TT 83: Superconductivity: (General) Theory

Time: Thursday 9:30–12:45 Location: HFT-FT 101

TT 83.1 Thu 9:30 HFT-FT 101

High-field superconductivity in ultra-thin films, interfaces, and superlattices — •Gertrud Zwicknagl[1], Lukas Debbeler[1,2], Simon Jahns[1], and Peter Fulde[3] — [1]Institut f. Mathemat. Physik, TU Braunschweig, Germany — [2]Dept. of Physics, University of Oregon, Eugene, OR 97403 (USA) — [3]MPI f. Physik komplexer Systeme, Dresden, Germany

In recent years, the manufacturing of controlled ultra-thin superconducting films has made impressive progress. Important examples are monoatomic or monomolecular layers on a substrate, superconducting layers in a superlattice, or superconducting interfaces and surfaces. These systems have in common the absence of inversion symmetry and hence the presence of Rashba-type spin-orbit interaction which can be tuned to some extent.

We discuss the superconducting properties of ultra-thin superconducting films with Rashba spin-orbit interaction in the presence of a parallel magnetic field. Thereby we cover the range from small to large spin-orbit interactions compared with the gap parameter. We find abrupt changes in the superconducting state at a critical value spin-orbit energy λ_c. We speculate that this might give rise to new phenomena.

TT 83.2 Thu 9:45 HFT-FT 101

Quantum Theory of Linear Magnetoresistance and Linear-in-Temperature Resistance — •Vincent Sacksteder — Royal Holloway University of London, UK

The physical mechanisms responsible for Linear Magnetoresistance (seen in many settings) and Linear-in-Temperature resistance (seen in cuprates and pnictides) are not yet fully understood. We propose that these phenomena are manifestations of quantum interference processes, similar to the logarithmic conductivity corrections known to be caused by weak antilocalization. We submit that the linear-in-temperature resistance is caused not by increased scattering but instead by scatterings interfering coherently to control the resistance. Strong correlations may be responsible for providing the coherence required by the quantum interference processes. We propose a numerically precise approach to analyzing and interpreting magnetotransport data which allows firm conclusions to be made about the length scales and quantum interference processes contributing to transport.

TT 83.3 Thu 10:00 HFT-FT 101

Higgs Spectroscopy of Superconductors in Nonequilibrium — •Benedikt Fauseweh and Dirk Manske — Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart, Germany

In previous studies it has been shown, that the non-equilibrium response of superconductors allows for probing of the amplitude-, or Higgs-, mode of the superconducting condensate [1]. This feature was predicted in theory with different quenching protocols [2,3] and found in experiments using ultra-short laser pulses in the THZ Regime [4]. So far only s-wave superconductors with a constant energy gap as a function of momentum have been investigated.

In our contribution we present a systematic study of Higgs oscillations using a combination of non-equilibrium excitation and symmetry analysis. This allows for a full characterization of the superconducting gap function, similar to Phonon spectroscopy. By investigating the non-equilibrium response of s- and d-wave superconductors we show, that non-equilibrium Higgs-spectroscopy opens a unique approach to distinguish between different symmetries of the condensate. Finally, we propose new methods to implement these ideas in experiments.

[1] Yuzbashyan, Dzero, Phys. Rev. Lett. 96 (2006) 230404
[2] Krull, Manske, Uhrig, Schnyder, Phys. Rev. B 90 (2014) 014515
[3] Krull et al., Nat. Commun. 7 (2016) 11921
[4] Matsunaga, Shimano Phys. Rev. Lett. 109 (2012) 187002,

TT 83.4 Thu 10:15 HFT-FT 101

Multiband superconductivity in noncentrosymmetric YPtBi — •Carsten Timm[1], Andreas P. Schnyder[2], Daniel F. Agterberg[3], and Philip M. R. Brydon[4] — [1]Institute of Theoretical Physics, Technische Universität Dresden, Germany — [2]MPI for Solid State Research, Stuttgart, Germany — [3]Department of Physics, University of Wisconsin, Milwaukee, U.S.A. — [4]Department of Physics, University of Otago, Dunedin, New Zealand

Half-Heusler superconductors such as YPtBi combine two aspects of high current interest: they display noncentrosymmetric and multiband superconductivity. We study bulk and surface states in two exemplary nodal superconducting phases, which transform as the A_1 and T_2 irreducible representations of the crystallographic point group, respectively. The A_1 phase preserves time-reversal symmetry. We find that flat surface bands persist in the presence of multiband pairing. In addition, there are symmetry-protected Fermi arcs of surface states. On the other hand, the T_2 phase breaks time-reversal symmetry. In the bulk, point and line nodes coexist with two-dimensional Bogoliubov Fermi surfaces. The surface exhibits Fermi arcs associated with the bulk point nodes.

