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FIELD-INDUCED ANTIFERROMAGNETISM IN THE CUPRATE HIGH-T_c SUPERCONDUCTOR $La_{2-x}Sr_xCuO_4$

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The cuprate high-transition temperature superconductor $La_{2-x}Sr_xCuO_4$ (LSCO) is structurally the most simple of the cuprate superconductors, making this system attractive for seeking the fundamental mechanisms behind high-temperature superconductivity. One class of theories connects the superconducting mechanism with the magnetic properties of the material[1], calling for detailed investigations of cuprate magnetism.

We have performed neutron scattering measurements on LSCO in zero and applied magnetic fields. In the superconducting phase, $T < T_c$ and $H < H_{c2}$, magnetic flux penetrates the superconductor via vortices while phase coherent superconductivity is suppressed to the lower field-dependent irreversibility temperature, $T_{irr}(H)$. We show that both optimally doped LSCO (x = 0.16, T_c = 38.5 K) and underdoped LSCO (x = 0.10, T_c = 29 K) have an enhanced antiferromagnetic response in a field.

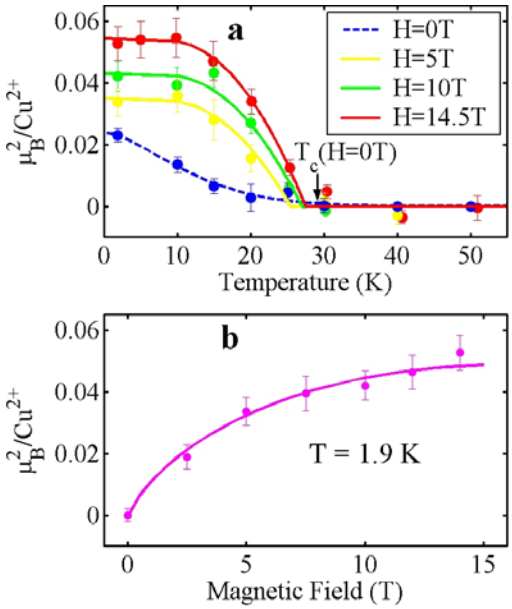

Fig. 1. (Upper panel) Zero field and field-induced elastic neutron signals at LSCO (x = 0.10) as a function of temperature. The superconducting transition temperature in zero field is marked with an arrow. Data were taken at the V2 spectrometer at HMI, Berlin. (Lower panel) Field induced ordered moment at T = 2 K shown as a function of applied magnetic field. The curve shows the theoretical prediction by Demler et al.[4], scaled by an overall factor.

Measurements of the optimally doped system in zero field show incommensurate short-range fluctuations at all energies above T_c while an energy gap opens up in the superconducting phase.[2] In an applied field of H = 7.5 T we observe incommensurate sub-gap spin fluctuations, which upon cooling disappear with the loss of finite resistivity at T_{irr}, but then reappear at a lower temperature.[3]

In the underdoped system, x = 0.10, long-range (>400 Å) antiferromagnetic order develops in zero field, and the order is significantly enhanced by application of a magnetic field. The field-induced signal vanish at the zero-field value of T_c. Phase coherent superconductivity is then established within the antiferromagnetic phase at the lower $T_{irr}(H)$. The strength of the field-induced signal is modelled perfectly by a theoretical prediction by Demler et al.[4], as shown in Fig. 1.

Our results imply that for optimally doped LSCO the vortices nucleate large antiferromagnetic regions extending beyond the vortex cores. For underdoped LSCO, the vortices link pre-existing regions of antiferromagnetic order, possibly nucleated by impurities. Our recent results indicate a field-induced correlation between antiferromagnetic regions in the direction perpendicular to the superconducting planes.

REFERENCES

1. M. R. Norman and C. Pépin, cond-mat/0302347, (2003)
2. B. Lake, G. Aeppli, K. N. Clausen, D. F. McMorrow, K. Lefmann, N. E. Hussey, N. Mangkorntong, M. Nohara, H. Takagi, T. E. Mason, and A. Schröder, Science **291**, 832 (2001)
3. B. Lake, H. M. Rønnow, N. B. Christensen, G. Aeppli, K. Lefmann, D. F. McMorrow, P. Vorderwisch, P. Smeibidl, N. Mangkorntong, T. Sasagawa, M. Nohara, H. Takagi, and T. E. Mason, Nature **415**, 299 (2002)
4. E. Demler, S. Sachdev, and Y. Zhang, Phys. Rev. Lett. **87**, 067202 (2001)