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Title: SHORT RANGE SPIN CORRELATIONS IN THE CMR MATERIAL $La_{1.4}Sr_{1.6}Mn_2O_7$

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Author(s): T. M. Kelley, D. N. Argyriou, R. A. Robinson, H. Nakotte, J. F. Mitchell, R. Osborn, and J. D. Jorgensen

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Short Range Spin Correlations in the CMR Material $La_{1.4}Sr_{1.6}Mn_2O_7$

T. M. Kelley[a], D. N. Argyriou[a], R. A. Robinson[a], H. Nakotte[a],
J. F. Mitchell[b], R. Osborn[b], J. D. Jorgensen[b]

a. Manuel Lujan, Jr., Neutron Scattering Center, Los Alamos National Laboratory, Los Alamos, NM 87545, U.S.A.

b. Materials Science Division, Argonne National Laboratory, Argonne, IL 60439 U.S.A.

The $(La_{1-x}Sr_x)_2Mn_3O_7$ compounds are layered materials that exhibit higher magneto-resistance than the corresponding 3D manganite perovskites. Quasi-elastic neutron scattering on a polycrystalline sample of $La_{1.4}Sr_{1.6}Mn_2O_7$ shows that the spin fluctuation spectrum of the these layered CMR materials is qualitatively similar to those found in the perovskite manganites $(La,Ca)MnO_3$; their concentration, lifetime, and coherence length increase as T decreases to $T_c$. Unlike the perovskites we find a lower spin-diffusion constant above $T_c$ of ~5 meV Å$^2$ .

Keywords: colossal-magneto-resistance, $(La_{1-x}Sr_x)_3Mn_2O_7$, magnetic polarons

T. M. Kelley, MS H805, Los Alamos National Laboratory, Los Alamos, NM 87545 U.S.A.
e-mail: tmk@.lanl.gov
FAX: (505) 665-2676
voice: (505) 665-3768

The close interplay among charge, spin, and lattice degrees of freedom in the colossal magneto-resistive (CMR) manganite oxides is widely believed to play an important role in the mechanism of transport in these itinerant ferromagnets. Among the current models of transport in the three-dimensional magneto-resistive perovskite materials is that magnetic polarons—mobile lattice distortions carrying spin—play a fundamental role, at least above the Curie temperature ($T_C$). [1,2]. Supporting evidence for this model have been provided recently by DeTeresa, *et al.* from in-field small angle neutron scattering experiments on the perovskite $La_{2/3}Ca_{1/3}MnO_3$.[2] In this paper we report inelastic neutron scattering measurements from the layered CMR material $La_{1.4}Sr_{1.6}Mn_2O_7$.

Inelastic neutron scattering data were taken from a 15g, single phase polycrystalline sample of $La_{1.4}Sr_{1.6}Mn_2O_7$ using the time-of-flight chopper spectrometer PHAROS at MLNSC, Los Alamos National Laboratory. Data were taken at 12 temperatures, ranging from 30 K to 320 K using an incident energy $E_i$=12.1 meV, except for data measured at 115 K where incident energies of 12.1 and 8.1 meV were used to extend the Q-range of the measurement. Neutron powder diffraction data were measured as a function of temperature from 20-300K, using (SEPD) at IPNS at the Argonne National Laboratory. This polycrystalline sample was characterized using a.c. susceptibility and resistivity; a PI-FM transition was observed at 116K.

Fig. 1 shows the spectrum at 115 K and 30 K, with a gaussian fit to each: while there is little statistically significant deviation from the gaussian at 30 K, at 115 K the gaussian is clearly unable to fit the data. The addition of a lorentzian term $L(\varepsilon)= BI\Gamma/p(\varepsilon^2+\Gamma^2)$ to fit the quasi-elastic component gives a much better fit to the data ($\varepsilon$ is the energy transfer, B the Bose-Einstein factor, I the integrated intensity, and $\Gamma$ the half-width at half maximum). This gives an intensity and a lifetime ($\tau = \hbar/\Gamma$) for the spin correlations at each temperature (Fig. 2). The quasi elastic scattering diverges as $Q \rightarrow 0$, suggesting that it is due to ferromagnetic spin-correlations. Similar observation have been made by Lynn *et al.* [3] for the three dimensional perovskite manganites.

The intensity of the quasi-elastic scattering increases as the sample is cooled from 322 K to $T_C$, then decreases below $T_C$, with similar behavior for the lifetime. Fitting the intensity as a function of Q gives a correlation length of ~12 Å at 128 K, while fitting the energy width as a function of Q gives a spin-diffusion constant of ~5 meV $Å^2$. This value is substantially lower than the 30 meV Å$^2$ measured for $La_{0.67}Ca_{0.33}MnO_3$[3] and may reflect the effect of reduced dimensionality on the dynamics of spin fluctuations.