TT 83.5 Thu 10:30 HFT-FT 101

Electromagnetic response of spiral magnetic states in two-dimensional metals — •Johannes Mitscherling and Walter Metzner — Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany

The superconductivity and the normal state of cuprates are not yet fully understood. In a seminal paper [1], Badoux et al. suppressed the superconductivity with high magnetic fields making the normal ground state accessible. Varying the doping in YBCO they found a rapid change of the Hall number near optimal doping indicating a Fermi surface reconstruction. A spiral magnetic ground state was shown to be a possible candidate for such a reconstruction [2]. A full treatment of the electromagnetic response for a two-dimensional metal with a spiral magnetic ground state beyond the long lifetime limit is necessary at the relevant experimental temperatures. In a systematic approach we extend the well-known results of Voruganti et al. [3] including all inter-band effects for arbitrary lifetime which leads to corrections to the conductivity and Hall conductivity. We clarify the conditions under which the well-known results are applicable, discuss the relation between the Hall number and the occupation number and apply it to the experiments mentioned above.

[1] Badoux et al., Nature 531, 210 (2016)
[2] Eberlein et al. PRL 117, 187001 (2016)
[3] Voruganti et al., PRB 45, 13945 (1992)

TT 83.6 Thu 10:45 HFT-FT 101

Spin pumping in a ferromagnet/superconductor/normal-metal trilayer in presence of spin-orbit coupling and Fermi-liquid effects. — •Xavier Montiel and Matthias Eschrig — Royal Holloway University of London, Egham, United Kingdom

The injection of spin current into superconducting (S) layer is of primary importance for superconducting spintronics [1]. The precession of a ferromagnet magnetization close to the ferromagnetic resonance (FMR) "pumps" spins from the ferromagnet (FM) layer into adjacent layers. The injected spin current into superconducting (S) layer is expected to decrease below Tc because singlet Cooper pairs do not carry spin and the addition of a metallic layer does not change this result [2]. Here we show that if an FM-S bilayer is capped on the superconducting side by a normal metal with strong spin-orbit coupling (Nso), as for example in a Py/Nb/Pt trilayer, then an additionnal spin current exists in the superconducting state associated with Fermi liquid corrections, and spin-triplet correlations are induced in the entire structure that are long-range within the F layer. We calculate the spin current accross a F/S/Nso structure as a function of temperature. We show that this effect is sensitive to the F/S and S/N proximity effect and depends on the S layer thickness. We discuss the magnitude of the injected spin current as function of the magnitudes of the spin-orbit coupling and of the Fermi-liquid parameters.

[1] M. Eschrig, Rep. Prog. Phys. 78, 104501 (2015)
[2] J. Morten.et al., Europhys. Lett. 84, 57008 (2008)

TT 83.7 Thu 11:00 HFT-FT 101

Nonunitary triplet pairing from the Edelstein effect in noncentrosymmetric superconductors — •Grigory Tkachov — Wuerzburg University

The search for new forms of spin-triplet pairing is an important goal in superconductivity. The purpose of this contribution is to point out a surprising connection between the Edelstein effect in noncentrosymmetric superconductors [1] and the nonunitary (spin-polarized) pairing in triplet superfluids with a complex **d** vector [2]. It will be shown that the Edelstein effect leads to a new form of the nonunitary spin-triplet pairing [3] which is generated electrically by a supercurrent in an initially TR-invariant (unpolarized) system. Such a nonunitary state can be induced in a wide class of noncentrosymmetric superconductors, including those with a real **d** vector and proximity structures with $\mathbf{d} = 0$. I will also discuss how to detect the nonunitary spin-triplet pairing by Andreev reflection. These results indicate an unexplored route for electrical manipulation of spin-triplet superconductivity in noncentrosymmetric materials.

This work has been supported by the German Research Foundation (DFG grant No TK60/4-1).

[1] V. M. Edelstein, Phys. Rev. Lett. **75**, 2004 (1995).
[2] A. J. Leggett, Rev. Mod. Phys. **47**, 331 (1975).
[3] G. Tkachov, Phys. Rev. Lett. **118**, 016802 (2017).

