HIGH PRESSURE TUNNEL DIODE OSCILLATOR EXPERIMENTS ON $CeCoIn_5$

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Introduction

For the past years, the heavy fermion superconductor $CeCoIn_5$ has received special attention because a new magnetic field induced ground state was observed in this compound at temperatures below a critical value T*~350 mK. The nature of the new state is still controversial, the proximity to a quantum critical point suggesting the existence of an antiferromagnetic order within the superconducting state, while the temperature and angular evolution of the new state are in good agreement with a field induced modulation of the superconducting order parameter (FFLO state). In order to elucidate the nature of this state, one of the most relevant experiments would be its study under pressure. We successfully tested the potential of the combination between a tunnel diode based radiofrequency resonator (TDO) and a diamond anvil cell (DAC) for pressure investigations of $CeCoIn_5$, in high magnetic field and temperatures lower than 100 mK.

Experimental

We have tested different configurations for the TDO/DAC combination in order to model the rf current flowing through the coil of the resonator and minimize if affect on sample temperature. The experiments were performed in the SCM1 facility at NHMFL (18T superconducting magnet and dilution refrigerator system).

Results and Discussion

One of the major issues with pressure measurements at dilution refrigerator temperatures is the local heating of the sample that is isolated from the bath and hence how to correctly determine the sample temperature. For the TDO case, the major source of heat is the due to the rf current flowing through the coil of the LC-resonator. We found that when the coil is placed inside the gasket of the DAC, the temperature at the sample could be as high as 400 mK while the bath is at a base temperature of about 60 mK. We have tested a configuration with the coil still inside the gasket, but the TDO biased in pulsed mode. Instead of dc biasing, by applying a 10 ms pulse every 5s, the average power at the sample was reduced by a factor of 500, and the temperature inside the cell was estimated to be very close to that of the bath. Moreover, the FFLO transition could be identified (see figure below) and its evolution with temperature at very low pressure was used to estimate the thermal link between the bath and the pressure cell.

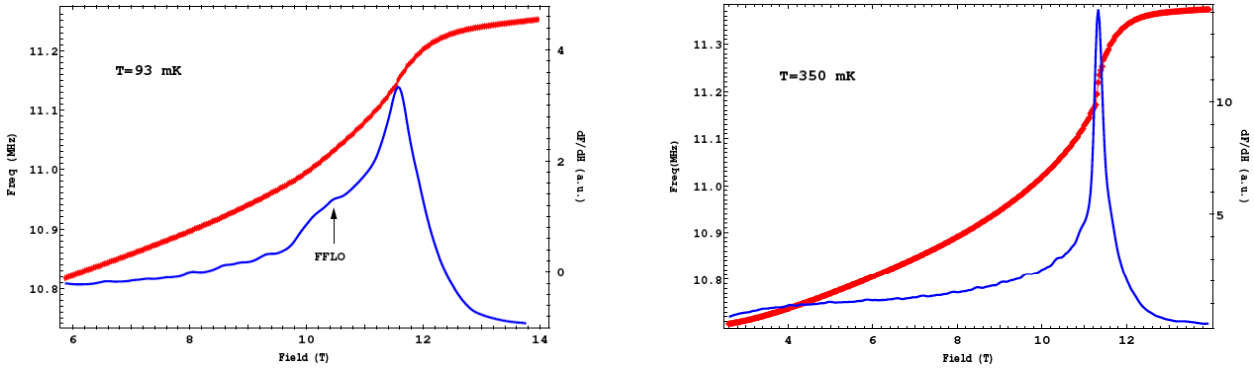

Fig. TDO frequency as a function of field (red trace) and its derivative (blue trace) for two sample temperatures: T=93 mK (right) and T=350 mK (left)

Conclusions

We have successfully tested the combination between the pulsed TDO and DAC for reliable pressure studies at high magnetic field and dilution refrigerator temperatures.

Acknowledgements

We would like to thank Mr. Ryan Newsome for machining the pressure cells and Mr. Andy Powell for his help in designing and building the pulse biasing circuit for the TDO.
This work was supported by the NNSA-DOE under DE-FG52-03NA0006