ESRF	**Experiment title:** Magnetic field dependence of the spin density in $SmMn_2Ge_2$	**Experiment number**: HE905
Beamline: ID15A	**Date of experiment**: from: 20/09/00 to: 28/09/00	**Date of report**: 02/03/01
Shifts: 21	**Local contact(s)**: Joanne McCARTHY	*Received at ESRF:*

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Report:

The spin moments of the layered ternary compounds $SmMn_2Ge_2$, was measured as a function of applied field on the high energy beamline ID15A using the magnetic Compton scattering technique. Our earlier results of measurements made on $SmMn_2Ge_2$ using magnetic Compton scattering (ID15A - IHR time) showed large spin and orbital moments present in the low temperature ferromagnetic phase (<105K), whilst the existence of a Sm *4f* spin moment was observed for the first time in the high temperature ferromagnetic phase (155K to 345K). These earlier results were published as a Rapid Communication in Phys. Rev. **B** **62** R6073. The purpose of this experiment was twofold

1. To determine whether the Sm sublattice in the low temperature phase is ferromagnetically ordered above 30K in a small applied field, as previous low field magnetisation measurements show a phase transition at this temperature which is attributed to ferromagnetic order on the Sm sublattice.
2. To confirm that, in the high temperature phase, the observed Sm site spin moment was not merely induced by the applied magnetic field (inherent to this type of experiment) and that that this observed spin moment was present in the ground state.

This compound is one example of naturally layered materials where the magnetic ordering depends critically on the Mn-Mn separation. For values above 2.87Å the compounds are ferromagnetic and below it they are antiferromagnetic. In $SmMn_2Ge_2$ the spacing is close to this borderline value and it is not surprising that it exhibits both re-entrant ferromagnetism and antiferromagnetism, the latter in the range 105-155K. It also shows GMR behaviour although with an opposite sign to the norm. Understanding its magnetic behaviour is of clear relevance to studies of artificial multi-layered GMR materials.

The data can be analysed in terms of Mn *3d* and Sm *4f* orbitals. At large momenta the spin resolved Compton profile must be well fitted by free atom modelling of the momentum density. This fact arises from the following energy considerations: the second moment of the Compton profile is proportional to the kinetic energy of the system and, via the virial theorem, the total energy. The small energy differences between free atom and solid that result in cohesion are necessarily associated with the low momentum region of the profile (p_z < 1.5 a.u.). This means that the high momentum region can be analysed confidently in terms of free atom Compton profiles. The Compton profile of a Sm *4f* electron is some 50% broader than that of a Mn *3d* electron and thus the MCP can be uniquely analysed at high momentum in terms of the *4f* and *3d* contributions this is demonstrated in ***Figs. 1*** and ***2*** where the MCP's for $SmMn_2Ge_2$ are analysed in terms of separate Mn *3d* and Sm *4f* contributions at 13K and 40 K respectively. The total spin moments, as well as the individual *4f* and *3d* contributions for each at the applied fields used are given in **Table 1** and **2**. The same approach is taken with the 230K data, here even though the Sm *4f* contribution is much smaller the fit to the experimental data is improved by including a *4f* contribution. **Fig. 3.** Shows the result of the measurements made as a function of field demonstrating that the technique may be used to examine the sublattice magnetisation as a function of magnetic specie in $SmMn_2Ge_2$. The results of the data analysis are tabulated in **Table 3.**

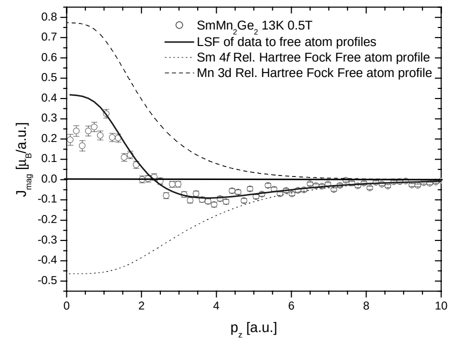

Fig.1. MCP for $SmMn_2Ge_2$ at 13K

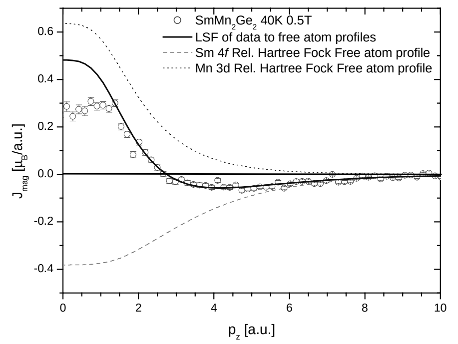

Fig.2. MCP for $SmMn_2Ge_2$ at 40K

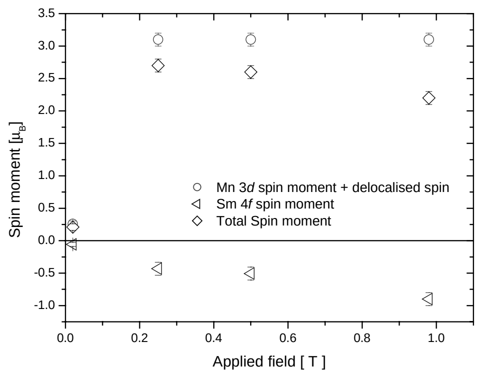

Fig 3. Spin sublattice magnetisation for $SmMn_2Ge_2$ at 230K along the 001 easy direction

Data taken at 13K.	1T*	0.5T	0.05T
Total Spin	-0.01(3)	0.01(3)	0.05(5)
Mn + delocalised Spin	3.5(1)	3.6(1)	1.07(3)
Sm Spin	-3.5(1)	-3.6(1)	-1.02(4)

Table 1. Summary of spin moments for $SmMn_2Ge_2$ 13K * denotes value from previous experiment.

Data taken at 40K.	1T*	0.5T	0.02T
Total Spin	0.02(3)	0.01(9)	0.09(4)
Mn + delocalised Spin	3.4(1)	2.96(8)	0.41(3)
Sm Spin	-3.4(1)	-2.96(5)	-0.32(2)

Table 2. Summary of spin moments for $SmMn_2Ge_2$ 40K * denotes value from previous experiment.

Data taken at 230K.	1T	0.5T	0.25T	0.02T
Total Spin	2.2(1)	2.6(1)	2.7(1)	0.21(5)
Mn 3d + delocalised Spin	3.1(1)	3.1(1)	3.1(1)	0.26(5)
Sm 4*f* Spin	-0.9(1)	-0.5(1)	-0.4(1)	-0.05(3)

Table 3. Summary of spin moments for $SmMn_2Ge_2$ 230K

Immediate conclusions are:-

1. There is no evidence for the Sm sublattice ordering is observed at 30K, our measurements confirm that the Sm sublattice is ordered throughout the low temperature ferromagnetic phase T_c = 105K.
2. The results taken indicate that the Sm sublattice order observed in earlier measurements in the high temperature ferromagnetic phase was not induced by the 1T applied field used to make the measurements.
3. A Sm moment is observed in applied fields as low as 200G.

Referring to **Fig 3.** It is clear that the Sm sublattice is not magnetically soft in the high temperature ferromagnetic phase of the material. By comparison with squid magnetisation measurements the Sm orbital component will be determined as it is thought to play a key role in the high temperature phase.