SUPERMAG: a superconducting 20 T magnet platform for applied and basic science

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Supramag offers a platform for applied and fundamental science. The superconducting magnet is designed to achieve 19 T at 4.2 K and 20 T at 2 K. In general, magnetic fields offer one of the most powerful tools to control, modify and probe the properties of matter. Novel and exotic electronic states, such as the integer and fractional quantum Hall effects, are induced by application of a magnetic field. The Supramag magnet extends significantly the maximum magnetic field achievable with superconducting magnets in Grenoble, so that new phenomena are within reach. In addition to its enhanced experimental window, it also offers a low noise environment that allows us to perform challenging experiments such as quantum oscillation, nuclear magnetic resonance (Fig. 1) or thermodynamic measurements (these techniques dramatically suffer from the environmental noise found in resistive magnets). Therefore, the 20 T magnet constitutes an additional input in the high magnetic field facility.

The Supramag platform is a central stage for the research of many scientists (5 PhD students, 2 postdoc fellows, 18 researchers) from NEEL, INAC and LNCMI who regularly gather at its location (Fig. 2). It is hence particularly well-suited for fostering new collaborations and projects. For example, researchers from NEEL and LNCMI have united force in order to determine the upper critical field of a high-T_c superconductor, a property which has remained elusive for decades and has generated much debate. Moreover, researchers from INAC and LNCMI have combined their expertise to make the first ultrasound measurements in superconducting ferromagnets. Originally focused on research on superconductors, the scope of use of Supramag is now widening to the whole community of physicists working in quantum and topological materials. A collaboration between researchers from NEEL and LNCMI on the development of thermodynamic tools to explore the quantum limit of semi-metals has just started.

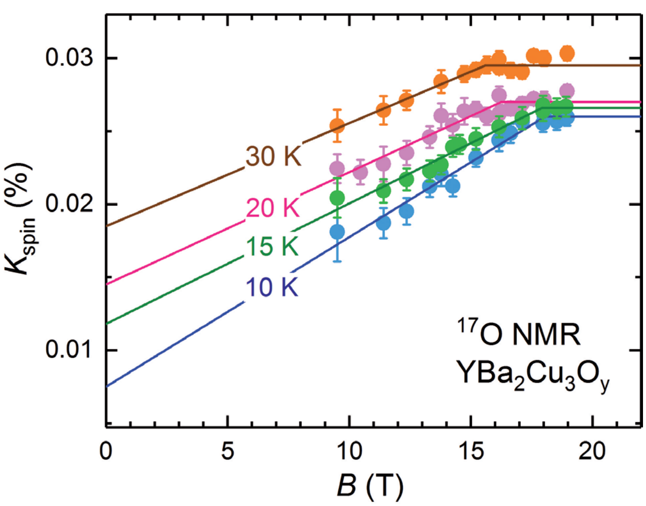

Fig. 1: Nuclear Magnetic Resonance measurements in a high-Tc superconductor as a function of magnetic field up to 20 T. at different temperatures. The 20 T magnet allows us to track the upper critical field down to the lowest temperatures.

Fig. 2: Heat capacity measurements on superconductors using the 20 T magnet.

OUTCOMES

[1] Thermodynamic signature of quantum criticality in cuprates, arXiv:1804.08502

[2] Unusual interplay between superconductivity and charge order un YBCO, arXiv:1805.06853

[3] High field charge order across the phase diagram of YBCO, NPJ Quant. Mat. 3, 11 (2018).

[4] Thermodynamic signatures of the field-induced states of graphite, Nat. Comm. 8, 1337 (2017).

[5] Observation of electronic bound states in charge-ordered YBCO, Phys. Rev. Lett. 118, 017001 (2017).

[6] Spin susceptibility of charge ordered YBCO across the upper critical field, PNAS 114, 13148 (2017).

[7] Calorimetric determination of the magnetic phase diagram in underdoped YBCO Nat. Commun. 6, 7927 (2015).

PhD: M. Frachet (2016-2019), C. Girod (2017-2020), B. Michon(2014-2017), M. Raba(2015-2018), I. Vinograd (2015-2018).

Users: D. Braithwaite, J.-P. Brison, G. Knebel, A. Pourret (INAC), X. Chaud, G. Seyfarth, I Sheikin, (LNCMI), K. Hasselbach, E. Lhotel, M. A. Méasson, P. Monceau, P. Rodière (NEEL)

Leverage: ANR project SCATE submitted at AAP2018, IRS project from UGA (2107/2018).