15 min. break.

TT 83.8 Thu 11:30 HFT-FT 101

Multi-particle theory of superconductivity — •Gareth Conduit and Thomas Whitehead — Cavendish Laboratory, J.J. Thomson Avenue, Cambridge, CB3 0HE, United Kingdom

A spin-imbalanced Fermi gas with an attractive contact interaction forms a superconducting state whose underlying components are multi-particle instabilities, each involving more than two fermions. This multi-particle superconducting state is energetically favourable to Fulde-Ferrell-Larkin-Ovchinnikov superconductivity, because it includes correlations between all available fermions. The ratio of the number of up- and down-spin fermions in the instability is a function of the ratio of the up- and down-spin densities of states in momentum at the Fermi surfaces, to fully utilise the accessible fermions.

TT 83.9 Thu 11:45 HFT-FT 101

Pair density waves from coexistence: properties and experimental signatures — •Pavel A. Volkov[1], Mikhail Malakhov[2], and Konstantin B. Efetov[1,3] — [1]Theoretische Physik III, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Institute of Physics, Kazan (Volga Region) Federal University, 420008 Kazan, Russian Federation — [3]National University of Science and Technology MISiS, 119049 Moscow, Russian Federation

Pair density wave (PDW) is a state of matter where the amplitude of superconducting pairing oscillates in space. One of the cases where PDW is expected to arise is in a system where uniform superconductivity coexists with a charge density wave. This situation is realized in underdoped cuprates, where PDW has been recently discovered in a scanning Josephson tunneling microscopy (SJTM) experiment [1]. In this regard, we consider a mean-field model with the Gor'kov formalism to study the structure of the PDW. We find that the PDW amplitude has an intricate momentum dependence that bears information about the order parameters as well as the underlying Fermi surface. We also consider the implications of our results for the SJTM experiments and discuss applications to other materials where coexistence of superconductivity and charge density waves has been reported.

[1] M. H. Hamidian et al., Nature 532, 343 (2016).

TT 83.10 Thu 12:00 HFT-FT 101

The Concept of Superconducting Fitness — •Aline Ramires[1], Manfred Sigrist[2], and Daniel Agterberg[3] — [1]Institute for Theoretical Studies, ETH Zurich, 8092 Zurich, Switzerland — [2]Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland — [3]Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, WI 53201, USA

In this talk, we present a general scheme to probe the compatibility of arbitrary pairing states with a given normal state Hamiltonian by the introduction of a concept called Superconducting Fitness. This quantity gives a direct measure of the suppression of the superconducting critical temperature in the presence of key symmetry-breaking fields and can be used as a tool to identify nontrivial mechanisms to suppress superconductivity in complex multi-orbital systems. This concept can also be employed as a guide to engineer normal state Hamiltonians in order to favor or suppress different order parameters. We discuss the application of this idea to Sr_2Ru0_4, $CePt_3Si$, KFe_2As_2 and $Cu_xBi_2Se_3$.

TT 83.11 Thu 12:15 HFT-FT 101

Renormalization group studies of supeconducting ordering in nickelates — •Michael Klett[1], David Riegler[1], Gang Li[2], and Ronny Thomale[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians University of Würzburg, 97074 Würzburg, German — [2]School of Physical Science and Technology, ShanghaiTech University, Shanghai 201210, China

Since the discovery of high T_c superconductivity in the cuprates by Bednorz and Müller, materials bearing similarities to copper oxide compounds have merged as a contemporary research topic of high interest. Although nickelates share many similarities with the cuprates, they exhibit no superconducting phase down to lowest temperatures. In this talk we sketch a simple two-band DFT model of the nickelates and argue why, based on renormalization group calculations competing superconducting ordering propensities make the nickelates belong to the class of low T_c materials

TT 83.12 Thu 12:30 HFT-FT 101

Chiral superconductivity in germanene on molybdenum disulfide — •Xianxin Wu, Domenico Di Sante, Mario Fink, Werner Hanke, and Ronny Thomale — Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, Würzburg, Germany

We investigate competing orders for germanene on molybdenum disulfide (Ge/MoS_2), where the Van Hove singularity point is close to the Fermi level, and can already be achieved by moderate electron doping. We find that the system harbors a d+id or f wave superconducting state depending on the electron doping and interaction profile. Our study indicates that Ge/MoS_2 promises to be a prototypical system to realize chiral superconductivity.