ESRF	**Experiment title:** Temperature dependence of the spin density in ferromagnetic gadolinium	**Experiment number**: HE778
Beamline: ID15a	**Date of experiment**: from: 31st May 2000 to: 5th June 2000	**Date of report**: 15/08/2000
Shifts: 18	**Local contact(s)**: Dr J.E. McCarthy	*Received at ESRF:*

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Report:

Gadolinium is the archetypal spin only 4*f* moment ferromagnetic system with T_C = 293K, at 232K the ferromagnetic structure exhibits a canted phase with the spins at a maximum of 65° from the c axis (easy axis). The temperature dependence of the conduction electron polarisation in ferromagnetic gadolinium has been the subject of several investigations: The reasons for this are twofold 1. The ½ filled S state 4*f* moment in gadolinium is spatially localised, thus the interaction between the polarised conduction band electrons (which are itinerant in nature) and the local moment are essential in order to have a ferromagnetic ground state. It is already well understood that the Gd system exhibits indirect (RKKY type) exchange between neighbouring local moments. 2. Recent photoemission experiments have implied that the itinerant electron moment is stable with respect to the disordering 4*f* localised moment. The temperature dependence of the itinerant conduction band electrons remains an interesting problem in condensed matter magnetism.

The aim of the experiment was to investigate systematically both the 4*f* moment and the itinerant conduction band moment as a function of temperature using magnetic Compton scattering. Magnetic Compton scattering (MCS) is an established technique, and has proved useful for investigating the momentum distribution of the bulk spin moment of magnetic materials. MCS measures a 1D projection of the momentum density of the spin-polarised electrons in a material by the use of circularly polarised x-rays. It is an ideal tool for investigating spin polarised band structures. Since the 4*f* moment in Gd is well localised one may easily model it using relativistic Hartree-Fock free atom Compton profiles, separating the local and the itinerant moments from the experimental magnetic Compton profile is therefore simple. The magnetic Compton profiles (MCPs)of the C axis direction (0001) of single crystal Gd were measured at 4 different temperatures namely 15K, 50K, 150K, 270K. The loss of 5 shifts due to beam loss, and a front end vacuum fault, resulted

in a premature end to the experiment and lack of integration time for the normalisation data, the loss of time was compound by an obscure error in the data collection program written for us at the ESRF the data for one of the magnetic field directions was repeatedly overwritten rather than summed in the raw datafile. This was not discovered until near the end of the subsequent experiment(HE780). The statistical errors were poor and measuring times were subsequently much longer than would otherwise have been necessary, consequently,only 4 temperatures were measured with a reduced statistic on each.

The experimental magnetic Compton profiles are presented in Fig.1-4. the data are of a lower statistical quality than we had hoped for as a result of the macro error, it is not yet certain whether further analysis will be successful. The results of an initial data analysis in order to separate the 4*f* and itinerant moments are presented in table.1.

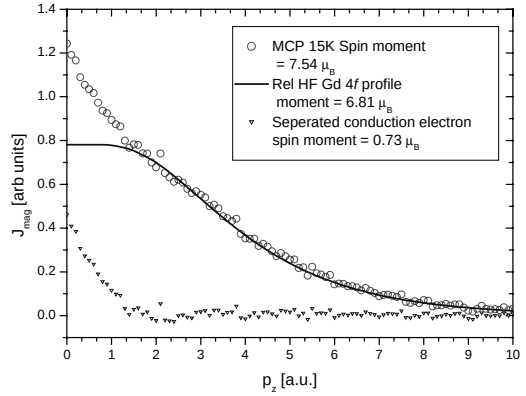

Fig. 1. MCP Of Gd (0001) at 15K

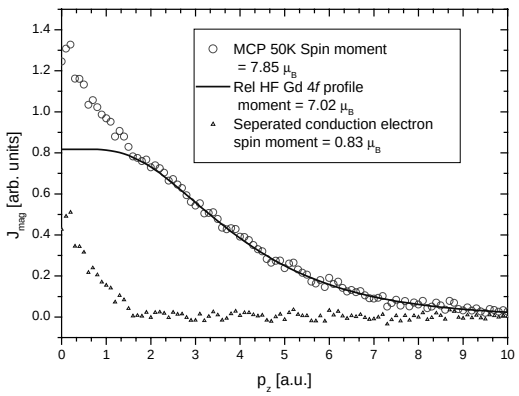

Fig. 2. MCP Of Gd (0001) at 50K

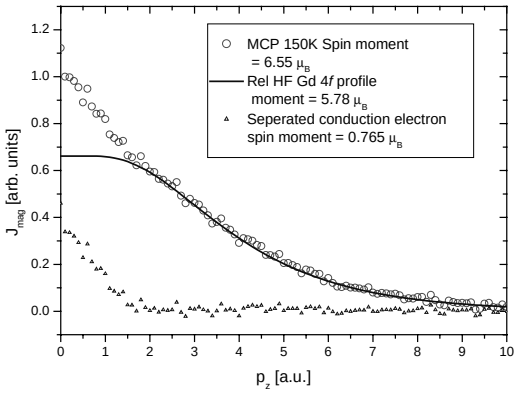

Fig. 3. MCP Of Gd (0001) at 150K

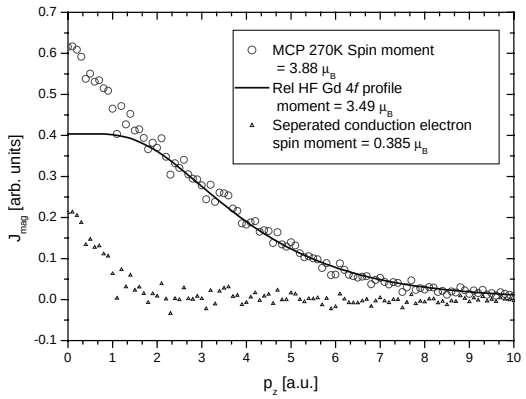

Fig. 4. MCP Of Gd (0001) at 270K

Gd	MCS exp Spin $[\mu_B]$ $\pm 0.1\mu_B$	4*f* moment $[\mu_B]$ $\pm 0.1\mu_B$	Implied Itinerant moment. $[\mu_B]$ $\pm 0.1\mu_B$
15K	7.54	6.72	0.73
50K	7.92	7.02	0.83
150K	6.55	5.69	0.76
270K	3.88	3.472	0.38

Table 1.

Immediate conclusions are that the itinerant moment does not appear to be stable with respect to the disordering 4*f* local moment but does in fact scale as a function of temperature reducing from $\approx 0.77\mu_B$ at 15K to $0.35\mu_B$ at 270K, although the variation is not linear the poor statistic ensures that any conclusions remain tentative.