Magnetism, Disorder, and Non-Fermi Liquid Behavior in Na$_{0.78}$CoO$_2$

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Introduction
In recent years, significant interest has been devoted to high Na-doped cobaltates, in which the competition between geometric frustration, strong electronic correlations, and magnetic interactions leads to disorder, either correlated or non-correlated, and a variety of ground states with various quantum phase transitions (QPTs) expected. The disorder related to the sample cooling rate in the critical temperature region of 190-230 K [1] may lead to the formation of ferromagnetic clusters. At very low temperatures, the clusters can behave collectively as giant spins and cause non-Fermi liquid (NFL) behavior of the electronic subsystem described by the Griffiths scenario [2-4]. These issues motivated the present work [5].

Experimental
Single crystals were cleaved from ingots, grown by the optical floating-zone method. Starting feed and seed materials were prepared from Na$_2$Co$_3$ and Co$_3$O$_4$ of 99.9% purity with the nominal composition of Na$_{0.78}$CoO$_2$, and details can be found elsewhere [6]. Magnetic susceptibility at low temperatures was performed in the Williamson Hall Annex (Room 123) of the High B/T Facility of the NHMFL in Gainesville. The ac (11 Hz to 555 Hz) mutual inductance coils were mounted on a dilution refrigerator equipped with a 10 T magnet. The sample was bathed in pure $^3$He, which provided intimate thermal contact with the mixing chamber, and the in-phase and out-of-phase signals of the susceptibility were recorded by a two channel lock-in amplifier. Typically the data were obtained by isothermal (45 mK $\leq$ T $\leq$ 4.2 K) field sweeps at a rate of 50 mT/min, and the data were independent of the direction of the field sweep.

Results and Discussion
To date, the magnetic studies down to 45 mK and in magnetic fields up to 10 T do not reveal the presence of any striking signatures. A set of data acquired while spanning a wide-range of frequencies will be crucial for judging the applicability of the Griffiths scenario. However, at this stage, the frequency dependence of the background signal from the coils prevents quantitative analysis.

Conclusions
Having now completed a full range of measurements with an empty coil, the background contribution and its frequency dependence, presumably arising from the superconducting wire in the primary coil and the magnetoresistance of the copper wire in secondary coils, prevents quantitative conclusions from being made. To improve upon the present situation, a new set of coils is being constructed, and if they are successful in completing the present study, then they will be available for other users.

Acknowledgements
Work supported, in part, by the Slovak Research and Development Agency under the contracts No. APVV-VVCE-0058-07 and No. APVV-0006-07, NSF DMR-0701400 (MWM), and the NHMFL via cooperative agreement NSF DMR-0654118 and the State of Florida. Material support from US Steel Košice s.r.o. is greatly acknowledged.

Aspects of this research were performed in the NHMFL High B/T Facility (Williamson Hall Annex (Room 123).

References