TT 19: Unconventional Superconductors

Time: Thursday 11:15–12:45 Location: H6

TT 19.1 Thu 11:15 H6

Characterization and spectroscopy of a new non-centrosymmetric superconductor — •Alfredo Spuri, Angelo Di Bernardo, and Elke Scheer — Universität Konstanz

Superconductor with a lack of inversion symmetry in their crystal structure have recently been proposed as systems hosting an unconventional and other topologically nontrivial superconducting states, which could pave their application for the fabrication of novel devices for superconducting spintronics and quantum computing. Moved by these motivations, we have investigated the transport and spectroscopic properties of the non-centrosymmetric superconductor Nb0.18Re0.82 down to the 2D limit. Hall transport measurements in the normal state and tunnelling spectroscopic experiments reveal the emergence of a complex physical behaviour, which suggests the existence of a superconducting order parameter with unconventional properties.

TT 19.2 Thu 11:30 H6

Spatially intertwined superconductivity and charge order in 1T-TaSSe revealed by scanning tunnelling spectroscopy — •Yaroslav Gerasimenko[1,2], Marion van Midden[2], Erik Zupanic[2], Petra Sutar[2], Zvonko Jaglicic[3], and Dragan Mihailovic[2,3] — [1]University of Regensubrg, Regensburg, Germany — [2]Jozef Stefan Institute, Ljubljana, Slovenia — [3]Univeristy of Ljubljana, Ljubljana, Slovenia

The interplay of different emergent phenomena - superconductivity (SC) and domain formation - appearing on different spatial and energy scales are investigated using high-resolution scanning tunnelling spectroscopy in the prototypical transition metal dichalcogenide superconductor 1T-TaSSe single crystals ($T_{SC} = 3.5\,\mathrm{K}$) at temperatures from 1 to 20 K. Our major observation is that while the SC gap size smoothly varies on the scale of $\lesssim 10\,\mathrm{nm}$, its spatial distribution is not correlated to the domain structure. On the other hand, there is statistically significant correlation of the SC gap Δ_{SC} with spectral weight of the narrow band at the Fermi level formed from the same Ta 5d orbitals as the Mott-Hubbard band. We show that the narrow band follows the evolution of Hubbard bands in space, proving unambiguously its relation to the charge order. The correlations between the two suggest a non-trivial link between rapidly spatially varying charge order and superconductivity common in many quantum materials, and high-temperature superconductors in particular.

TT 19.3 Thu 11:45 H6

Angular dependence of the superconductivity in $\mathbf{CeRh_2As_2}$ — •Javier Landaeta[1], Pavlo Khanenko[1], Jacinta Banda[1], Ilya Sheikin[2], Sanu Mishra[2], Seunghyun Khim[1], Manuel Brando[1], Christoph Geibel[1], and Elena Hassinger[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]Univ. Grenoble Alpes, CNRS, LNCMI EMFL, F-38042 Grenoble, France

$CeRh_2As_2$ is an unconventional superconductor with multiple superconducting phases. When $\mu_0 H \parallel c$, this material shows a field-induced transition from a low-field superconducting state SC1 to a high-field SC2 with critical field $H_{c2} = 14$ T and $T_c = 0.26$ K. For $\mu_0 H \parallel ab$, only the SC1 with $H_{c2} = 2$ T is observed. The phase-diagrams and their anisotropy might be explained by the influence of Rashba-spin-orbit coupling at the Ce sites where the inversion symmetry is broken locally. Above T_c, a possibly quadrupolar phase is present at $T_0 \approx 0.4$ K, whose influence on the superconducting state remains unknown. Here, we present a comprehensive study of the angular dependence of the upper critical fields and T_0 using low temperature magnetic ac susceptibility, specific heat and torque in single crystalline $CeRh_2As_2$. The SC2 state is strongly suppressed when rotating the magnetic field away from the c-axis and disappears for an angle of 35°. We find that the H_{c2} of SC2 for angles departing from the c axis is attained when the in-plane component of the field reaches the in-plane Pauli limit. This result corroborates idea that the field-induced state SC2 is an odd-parity state with a d-vector in the plane in $CeRh_2As_2$.

