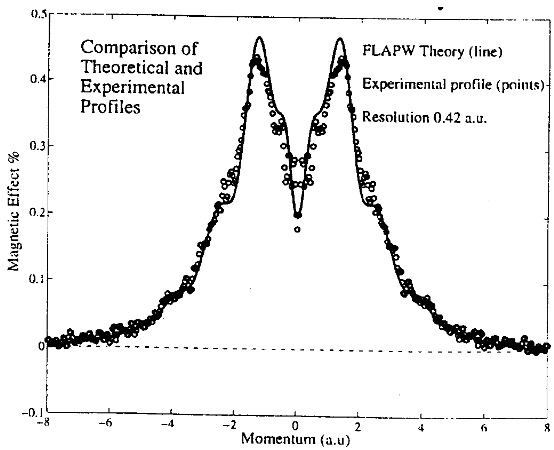

Figure 2

This study shows that the size of the magnetic effect increases proportionally to the magnitude of the scattering vector which increases with incident energy, and that at least up to energies of ~250keV, there is no background contribution from the pure magnetic term. This is in agreement with the cross-section term given by Lipps and Tolhoek. It is clearly beneficial to do magnetic Compton measurements at high energies as there is an increase in magnetic effect and an improvement of ~25% in momentum resolution. An optimum energy for magnetic Compton measurements should be high enough to achieve good resolution and a larger magnetic effect, without introducing a measurable pure magnetic background. Up to E=250KeV, this is the case but the situation is still unclear at energies of 500keV and higher. This work is currently being prepared for publication.