Preliminary RF Measurements up to 100 T in the Model Cuprate HG1201

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Introduction

The observation of quantum oscillations (QO) for underdoped Y123 and Y124 implies the presence of a very small pocket (covering only ~2-3% of the Brillouin zone), in stark contrast to the situation at high hole concentrations, where a large Fermi surface (FS) was observed corresponding to approximately 65% of the first Brillouin zone. While this result can been taken as evidence for a dramatic change of the FS associated with the quintessential CuO_2 planes, it may also be attributed to the existence of a non-universal FS piece related to the CuO chains in Y123 and Y124. Consequently, it has remained a pivotal open question whether the FS reconstruction has anything to do with aspects of the unidirectional structures, or if it is a universal property of the cuprates. Recently we have settled this issue through the observation of QO in the magnetorestivity of Hg1201 at $p \approx 0.09$ in pulsed magnetic fields of up to 80 T [1]. Hg1201 has a simple crystal structure (one copper-oxygen plaquette per unit cell and tetragonal P4/mmm crystal symmetry) and the highest T_c at optimal doping of the single-layer cuprates. Together with the availability of high-quality single crystals [2,3], this makes Hg1201 a particularly interesting compound for the study of the change of the Fermi-surface topology.

Experimental

We have conducted test RF (radio frequency) measurements with the 65 and 100 T magnet systems on several underdoped ($p \approx 0.07$-0.09) samples of the model cuprate Hg1201. Such measurements are particularly interesting, since they are contactless and yield angle-dependent information of the Fermi surface topology.

Results and Discussion

The preliminary RF-conductivity data are promising. Typical data, taken at 1.4 K, are shown in Fig. 1. The frequency shift at the irreversibility field is about 40 kHz, which indicates that the sample is moderately well coupled to the measurement coil. Between 40 T and 92 T a (relatively weak) ~400 Hz oscillatory signal is observed, which we tentatively attribute to a small pocket. With this RF-technique, the zero-resistance state is more difficult to identify than in conventional transport measurements. From the inflection as a function of field and temperature, we estimate that the irreversibility field and T_c maybe a little higher than in dc measurements [1].

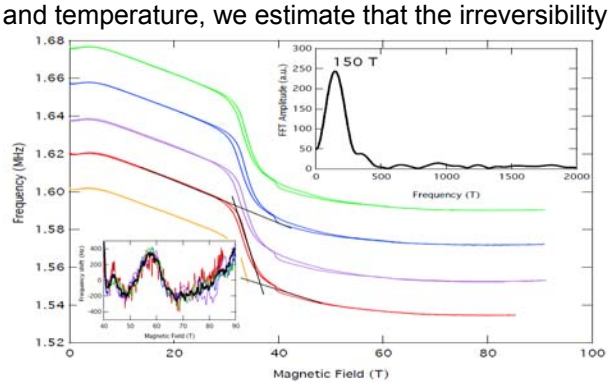

Figure 1. RF-frequency shift for Hg1201 sample at 1.4 K, recorded during five shots up to 92 T. Oscillations are obvious once a third-order background is subtracted, as shown in the left inset. The high reproducibility of the data indicates that the observed phenomenon is not an artifact. On the averaged oscillatory part a Fourier transform analysis was performed. A single peak is observed, at F = 150 T, shown in the right inset. The obtained frequency is significantly lower than that observed on other samples which were measured by dc-transport [1]. This could be perhaps attributed to the different doping of the samples.

Conclusions

The preliminary measurements demonstrate that the combination of the RF technique, samples of the model cuprate Hg1201, and the world's highest magnetic field available at LANL provides the best possible experimental conditions for establishing the topology of the high-field low-temperature state in cuprates.

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References

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