TT 19.4 Thu 12:00 H6

Twisted Superconductivity in the high magnetic field phase of $\mathbf{CeRh_2As_2}$ — •Aline Ramires[1] and David Möckli[2] — [1]Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [2]Instituto de Física, Universidade Federal do Rio Grande do Sul, 91501-970 Porto Alegre, Brazil

$CeRh_2As_2$, a locally noncentrosymmetric heavy fermion material, was recently reported to host a remarkable magnetic field versus temperature phase diagram with two superconducting phases and upper critical fields much above the Pauli limit [1]. In this material, the two inequivalent Ce sites per unit cell, related by inversion symmetry, introduce a sublattice structure corresponding to an extra internal degree of freedom. In this talk, I briefly review some mechanisms that allow for Pauli limit violation and discuss what properties of the normal state are key for the development of a superconducting state robust against magnetic fields. I discuss intra-sublattice and inter-sublattice pairing scenarios and how we can construct superconducting states that violate the Pauli limit by twisting the most stable superconducting state with respect to the internal sublattice degree of freedom [2]. I will also comment on ongoing work that highlights the role of normal state electronic structure parameters, as well as effects of impurities, and subleading instabilities in the phase diagram of this material [3].

[1] S. Khim *et al.*, arXiv:2101.09522 (2021)
[2] D. Möckli and A. Ramires, Phys. Rev. Research **3**, 023204 (2021)
[3] D. Möckli and A. Ramires, arXiv:2107.09723 (2021)

TT 19.5 Thu 12:15 H6

Nematicity and checkerboard order in the surface layer of $\mathbf{Sr_2RuO_4}$ — •Carolina A. Marques[1], Luke C. Rhodes[1], Rosalba Fittipaldi[2], Veronica Granata[3], Chi Ming Yim[1], Renato Buzio[2], Andrea Gerbi[2], Antonio Vecchione[2], Andreas W. Rost[1,4], and Peter Wahl[1] — [1]SUPA, School of Physics and Astronomy, University of St Andrews, UK. — [2]CNR-SPIN, Italy. — [3]Dipartimento di Fisica, Università di Salerno, Italy. — [4]Max-Planck-Institute for Solid State Research, Stuttgart, Germany.

Superconductivity in strongly correlated systems is often found near exotic electronic phases, such as antiferromagnetism and electronic nematicity. These phases can be highly sensitive to minor changes in the crystal structure, induced by doping or strain. In the unconventional superconductor Sr_2RuO_4, a 6° rotation of the RuO_6 octahedra at the surface seems to suppress its superconducting state and pushes a van Hove singularity below the Fermi energy. Using ultra-low temperature Scanning tunnelling microscopy, we study the low energy electronic properties of the reconstructed surface of Sr_2RuO_4[1]. Our measurements show clear signatures of C_4 symmetry breaking, together with the appearance of a checkerboard order, associated with a peak in the tunnelling spectrum, which splits in a magnetic field, revealing a charge nature. Tight binding calculations show that a nematic order parameter coexisting with a charge modulation reproduces the observed low energy density of states. Understanding the underlying physics at this surface provides a new platform to study the strongly correlated phases of Ruthenate materials.

[1] Adv. Mat. 2100593 (2021)

TT 19.6 Thu 12:30 H6

Quasiparticle Interference of the van-Hove singularity in $\mathbf{Sr_2RuO_4}$ — •Andreas Kreisel[1], Carolina A. Marques[2], Luke C. Rhodes[2], Xiangru Kong[3], Tom Berlijn[3], Rosalba Fittipaldi[4], Veronica Granata[5], Antonio Vecchione[4], Peter Wahl[2], and Peter J. Hirschfeld[6] — [1]Institut für Theoretische Physik, Universität Leipzig — [2]SUPA, University of St Andrews,UK — [3]CNMS, Oak Ridge National Laboratory, USA — [4]CNR-SPIN, UOS Salerno, Italy — [5]Dipartimento di Fisica, Università di Salerno, Italy — [6]Department of Physics, University of Florida, USA

The single-layered ruthenate Sr_2RuO_4 is one of the most enigmatic unconventional superconductors. While for many years it was thought to be the best candidate for a chiral p-wave superconducting ground state, desirable for topological quantum computations, recent experiments suggest a singlet state, ruling out the original p-wave scenario. The superconductivity as well as the properties of the multi-layered compounds of the ruthenate perovskites are strongly influenced by a van Hove singularity in proximity of the Fermi energy. Tiny structural distortions move the van Hove singularity across the Fermi energy with dramatic consequences for the physical properties. Here, we determine the electronic structure of the van Hove singularity in the surface layer of Sr_2RuO_4 by quasiparticle interference imaging. We trace its dispersion and demonstrate from a model calculation accounting for the full vacuum overlap of the wave functions that its detection is facilitated through the octahedral rotations in the surface layer.