High-field ^{63}Cu NMR Measurements of the Cuprate Superconductor $Nd_{1.85}Ce_{0.15}CuO_{4-y}$

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Introduction

Recent observations of quantum oscillations in underdoped cuprates, including the electron-doped $Nd_{2-x}Ce_xCuO_{4-y}$ (NCCO) are interpreted as evidence for a reconstructed Fermi surface. In the case of NCCO, magnetotransport experiments are consistent with a multiply-connected Fermi surface for a range of dopings extending to x=0.17 [1]. A proposed explanation for the reconstruction is a field-induced spin density wave ground state, since the undoped parent compound is an antiferromagnetic (AF) Mott insulator, and the AF state persists beyond x~0.13. The high-field ^{63}Cu NMR experiments carried out at the NHMFL were motivated the possibility of a field-induced magnetic phase transition, which would be evident in the distribution of hyperfine fields and low frequency spin fluctuations.

Experimental

The single crystal sample of NCCO with x=0.15 (T_c=26K) was prepared at the Walther Meissner Institute by the travelling solvent floating zone method. ^{63}Cu NMR spectroscopy and relaxation measurements were carried out at the NHMFL in a superconducting magnet in fields 7-16T, and in a resistive magnet (cell 2) in fields up to 30T and covering temperatures T=1.5-200K. The magnetic field was oriented close to B//c.

Results and Discussion

The linewidth and temperature-dependent shifts of the ^{63}Cu central transition (I=3/2) are dominated by local fields produced by the Nd^{3+} moments, and this is a challenge for extracting information pertaining to the CuO_2 planes. Nevertheless, large B/T polarizes the Nd moments and the linewidths are observed to saturate. To within these experimental limitations, there is no additional line-broadening.

Given that the spectroscopy cannot exclude onset of magnetic order, the spin lattice relaxation rate $1/T_1$ was investigated. At B=7T, $1/T_1$ is nearly independent of temperature. As the field is increased, a clear maximum, which increases with field, is observed near T~30K. At the lowest temperatures, the relaxation decreases in a manner consistent with polarized Nd moments, and therefore we tentatively associate the peak near 30K with the same moments. One possible (and speculative) explanation is to associate the observed field dependence with AF spin fluctuations originating with the CuO_2 plane, which strengthen with field. In that case, the coupling to the nuclear spins would most likely have to include an indirect component, where the Nd moments are exchange coupled to the Cu 3d spins, and also interact with the ^{63}Cu nuclear spins.

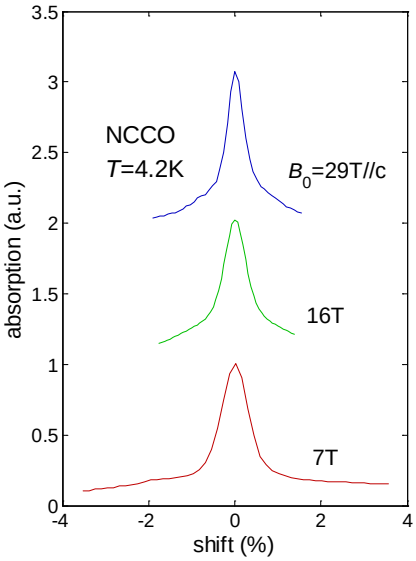

Figure 1. ^{63}Cu NMR spectrum, B//c. The absorption maximum is centered at 0% shift in each case.

Conclusions

^{63}Cu NMR spectroscopy and relaxation measurements were carried out in magnetic fields B=7-30T. No evidence for a field induced magnetic transition was found. However, a clear maximum in $1/T_1$ was observed near T=30K, which monotonically increased with magnetic field strength. A possible explanation associates the peak with field-dependent AF spin fluctuations.

Acknowledgements

Work done at the NHMFL was supported by NSF-DMR- 0654118, the State of Florida, and the DOE, and by NSF under grant nos. DMR-1005293 (JSB) and DMR-1105331 (SB).

Reference

[1] Helm, T., *et al*., Phys. Rev. Lett., **105**, 247002 (2010).