TT 28: Unconventional Superconductors

Time: Wednesday 9:30–11:15 Location: HSZ 103

TT 28.1 Wed 9:30 HSZ 103

Fermi surface study of the putative spin-triplet superconductor UTe_2 — •Alexander Eaton[1], Theodore Weinberger[1], Zheyu Wu[1], Alexander Hickey[1], Nicholas Popiel[1], and Michal Valiska[2] — [1]Cavendish Laboratory, University of Cambridge, UK — [2]MGML, Charles University, Prague

The unconventional superconductor UTe_2 exhibits numerous properties indicative of spin-triplet pairing, including an upper critical field far in excess of the Pauli paramagnetic limit, and re-entrant superconductivity at high magnetic fields > 40 T. However, a detailed understanding of the material's Fermi surface remains a key open question hampering efforts to attain a more detailed theoretical picture of the microscopic pairing mechanism(s) at play.

Here, we report a detailed de Haas-van Alphen study of the Fermi surface of UTe_2. We measured quantum oscillations in the magnetic torque and contactless resistivity of several high quality samples (RRR $\sim$ 900, Tc = 2.1 K) in a dilution refrigerator at temperatures down to 19 mK and magnetic fields up to 28 T, through two orthogonal rotation planes. Importantly, access to field strengths this high allowed us to measure directly along the [001] direction, which has previously been proposed to run parallel to the axis of cylindrical Fermi surface sections.

We present a summary of our angle- and temperature-dependent results performed to date, and compare to DFT and DMFT calculations that we find to capture the majority of the observed behaviour.

TT 28.2 Wed 9:45 HSZ 103

High pressure study of the unconventional superconductor $CeRh_2As_2$ — •Meike Pfeiffer[1], Konstantin Semeniuk[2], Seunghyun Khim[2], and Elena Hassinger[1] — [1]Technische Universität Dresden Institut für Festkörper- und Materialphysik, 01069 Dresden — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden

The heavy-fermion superconductor $CeRh_2As_2$ hosts two distinct superconducting states which are currently understood as even- and odd-parity states. The compound crystallizes in a layered lattice that is globally centrosymmetric but lacks local inversion symmetry at the Ce sites. This results in a strong spin-orbit coupling, believed to lead to a very high ratio of upper critical field (> 15 T) to critical temperature ($T_c = 0.26$ K). The normal state of the compound hosts an additional phase below 0.4 K, believed to be a quadrupole-density wave (QDW) order. We present a high-pressure electrical resistivity study of $CeRh_2As_2$ across different generations of samples. The QDW order is highly sensitive to lattice compression and gets fully suppressed at $P_c \approx 0.6$ GPa. The superconducting transition temperature T_c decreases at a significantly lower rate, and both superconducting phases persist well above 2 GPa. Thus, we confirm that the QDW is not responsible for the phase switching from even- to odd-parity state. At the same time, the in-plane magnetic field peaks at P_c, suggesting a different kind of interplay between the two orders.

TT 28.3 Wed 10:00 HSZ 103

Superconductivity versus quadrupole density wave in $CeRh_2As_2$ — •Konstantin Semeniuk[1], Daniel Hafner[1], Pavlo Khanenko[1], Javier Landaeta[1], Thomas Lühmann[1], Christoph Geibel[1], Seunghyun Khim[1], Elena Hassinger[2], and Manuel Brando[1] — [1]MPI-CPfS, Dresden, Germany — [2]TU Dresden, Dresden, Germany

A heavy-fermion superconductor $CeRh_2As_2$ ($T_c \approx 0.3$ K) undergoes a phase transition at the temperature $T_0 \approx 0.5$ K, proposed to be a quadrupole density wave (QDW) instability. The compound hosts two distinct superconducting (SC) phases, presumably of different parity. These are separated by a first order phase boundary at magnetic field $\mu_0 H^* = 4$ T, applied along the c axis of the tetragonal lattice. Recent studies suggest that the QDW phase boundary could meet the $T_c(H)$ line at exactly at H^*. This would imply that the SC phase switching is driven by the field-induced suppression of the QDW order coexisting with the superconductivity. Inability to reliably track T_0 near 4 T has left the question standing.

We present a study of a new generation of $CeRh_2As_2$ crystals, showing sharper signatures of phase transitions. From our measurements of heat capacity and electrical resistivity in c-axis magnetic field, we produce a more detailed phase diagram which shows that the QDW and SC phase boundaries meet at 6 T. We conclude that the QDW state is not responsible for the SC phase switching at H^* and discuss the possible interplay between the two orders with reference to the Fermiology of $CeRh_2As_2$ as well as thermodynamic considerations.

