Resonant Ultrasound Spectroscopy (RUS) In Magnetic Field on Ultra-High Quality YBCO Single Crystal Cuprates

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Introduction

Recently we have established the thermodynamic singularity at the pseudogap phase boundary via a series of resonant ultrasound measurements [1]. These measurements in a magnetic field will provide further information on the symmetry of the order parameter in the pseudogap phase and reveal the field evolution of the ultrasonic signature of superconducting transition.

Experimental

The design of experimental RUS probe has been simplified to explore the difficulties presented by resonant ultrasound measurements in a superconducting (20T) magnet. After a few iterations we have successfully constructed RUS probe that gave consistent signal. The crystal mounting assembly needs further work to allow for flexibility in orientation of the crystal with respect to field while maintaining minimum contact between crystal and transducer. Current design does not have such flexibility. This probe was used in a series of RUS-in-field measurements on two YBCO crystals (same as in work [1]) and a pure niobium single crystal.

Results and Discussion

One of the original motivations for this measurement was to measure the evolution of the resonant frequencies in fixed-temperature field sweeps. These however did not produce consistent and informative results. In future work we will explore better ways of fixing the crystal orientation during the field sweep. In this set of measurements we have, instead, studied the temperature evolution of the resonance frequencies at fixed field. In underdoped crystal this was only done in the temperature range around and below the superconducting transition which gave an important insight into the field evolution of the effect of the superconductivity on the elastic-moduli in the broad temperature range below Tc. In future publication these measurements will be discussed in the context of magneto transport measurements on similar compounds. In the test measurement on a niobium superconductor somewhat similar field evolution of the superconducting signature was observed with the important twist that the sign of the effect is negative compared to YBCO cuprates. This must be associated with the fact that the pressure derivative of the superconducting temperature has opposite sign in these two compounds. Measurements in slightly over doped (Tc=88K) YBCO compound reveal that the magnetic field leads to enhancement of the attenuation maxima which in the work [1] has been attributed to the fluctuations associated with the pseudogap physics.

Conclusions

These measurements reveal a field evolution of the elastic signature of the superconducting transition. Further experimental work is needed to address the pseudogap behavior in more detail.

References

[1] Shekhter et.al , "Bounding the pseudogap with a line of phase transitions in YBa2Cu3O6+δ", Nature 498, 75 (2013).