Thermal Conductivity and Torque Magnetization in $YBa_2Cu_3O_{6.6}$ in High Magnetic Fields

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Introduction

Recent diffraction, NQR and transport experiments have uncovered several (tentative) phase boundaries or crossover lines in the *T* vs *H* (temperature vs. field) phase diagram of the underdoped (UD) cuprate superconductor $YBa_2Cu_3O_{6.6}$. There is evidence that the high-field state (*H*> 24 T) is either a charge density wave (CDW) state co-existing with d-wave superconductivity or a CDW state without any Cooper pairing (apart from fluctuations). We carried out measurements of the thermal conductivity K_{xx} vs. *H* and the magnetization *M* vs. *H* to address these issues.

Experimental details

We carried out measurements of K_{xx} vs. *H* on high-quality crystals of UD YBCO in the 35-T DC magnet. We also measured the thermal Hall conductivity K_{xy}, but the signal to noise ratio was too low to be useful. Torque magnetometry measurements on the same set of samples were performed as well in the same magnet. Preliminary torque magnetization curves were taken in the 65-T pulsed field magnet at Los Alamos. We also calibrated thermometers to 60 T using the pulsed fields.

Results and Conclusions

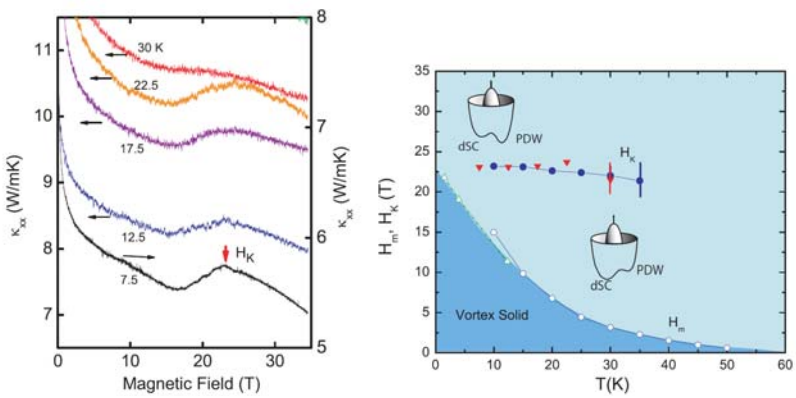

Fig 1 (Left panel, A) Thermal conductivity K_{xx} vs. *H* measured on an untwinned $YBa_2Cu_3O_{6.43}$ crystal. The anomaly at 23 T indicates the crossover field H_K (red arrow). (Right panel, B) The tentative phase diagram inferred from the K_{xx} and magnetization results showing the melting field H_m and the field H_K. The pair condensate remains finite to fields above 35 T. (Adapted from Ref. 1).

From the traces of K_{xx} vs. *H*, we determined the field H_K as a prominent anomaly (Fig. 1A). In our view, H_K is the crossover from a uniform *d*-wave pairing symmetry to one that has a CDW coexisting with the pair condensate or a pair-density-wave state (PDW) with finite momentum pairing. The curves of the torque magnetization **M** also yield H_K. The phase diagram inferred is shown in Fig. 1B. The melting curve H_m separates the vortex solid from the vortex liquid. The vortex liquid extends to fields above 35 T. Our results preclude the existence of a mean-field upper critical field line H_{c2} terminating at 24 T. Further experiments to confirm this picture are in progress.

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References

[1] Fan Yu, Max Hirschberger, Toshinao Loew *et al*., “Diamagnetic response in under-doped $YBa_2Cu_3O_{6.6}$ in high magnetic fields,” arXiv:1402.7371v1, submitted.