Influence of a nematic phase on high-temperature superconductivity

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The term "nematic state" might sound exotic, but you may well carry examples in your digital watch or calculator display. In a nematic phase, the molecules display elements of both liquids and solids, hence the term "liquid crystal display". By coupling high magnetic fields and high pressures, MagLab users have found that electrons in $FeSe_{0.89}S_{0.11}$ change from a nematic phase at low pressures to a standard metallic tetragonal phase at higher pressures, crossing a nematic quantum critical point (NQCP) above 5 kbar.

Differences between the electron phases greatly affect the quantum mechanical states that emerge. In $FeSe_{0.89}S_{0.11}$, this results in two distinct superconducting phases, as seen in Fig.1a. *The MagLab's 45T hybrid magnet drove $FeSe_{0.89}S_{0.11}$ into the normal state above 20 T (Fig. 1b) enabling users to trace the evolution of the Fermi surface (Fig. 1c) and electron correlations (Fig. 1d) as a function of pressure up to 20 kbar.*

The data reveal that a Lifshitz transition (topological change in the Fermi surface) separates the two superconducting regions. *The low pressure superconducting state ("SC1" in Fig. 1a) emerges from the nematic phase with a small Fermi surface and strong non-divergent electronic correlations, while the high pressure superconducting state ("SC2") emerges from the tetragonal metallic phase possessing a large Fermi surface and weak electron correlations.*

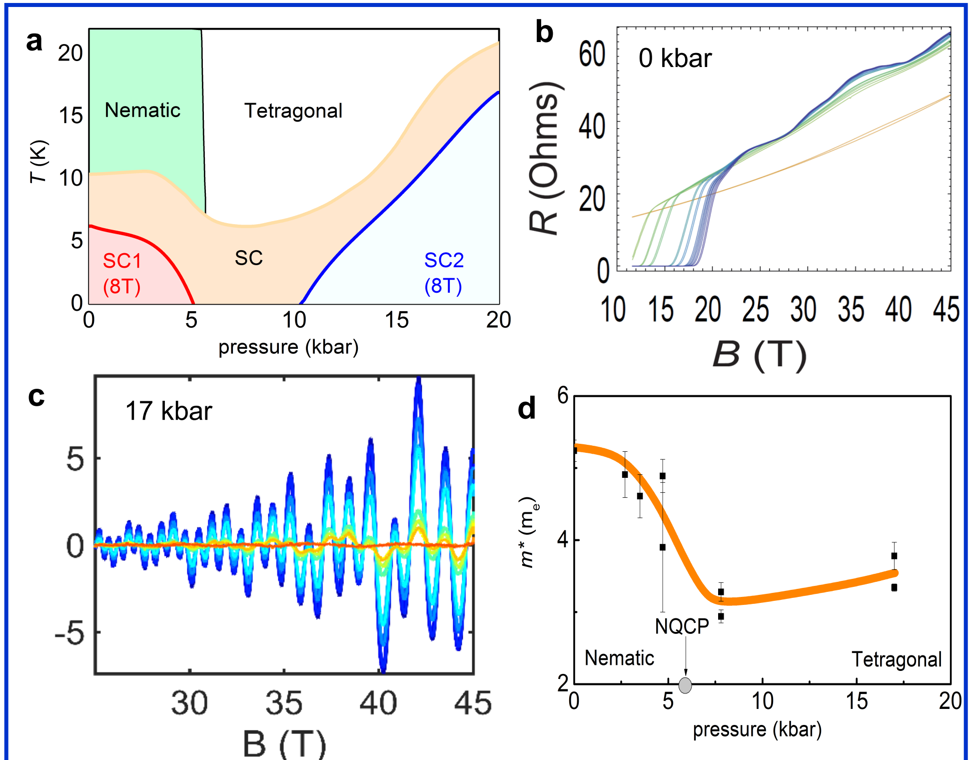

Figure 1. a) Phase diagram of the nematic superconductor $FeSe_{0.89}S_{0.11}$ tuned by pressure indicating two superconducting phases that exist below the nematic and tetragonal phases. b) Resistance versus magnetic field at temperatures below 1.5 K. c) Quantum oscillations at 17 kbar across a range of temperatures, where blue indicates the lowest temperatures of ~0.3K. d). The changes in the effective mass of the charge carriers across the nematic phase transition. The nematic critical point ("NQCP") is indicated by an arrow around 5.8 kbar.

Facilities used: NHMFL DC Field Facility, 45T hybrid magnet.

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