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Report:

The magnetism of the $GdMn_2$ Laves phase was investigated by non-resonant and resonant x-ray magnetic scattering at the L_2 and L_3 Gd absorption edges (7.928 keV and 7.242 keV respectively). Because of the large Gd neutron absorption cross-section, the magnetic structure has not been solved by neutron diffraction so far and the propagation vector was not known, which has made the experiment a very difficult and challenging one.

An 8 mm long cylindrical single crystal (1.5 mm in diameter) was cut with a [111] surface normal and put in a closed-cycle refrigerator. The experiment was performed on the Magnetic Scattering beamline ID20 in vertical scattering geometry. A propagation vector τ=[2/3 2/3 0] was found and the related integrated intensity of the (331)+τ superstructure reflection was followed in temperature up to T_N=100 K where the reflection disappears. The expected anomaly at T_c=40 K in the temperature dependence that would result from a reorientation of the Gd sublattice [1] could not be detected within the experimental error.

The polarisation of the diffracted beam was then analysed by the (006) reflection of a Pyrolytic Graphite single crystal and the energy dependence of the peak intensity of selected reflections was checked by means of energy scans in both σ–σ and σ–π channels. No resonant signal was detected in the σ–σ channel at both L_2 and L_3 edges, indicating that the quadrupolar contribution to the scattering is either extremely weak or inexistent. At the L_3 edge the resonant signal is clearly of dipolar origin, and thus can be related directly to the polarisation of the Gd *5d* band. If one takes for granted that the Gd sublattice is ferromagnetically ordered above 40 K [2], the temperature dependence of the magnetic reflections indicates that the 5d band is polarised by the Mn sublattice (a resonant signal is observed up to T_N=100 K).

The resonant and non-resonant integrated intensities of a set of magnetic reflections corresponding to a center of zone in the (*hhl*) plane and to the propagation vector τ (+ symmetry equivalent) were also measured in both polarisation channels. These intensities were then reduced to squared magnetic structure factors after correction for absorption (as deduced from fluorescence measurements) and Lorentz factor, for comparison with various structure models. A striking feature is that for all the reflections the σ–σ intensity is stronger than the σ–π by nearly two orders of magnitude, indicating a large component of the spin moment perpendicular to the scattering plane. This would be consistent with moments along the [001] direction. The conclusion nevertheless is not straightforward because all Mn *3d*, Gd *4f* and *5d* moments contribute to the non-resonant scattering amplitude. Moreover, the intensities of a set of reflections corresponding to symmetry -equivalent propagation vectors seem to indicate that the domain population is not equivalent, which makes the analysis even more complex. No simple magnetic structure is consistent with both resonant and non-resonant intensities; these data are still being analysed and will be compared to polarised neutron data being currently analysed [2].

In conclusion, measurements were performed at both the L_2 and L_3 Gd absorption edges. Though the structure has to be solved yet, some progress has been made: an antiferromagnetic propagation vector [2/3 2/3 0] was found for a magnetic structure that disorders at T_N=100 K. The Gd *5d* band seems strongly polarised by the Mn *3d* sublattice and no evidence was found for a reorientation of the Gd sublattice at 40 K.

Similar measurements at the Mn K-edge appear necessary to help solving the complex magnetic behaviour of the frustrated $GdMn_2$ compound.

References:

[1] J. Przewoznik, J. Zukrowski, K.Krop, J. Magn. Magn. Mater. 119 (1992) 1559

[2] R. Ballou et al, private communication