Phase Separation and Giant Magnetoresistance in a Perovskite Oxide

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Nanoscale inhomogeneity in $La_{1-x}Sr_xCoO_3$ has been investigated in single crystal samples grown by the floating zone method for $0.05 \leq x \leq 0.3$ using ^{139}La NMR as a direct probe of the internal magnetic field distribution as a function of x and temperature .The highly asymmetric spectra were analyzed using a skew normal Gaussian function which provides information on the evolution of phase separation and phase uniformity. The results show that phase separation occurs only for x near the metal-insulator critical concentration x_C =0.17. The phase separation is confined to a much smaller range of x than that found in polycrystalline samples, where a ferromagnetic (FM) component is observed from x=0.1 to 0.19, even though the bulk magnetic properties are similar. In the single crystals it is found that with increasing x large spin polarized regions (FM) merge into networks while smaller regions, identified as spin polarons, coexist with the larger regions. The evolution of the inhomogeneous internal field distribution with x and temperature is summarized in the phase diagram shown in Fig.1. It appears that near x_C hole rich regions grow at the expense of hole-poor regions due to either electronic phase separation or, possibly, departures from a statistically inhomogeneous distribution of Sr^{2+} ions. The model proposed is a matrix of magnetic polarons which evolve in size with x and T, with FM clusters forming at the high x values and at low temperature.

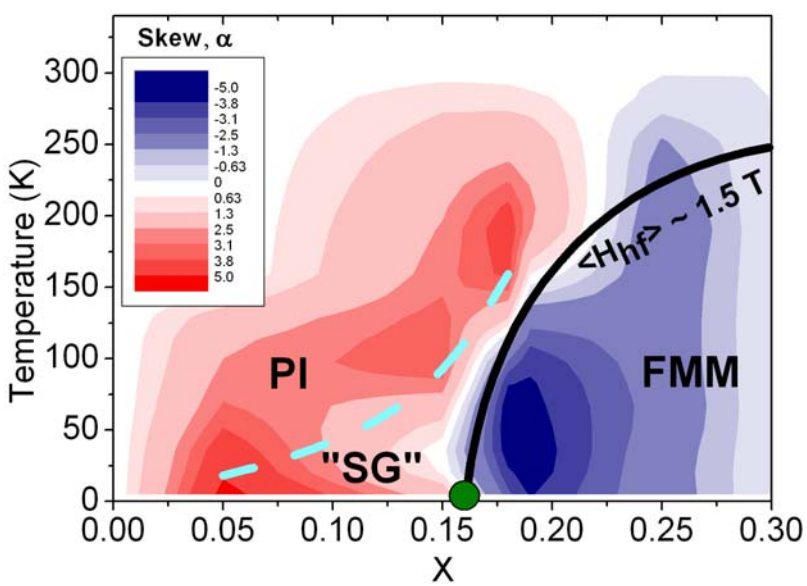

Fig 1. Contour plot of the skewness of the ^{139}La NMR spectral fit parameter overlaid on the thermodynamic phase diagram of Ref. 1. The solid line marks the boundary where we find $\langle H_{hf} \rangle \approx 1.5$ T, which closely matches the transition to a ferromagnetic metal (FMM) found in transport and magnetization measurements [1]. The green dot is the 0 K insulator – metal transition, and the dashed line is the spin glass (SG) region from Ref 1, which we argue is rather an expected region of glassy behavior in our polaron model. The dark red and blue regions denote the inhomogeneous region around the FMM transition at which the NMR spectra exhibit a large skewness parameter $|\alpha| > 2.5$ ascribed to the coexistence of PI and FMM phases over a large region of the temperature

References

1. M.J.R. Hoch, *et al* Phys. Rev. B **70**,174443 (2004).