DISORDER AND DOUBLE EXCHANGE SPIN DYNAMICS IN $La_{0.7}Sr_{0.3}MnO_3$ AND $La_{0.7}Sr_{0.3}CoO_3$ VIA NMR HYPERFINE COUPLINGS

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Introduction

The hole-doped transition metal oxides $La_{1-x}Sr_xMnO_3$ (LSMO) and $La_{1-x}Sr_xCoO_3$ (LSCO) show similarities in their physical properties but also some marked differences. In the metallic–ferromagnetic doping range, important properties of these materials, such as nanoscale phase separation, are attributed to competing double exchange (DE) ordering interactions and disordering Jahn–Teller (JT) distortions. For LSCO important property differences compared to LSMO include multiple spin states and much larger magnetic anisotropy. Ferromagnetic (FM) NMR at small external field of ^{55}Mn and ^{59}Co in x = 0.3 samples has provided information on changes in hyperfine couplings and spin dynamics, as a function of temperature for these systems.

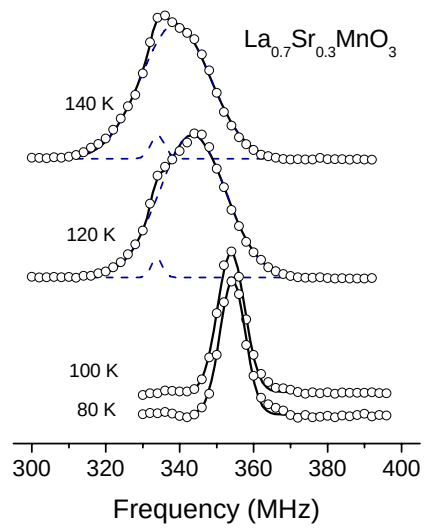

Fig. 1 Evolution of LSMO spectra as a function of temperature.

Results and Discussion

The samples were grown using floating zone (LSCO) and sintering (LSMO). The crystal structures for both are rhombohedral (pseudo-cubic). NMR spectral lineshape and relaxation rate measurements shown in Figs.1 and 2 show marked differences in behavior of LSMO and LSCO. Note the evolution of the LSMO spectrum as a function of T in Fig. 1, and the evidence for two FM phases with slightly different hyperfine couplings that appears above 120 K. The LSCO spectra (not shown) are broad and show no change with temperature in the range 2 – 30 K over which measurements could be made. Above 30 K T_2 becomes too short to observe the spectrum. The relaxation rate results are analyzed using theoretical expressions for conduction band electron hyperfine couplings involving an orbital mechanism. In LSCO, it is concluded that the carrier scattering mechanism plays a dominate role in ^{59}Co relaxation over the temperature range 2 – 30 K. In LSMO, anisotropic hyperfine couplings become important only for T > 120 K while they are important in the relaxation at low temperature in LSCO. For T < 100 K ^{55}Mn spin-lattice relaxation in LSMO involves a two-magnon process with measured relaxation rates much smaller than in LSCO. The observed changes in linewidth and relaxation rate are reversible with T and are consistent with cooperative lattice distortions. The contrasting behaviors of the systems are attributed to differences in DE couplings, which are larger in LSMO than in LSCO, and in JT distortions that result in more local disorder in LSCO at low T than is found in LSMO.

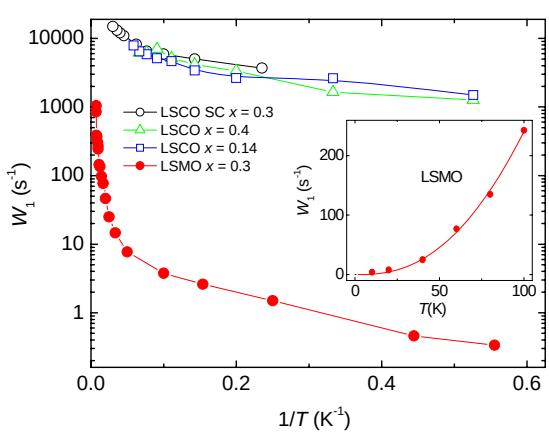

Fig. 2 Comparison of LSCO and LSMO T_1 data.

Conclusion

A major difference between metallic LSCO and LSMO appears to be the enhanced importance of low – temperature local lattice distortions in LSCO compared to LSMO. It is only for T > 100 K in LSMO that local JT distortions 'kick in', as revealed by the FM-NMR results, leading to changes in the transport and magnetic properties.