TT 28.4 Wed 10:15 HSZ 103

Exploring the unconventional superconducting state in Ce_3PtIn_{11} — Jan Fikáček[1], Sarah R. Dunsiger[2], Sébastien Laughrea[3], Andrea D. Bianchi[3], Shinsaku Kambe[4], Hironori Sakai[4], Yo Tokunaga[4], Manuel Brando[5], and •Jeroen Custers[1] — [1]Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Prague 2, Czech Republic — [2]Centre for Molecular and Materials Science, TRIUMF, Vancouver, British Columbia, Canada V6T 2A3 — [3]Département de Physique, Université de Montréal, Montréal, Canada — [4]Advanced Science Research Center, Japan Atomic Energy Agency, Tokai-mura, Ibaraki 319-1195, Japan — [5]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Strasse 40, D-01187, Dresden, Germany

The properties of the heavy fermion compound Ce_3PtIn_{11} are certainly enigmatic. At ambient pressure, the compound displays two consecutive magnetic transitions into antiferromagnetic (AFM) states at $T_{N1} = 2.2$K and $T_N = 2.0$K, respectively. Below $T_c = 0.32$K superconductivity (SC) is found. It has been speculated that AFM and SC coexist because the compound harbors two inequivalent Ce sites each having a specific environment favoring either a magnetic or superconducting state. We focus on the SC state and present specific heat, ^{115}In NQR and recent μSR experiments at ambient pressure and down to 20mK. The results sketch a picture of an unusual unconventional SC state.

TT 28.5 Wed 10:30 HSZ 103

Surface-acoustic-wave-induced unconventional superconducting pairing — •Viktoriia Kornich — Julius-Maximilians-Universität Würzburg

Exotic materials, topological states, and quantum collective phenomena are of high interest for fundamental science and technology, because they provide complex and stable performance even at a very small scale. The field of unconventional superconductivity investigates new features and phenomena occurring in superconducting materials and setups. However, the exact processes, which lead to unconventional superconducting states are usually not clear and subject to numerous hypotheses and attempts to experimentally verify them. Here, I will discuss how to use externally applied acoustic waves in order to induce unconventional superconducting pairing of different types in solid state matter, primarily in thin films and 2D materials. I will consider a simple setup consisting of a solid state material with conduction electrons and an applied surface acoustic wave, that breaks spatial translation symmetry. I will show that the symmetries of the possible surface-acoustic-wave-induced order parameters depend on the shape of the applied wave. As an example, I will show that even-frequency spin-triplet odd-parity order parameter can occur due to Rayleigh surface acoustic wave.

Invited Talk TT 28.6 Wed 10:45 HSZ 103

Studying the Fulde-Ferrell-Larkin-Ovchinnikov order parameter in quasi-2D organic superconductors — •Tommy Kotte[1], S. Molatta[1], D. Opherden[1], G. Koutroulakis[2], S. E. Brown[3], J. A. Schlueter[4,5], H. Kühne[1], G. Zwicknagl[6], and J. Wosnitza[1,7] — [1]Hochfeld-Magnetlabor Dresden, HZDR — [2]UC Santa Barbara, USA — [3]UC Los Angeles, USA — [4]NSF, Alexandria, USA — [5]ANL, Argonne, USA — [6]IMP, TU Braunschweig — [7]IFMP, TU Dresden

The Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state can emerge in superconductors for which the orbital critical field exceeds the Pauli limit. This unconventional superconducting state is characterized by a spatial modulation of the superconducting order parameter. Although evidence of the formation of an FFLO state has been found in various classes of materials, it is still theoretically debated and experimentally unexplored how the superconducting order parameter evolves within the FFLO phase. Here, we present two fundamental studies concerning this question in quasi-2D organic superconductors, which are well established to host an FFLO state: (i) By means of ^{13}C NMR spectroscopy on β"-$(ET)_2SF_5CH_2CF_2SO_3$, we were able to quantify the modulation amplitude of the spin polarization throughout the FFLO state. This quantity is related to the modulated superconducting gap, hence representing the order parameter. (ii) By means of angular-resolved specific-heat measurements on κ-$(ET)_2Cu(NCS)_2$, we furthermore show how the FFLO order parameter becomes unstable against orbital interactions, leading to a crossover from the FFLO into Abrikosov-like states of higher-order Landau levels.