Lattice-Spin Correlations in the Itinerant Ferro-Magnet $Sr_4Ru_3O_{10}$

F. Weickert, L. Civale (MPA-CMMS, LANL, Los Alamos); M. Jaime (MPA-CMMS, NHMFL, LANL, Los Alamos); E. Carleschi, A. Strydom (University Johannesburg, South Africa)

Introduction

$Sr_4Ru_3O_{10}$ (SRO) is a member of the Ruddlesden-Popper series with n = 3. It crystallizes in a monoclinic crystal structure with P_{bam} symmetry. For temperatures below 105 K, ferromagnetic (FM) order along the crystallographic c-axis is observed [1]. Neutron scattering experiments identified 12 different Ru^{4+} positions in the crystal structure carrying two different magnetic moments 1.59 μ_B, and 0.92 μ_B [2]. For T < 50 K, metamagnetic (MM) behavior occurs for magnetic fields parallel to the magnetic hard-plane (*ab*) that cannot be described by a simple spin reorientation process [1]. Fig. 1 (left) shows the magnetization versus magnetic field up to 7 T, at T = 1.8 K in both field directions. A typical FM hysteresis loop is observed for $H \parallel c$ with a saturation value of 1.5 μ_B /Ru that is significant smaller than the expected Ru^{4+}, S = 1 spin state (2 μ_B/Ru). By applying fields $H \parallel ab$, a MM transition takes place at $\mu_0 H \approx 2$ T, and the polarized magnetic moment carries only 1.25 μ_B/Ru. Several aspects of the metamagnetism in SRO are currently not understood. i) Where is the missing magnetic moment (0.5 μ_B for $H \parallel c$ and 0.75 μ_B for $H \parallel ab$-plane)? ii) Is the magnetism in SRO of itinerant or localized nature? iii) How does the electronic system couple to the lattice? Recent Raman scattering investigations e.g. suggest a distinct structural contribution to the MM transition in SRO.

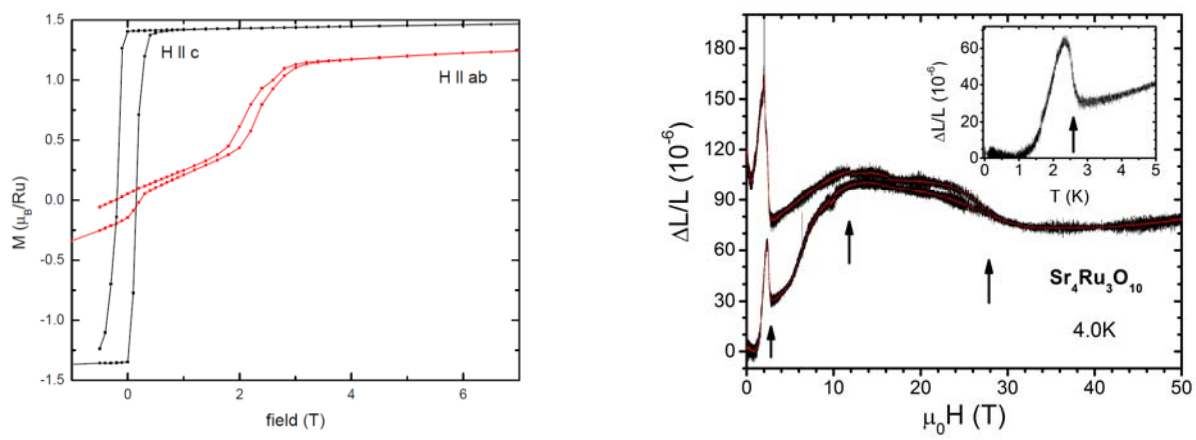

Figure 1 Left: magnetization (M) vs. magnetic field for H// *c*-axis and H//*ab*-plane**. Right:** Magnetostriction (ΔL/L) vs. field for H//*ab*-plane. A sharp drop in the lattice parameter is observed at the MM transition (inset) in addition to two shoulder-like features at μ_0H = 12T and 28T (main) that give evidence for the involvement of lattice degrees of freedom in the magnetism of SRO.

Experimental

Fig. 1 (left) shows the magnetization vs. field measured at T = 1.8K in a SQUID QD-MPMS magnetometer. Fig. 1 (right) shows the length change $\Delta L/L$ measured at the NHMFL-LANL 60T long pulse magnet between T = 4 K and 1.3 K.

Results and Discussion

The MM transition at 2 T is observed clearly in both thermodynamic quantities M and $\Delta L/L$ versus H. Additionally we observe a plateau-like structure in $\Delta L/L$ between $\mu_0 H \approx 12$ T and $\mu_0 H \approx 28$ T. The origin of these feature is still unclear, but suggests a further change in the magnetic properties of SRO with higher fields.

Conclusions

We propose to extend our ongoing investigations on SRO to high field magnetization measurements in the near future.

Acknowledgements

FW acknowledges support from the DOE-LDRD program at LANL. MJ acknowledges funding by the DOE-BES grant "Science of 100 T", NSF, and the NHMFL UCG program.

References

[1] Crawford, M. K. *et al*., Phys. Rev. B **65**, 2144121-2144125 (2002).
[2] Granata, V. *et al*, J. Phys.: Condens. Matter **25**, 0560041-0560046 (2013).