Spin Dynamics in the Ferromagnetic Phase of the Colossal Response Bilayered Manganite La$_{1.2}$Sr$_{1.8}$Mn$_2$O$_7$

M.J.R. Hoch (NHMFL), P.L. Kuhns (NHMFL), W.G. Moulton (NHMFL), Jun Lu (NHMFL), A.P. Reyes (NHMFL), and J.F. Mitchell (Materials Science Division, Argonne National Laboratory)

Introduction
The bilayered manganites La$_{2-2x}$Sr$_{1+2x}$Mn$_2$O$_7$ exhibit challenging magneto-electronic properties, such as colossal magnetoresistance (CMR).[1] No previous NMR relaxation rate measurements appear to have been made on this material. The present experiments have used zero-field and low-field $^{55}$Mn NMR to probe the dynamics of the ferromagnetic (FM) metallic phase of La$_{1.2}$Sr$_{1.8}$Mn$_2$O$_7$. Open questions for this system include the presence or absence of polarons in the FM phase and the importance of effects such as weak localization and electron-electron interaction at low temperatures.

Experimental
The x=0.4 single crystal sample was cut from a larger crystal grown in a floating-zone furnace. NMR spin echo experiments were carried out in zero-field and in fields up to 10 T with a computer controlled variable frequency spectrometer at the NHMFL. The phase diagram is shown in Fig.1. Magnetoresistance reaches a maximum at x=0.4.

Results and Discussion
$^{55}$Mn NMR spectra for the FM phase of La$_{1.2}$Sr$_{1.8}$Mn$_2$O$_7$ show a broad distribution of hyperfine fields at Mn sites.

55Mn spin – lattice relaxation rates $W_1$ have a surprisingly weak dependence both on $T$ and $H$. Departures of the relaxation rate from Korringa form $W_1$ at $T$ below 40 K, as shown in Fig. 2 provide evidence for non-Fermi liquid behavior. At temperatures approaching $T_C$ from below anomalous behavior is found in the relaxation rate $T$ dependence. Spin waves play no detectable role in relaxation. In the FM metallic phase electron scattering is the dominant mechanism well below $T_C$ where weak Korringa-like behavior found over the range 40 – 90 K. The departure from Korringa behavior below 40 K is likely due to changes either in the density of states or in the wave function at the Fermi surface due to local changes in orbital ordering. Above 90 K polarons, which are important in magnetoresistance, are likely to cause the anomalous decrease in $W_1$.

Conclusions
The results provide evidence for changes in the electronic structure with temperature in this FM poor metal. At low $T$ the changes may be linked to orbital ordering effects. Above 90 K the emergence of polarons is likely to be responsible for the observed decrease in the relaxation rate.

Acknowledgements
Financial support was provided through grants from the NSF (DMR-0084) and by the state of Florida. Work at Argonne National Laboratory was supported by the U.S. DOE Office of Science, under contract No.DE-AC02-06CH11357.

References