Neutron powder diffraction measurements from the same sample used for the inelastic scattering measurements show that a relaxation of the lattice occurs at $T_C$. For the perovskite materials this has been interpreted as the relaxation of localized lattice distortions from lattice polarons. The close correlation of the spin-dynamics (i.e. the increase of the quasi elastic scattering as $T \rightarrow T_C$), with the relaxation of the lattice suggests that these two phenomena are coupled. This observation is qualitatively similar to results reported by De Teresa *et al.*[2] for $La_{2/3}Ca_{1/3}MnO_3$. However, magnetic scattering from layered $La_{1.4}Sr_{1.6}Mn_2O_7$ is complicated by the fact that in two-dimensional magnetic systems critical magnetic fluctuations can be enhanced well above $T_C$ (e.g. $K_2CuF_4$[4]). Work is currently underway to decouple the expected 2-D ferromagnetic fluctuations from any additional signal that may emerge from magnetic polarons.

In conclusion, we observe a quasi-elastic magnetic scattering in $La_{1.4}Sr_{1.6}Mn_2O_7$, between $0.7<T_C<2.8T_C$. The intensity of the scattering and the lifetime of spin fluctuations increases as T decreases to $T_C$. This phenomenon correlates strongly with the electronic (insulator-metal) and structural transition at the onset of 3D magnetic ordering.

