Interplay between charge-density waves and high-Tc superconductivity in cuprates

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The origin of superconductivity in cuprates is among the toughest problems in condensed matter physics. One of the most spectacular advances in the field is the recent discovery that superconductivity actually competes with a charge-density wave (CDW). The exact nature of their relationship, however, remains debated.

In his PhD, I. Vinograd has used four complementary parameters (temperature, magnetic field, carrier concentration and hydrostatic pressure) to tune the competition between CDW and superconductivity in $YBa_2Cu_3O_y$. [1-3]

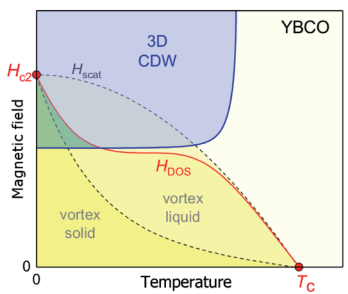

Fig. 1: Sketch of H-T phase diagram highlighting the field HDOS above which superconductivity ceases to affect the electronic density of states.

One of the most remarkable outcomes is a set of NMR data (obtained on the 20 T magnet funded by LANEF) suggesting that, beyond their fierce competition, CDW and superconductivity eventually establish a form of cooperation in order to coexist at low temperature. [2]

Cooperation has been predicted to arise from a novel state called pair-density wave in which Cooper pairs carry a finite momentum k (k=0 in BCS theory) and the superconducting gap amplitude varies in space as does the charge density. The work of I. Vinograd thus opens exciting perspectives as a further scrutiny of this phase is likely to shed new light on the high-Tc problem.

OUTCOMES

[1] NMR study of the pressure-tuned competition between charge-density waves and superconductivity in YBa_2Cu_3Oy, in preparation (2018).

[2] Unusual interplay between superconductivity and charge order in underdoped YBa_2Cu_3Oy, arxiv 1805.06853 (2018).

[3] Spin susceptibility across the upper critical field in charge ordered YBa2Cu3Oy, PNAS 114, 13148 (2017).

Poster presentation, School on Unconventional Superconductivity, Cargèse, France, 2017.

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