

# Magnetic Compton scattering in high fields at the ESRF: spin and orbital moments in $\text{Ca}_3\text{Co}_2\text{O}_6$ .

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We report on the development and use of high-field magnetic Compton scattering measurements at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. To achieve this, an Oxford Instruments Spectromag cryomagnet was purchased and installed for use on the high energy beamline, ID15. The magnet can provide magnetic fields up to 9 Tesla, at temperatures down to 1.3K, whereas previously the sample environment was limited to a maximum field of 1T, with temperatures down to 2.2K. The commissioning of this new facility was successful [1], and it will vastly increase the range of problems that can be addressed using magnetic Compton scattering.

We present results for our recent research on the spin and orbital moments in  $\text{Ca}_3\text{Co}_2\text{O}_6$ .  $\text{Ca}_3\text{Co}_2\text{O}_6$  is a low dimensional, spin chain compound which shows geometrical frustration, and a number of metamagnetic transitions [2]. A recent calculation [3] suggested that the Co 3d orbital splitting would lead to a significant unquenched orbital magnetic moment. Furthermore, a large O 2p spin moment was predicted. Table 1 shows these results together with those of a recent experimental XMCD study, and the results from our magnetic Compton scattering experiment. The XMCD experiment [4] at the Co edges was analysed using sum rules and simulation (denoted A and B respectively in the table) giving differing orbital moments, neither agreeing with the prediction. In our study, using magnetic Compton scattering, we measured the spin moment to be  $(3.93 \pm 0.04)\mu_B$ , a value which was obtained unambiguously. At 5T and 7T, an orbital moment of  $(1.3 \pm 0.1)\mu_B$  was determined by comparison with the bulk magnetisation of  $(5.2 \pm 0.1)\mu_B$  measured on the same sample. Our value agrees well with the sum-rule derived XMCD result, rather than the theory and the simulation, which over-estimate the orbital moment [4]. Our data are indicative of an O 2p moment of approximately  $0.9\mu_B$ .

	Spin	Orbital	Total	Magnetisation
Theory [3]	Co 2.99 O 1.3	1.57 -	5.9	
XMCD (A) [4]		1.2		4.8
XMCD (B) [4]	3.6	1.7	5.3	4.8
Compton	$3.93 \pm 0.04$	$1.3 \pm 0.1$		$5.2 \pm 0.1$

Table 1. Magnetic moments for  $\text{Ca}_3\text{Co}_2\text{O}_6$  in units of  $\mu_B$  per formula unit. The spin moment from magnetic Compton scattering is obtained directly, and the orbital moment by comparison with the bulk magnetization.

## References

- [1] C. Shenton-Taylor *et al.*, J. Phys.: Condens. Matter **19** 186208 (2007).
- [2] Y.B. Kudasov, Phys. Rev. Lett., **96** 027212 (2006); R. Soto *et al.*, Phys. Rev. B **79** 184422 (2009).
- [3] Hua Wu *et al.*, Phys. Rev. Lett., **95** 186401 (2005).
- [4] T. Burnus *et al.*, Phys. Rev. B **74** 245111 (2006).

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