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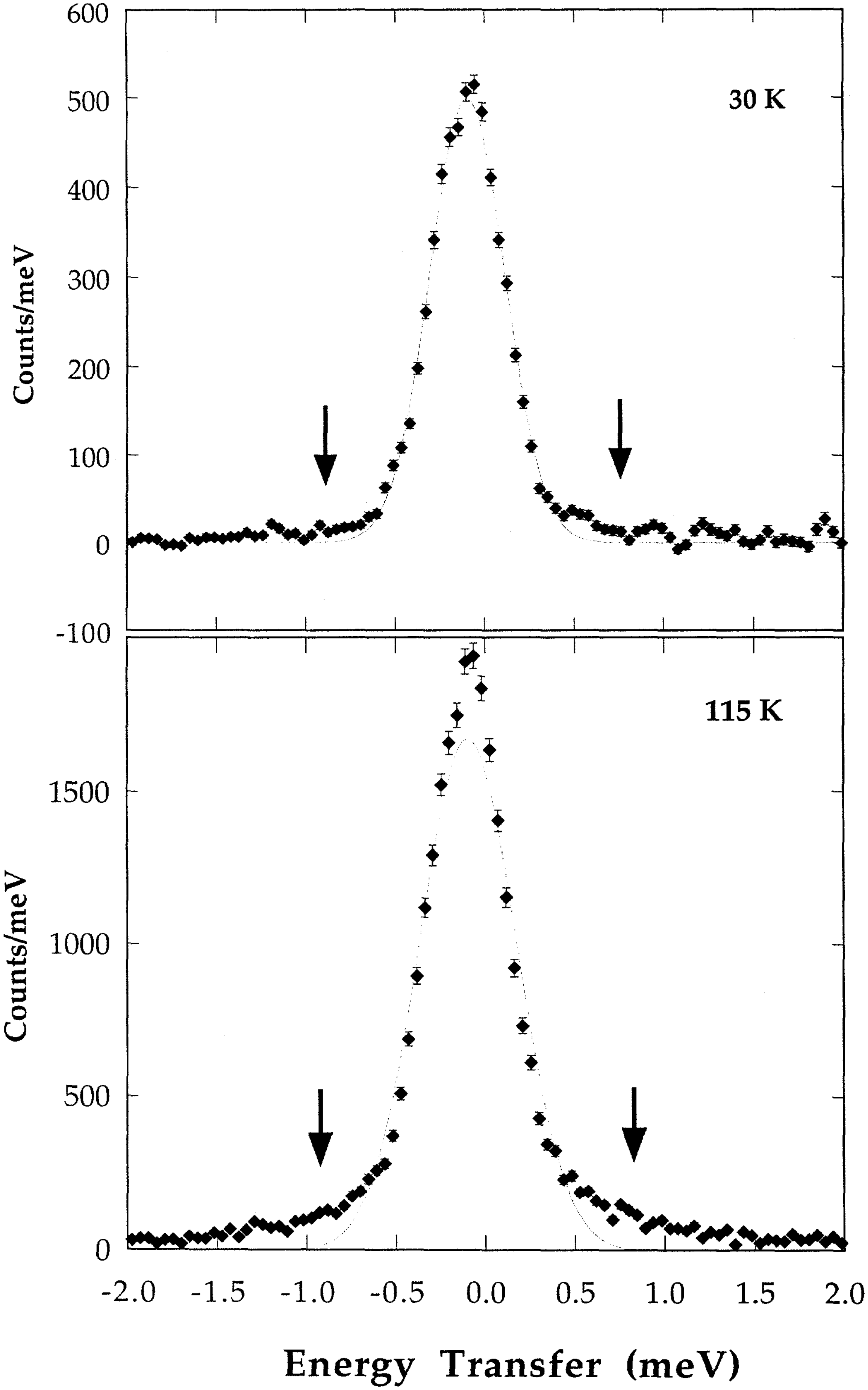
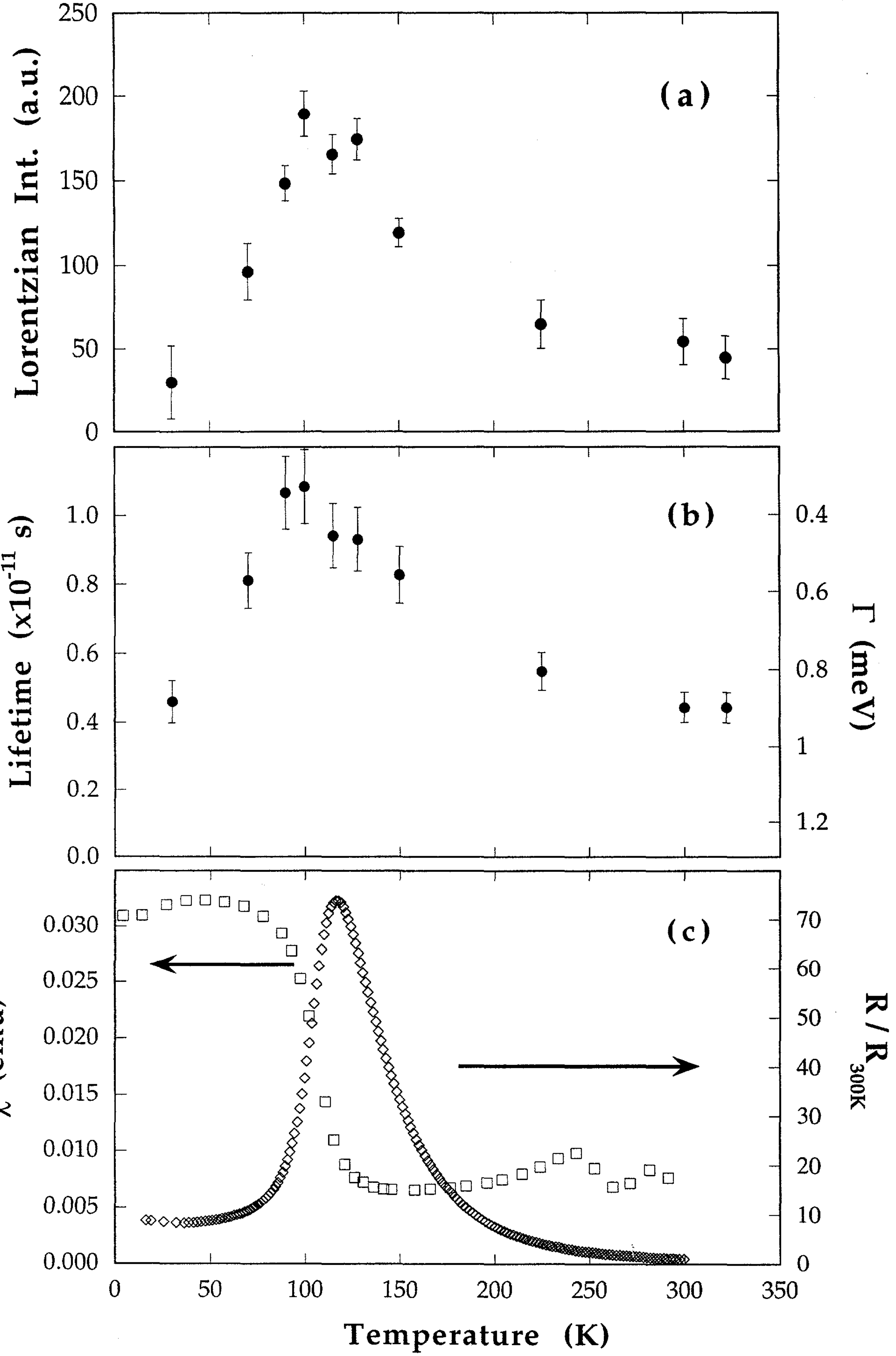
Figure captions:

Fig. 1: Quasi-elastic spectrum from $La_{1.4}Sr_{1.6}Mn_2O_7$ at 30 K (top) and 115 K (bottom). The data are integrated over the available Q range of ~0.15 to 0.45 $Å^{-1}$. The solid curves are gaussian fits.

Fig. 2: (a) Intensity of the quasi-elastic component as a function of temperature. (b) Lifetime ($=\hbar/\Gamma$) as a function of temperature. Both the intensity and lifetime were obtained by fitting to the data integrated over the available Q-range of ~0.15 to 0.45 $Å^{-1}$. (c) Susceptibility and resistivity data from this sample.


600
500
400
300
200
100
0
-100
30 K
Counts/meV
1500
1000
500
0
115 K
Counts/meV
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Energy Transfer (meV)



(a)
Lorentzian Int. (a.u.)
250
200
150
100
50
0
(b)
Lifetime (x10$^{-11}$ s)
1.0
0.8
0.6
0.4
0.2
0.0
Γ (meV)
0.4
0.6
0.8
1
1.2
(c)
χ (emu)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
R / R$_{300K}$
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
Temperature (K)