EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **Asymmetric Compton Scattering**	**Experiment number**: HE-2134
Beamline: ID15B	**Date of experiment**: from: 12/4/06 to: 18/4/06	**Date of report**: 18/4/06
Shifts: 18	**Local contact(s)**: V Honkimaki, T Buslaps	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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D Laundy *(CLRC Daresbury Laboratory, UK)*

M Golshan *(CLRC Daresbury Laboratory, UK)*

Report:

The primary goal of this project is to assess the magnitude of asymmetry in the electron momentum distribution in non-centrosymmetric ferromagnetic materials by means of Compton scattering. Compton scattering measures a one-dimensional projection of the total electron momentum density – the Compton Profile, $J(P_z)$ – and these functions are generally taken to be symmetric. It can be shown that for systems that exhibit either spatial (inversion) or time-reversal symmetry, $\rho(\mathbf{p}) = \rho(-\mathbf{p})$, and so $J(P_z) = J(-P_z)$. For systems that have neither inversion or time-reversal symmetry, such as a non-centrosymmetric ferromagnet, there is no general argument to require a symmetric profile. A difference measurement, whereby the Compton profiles for oppositely magnetized samples are subtracted, should eliminate the common symmetric part and reveal a purely antisymmetric difference profile.

There is currently considerable interest in materials that violate both space and time symmetry, and lead to phenomena such as the magnetoelectric effect and nonreciprocal x-ray gyrotropy [1]. Compton scattering is a relavely 'clean' probe, where the measured differential cross-section bears a simple relationship to ground-state densities. Unfortunately, no theory exists to predict the magnitude of the asymmetry.

The sample chosen for this pilot study MnSi, which crystallizes in the cubic, non-cenrosymmetric space group $P2_13$. The magnetic structure of this material, below Tc=29.5 K is a spiral with propagation vector along 111. However, application of an external field of

~0.6 T forces the moments to align parallel to the field direction. Thus, with the above temperatures and applied field, MnSi exhibits the required properties for the observation of anisotropic Compton scattering.

The experimental geometry for measuring asymmetric Compton scattering is similar to that adopted for magnetic Compton scattering [2], except that the polarization of the 88 keV photon beam is *linear* and a ±1T magnetic field was aligned *perpendicular* to the scattering vector. Measurements were carried out with the sample 3-fold axis vertical and the magnetic field perpendicular to this axis and the momentum transfer vector, **Q**. First results show that if such an asymmetry exists then its magnitude is not greater than one part in 20,000 of the symmetric profile. The results are not inconsistent with an effect of this size, and indeed there is a hint of an antisymmetric difference in the accumulated data, although the signal to noise ratio is not sufficient to assert a positive result with any confidence.

For the second part of the study, the experimental set-up was configured for magnetic Compton scattering: polarization was set to 80% circular and the field aligned parallel to **Q**. Measurements were taken at T~20K and T~35K. Since the magnetic phase transition vanishes at high field [3], the total magnetization of the sample decreases continuously as temperature is increased. This is reflected in the reduction of the magnetic difference with increasing temperature. There is still a sizeable spin moment at T=50K - well above the magnetic ordering temperature of T=29.5K in the absence of an external field. The magnetic Compton profiles are qualitatively similar to other itinerant ferromagnets, where one finds a central dip that is characteristic of negatively polarised conduction electrons.

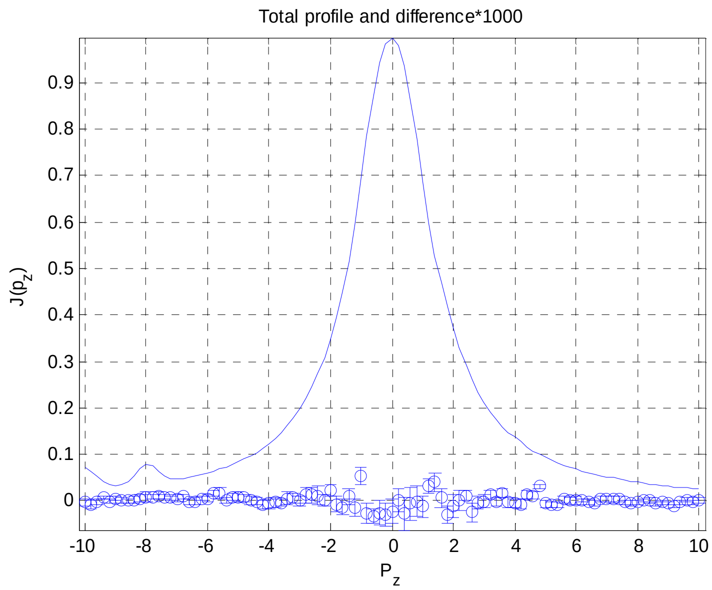

Figure 1: Asymmetry in the Compton profile of MnSi. Any asymmetry should appear as an antisymmetric difference spectrum. The data indicate that such an effect must be no larger than 5x10^{-5} of the symmetric component.

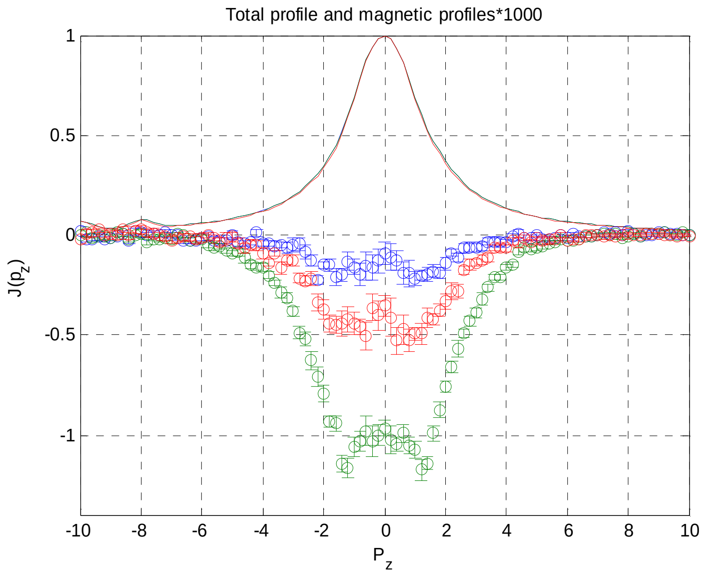

Figure 2: The magnetic Compton profiles of MnSi, B=±1 T, T=20K (green), T=35K (red), T=50K (blue).The scaled total profile is solid red.

References

[1] J Goulon *et al*, Phys.Rev.Lett. **85**, 4385 (2000)

[2] S W Lovesey and S P Collins *X-ray Scattering and Absorption by Magnetic Materials* (Oxford: Clarendon) (1996)

[3] G Shirane et *al*, Phys.Rev. **B28** 6251 (1983)