TT 25: Superconductivity: Heterostructures, Andreev Scattering, Proximity Effect, Coexistence

Time: Wednesday 14:00–15:30 Location: H 3010

TT 25.1 Wed 14:00 H 3010

Andreev bound state spectrum in half-metallic ferromagnets — •Matthias Eschrig — Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe

Half-metallic ferromagnets are important for potential applications in spintronics and as sources of completely spin-polarized currents. In heterostructures with superconductors they introduce new effects in the interface regions, like spin-mixing and triplet rotation. A triplet supercurrent trough a half metal has been prediced [1] and experimentally verified [2]. Another interesing question regards the question how the density of states is modified in the half-metallic region. Here we present results of the Andreev bound state spectrum in a half-metal/superconductor proximity structure. We discuss the dependence on the interface parameters that enter the interface scattering matrix of the heterostructure. We discuss the role of odd-frequency pairing amplitudes in the proximity structure [3]. We also study the modification of the Andreev bound state spectrum in a superflow.

[1] M. Eschrig et al., Phys. Rev. Lett. **90**, 137003 (2003).
[2] R.S. Keizer et al., Nature, **439**, 825-827 (2006).
[3] M. Eschrig, T. Löfwander, submitted to Nature Physics.

TT 25.2 Wed 14:15 H 3010

Transport through ferromagnet-superconductor contacts — •Georgo Metalidis and Matthias Eschrig — Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe

Rapid advances in nanofabrication techniques have made it possible to create high quality ferromagnet-superconductor heterostructures. Apart from potential device applications, a variety of fundamental physical phenomena make such structures interesting both from the experimental and theoretical point of view. The behavior of hybrid ferromagnet-superconductor devices is largely determined by the phenomena proximity effect and Andreev scattering. In the present work, we make use of the quasiclassical theory of superconductivity in order to study Andreev reflection processes at ferromagnet-superconductor interfaces. We address the role that impurities play in the phenomenon of crossed Anreev reflection.

TT 25.3 Wed 14:30 H 3010

Non-local Andreev reflection in superconducting quantum dots — •Dmitry Golubev and Andrei Zaikin — Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021, Karlsruhe, Germany

With the aid of the Keldysh technique we develop a microscopic theory of non-local electron transport in three-terminal NSN structures consisting of a chaotic superconducting quantum dot attached to one superconducting and two normal electrodes. Our theory fully accounts for non-equilibrium effects and disorder in a superconducting terminal. We go beyond perturbation theory in tunneling and derive a general expression for the system conductance matrix which remains valid in both weak and strong tunneling limits. We demonstrate that the proximity effect yields a decrease of crossed Andreev reflection (CAR). Beyond weak tunneling limit the contribution of CAR to the non-local conductance does not cancel that of direct electron transfer between two normal terminals. We argue that temperature dependence of the non-local resistance of NSN devices is determined by the two competing processes – Andreev reflection and charge imbalance – and it has a pronounced peak occurring at the crossover between these two processes. This behavior is in a good agreement with recent experimental observations.

TT 25.4 Wed 14:45 H 3010

Superconducting spin valve structures grown on epitaxial [Fe/V]-(001) superlattices — •Gregor Nowak[1], Hartmut Zabel[1], Björgvin Hjörvarsson[2], and Kurt Westerholt[1] — [1]Experimentalphysik /Festkörperphysik, Ruhr - Universität Bochum, Germany — [2]Department of Physics, University of Uppsala, Sweden

In a superconducting F1/S/F2 spin valve trilayer structure a superconducting layer (S) is imbedded by a ferromagnetic layer F1 and F2. Model calculations based on the F/S proximity effect have shown that with suitable parameters for the thicknesses and correlations lengths of the F and S-layers the superconductivity can be switched off and on by rotating the magnetization of F1 and F2 from a parallel to an antiparallel orientation. Experimentally, however, it turned out to be challenging to optimize the F1/S/F2 device and until now only very small differences of the superconducting (SC) transition temperature Ts between the parallel and antiparallel orientation has been observed. We have prepared epitaxial F1/S/F2 spin valve systems using an [Fe/V] superlattice as F1, V as the superconducting layer S and Co, Fe(1-x)V(x) layer as F2. The epitaxial quality in this kind of heterostructures reduces the impurity and surface electron scattering so that the superconducting coherence length approaches the thickness of the V-layer. We observe a well pronounced spin valve effect, especially in the system with the Fe(1-x)V(x)-alloy layers, which can be as high as tens of mK.

TT 25.5 Wed 15:00 H 3010

Josephson Effect in Hybrid Oxide Heterostructures with an Antiferromagnetic Layer — •Philipp Komissinskiy[1,2,3], Gennady Ovsyannikov[2,3], Igor Borisenko[2], Yulii Kislinskii[2], Sandra Heinz[1], Dag Winkler[3], and Lambert Alff[1] — [1]Department of Materials Science, Darmstadt University of Technology, 64287 Darmstadt, Germany — [2]Institute of Radio Engineering and Electronics Russian Academy of Sciences, 125009 Moscow, Russia — [3]Department of Microtechnology and Nanoscience, Chalmers University of Technology, 41296 Gothenburg, Sweden

Josephson coupling between an *s*- and *d*-wave superconductor through $Ca_{1-x}Sr_xCuO_2$ antiferromagnetic layer was observed for the hybrid $Nb/Au/Ca_{1-x}Sr_xCuO_2/YBa_2Cu_3O_{7-\delta}$ heterostructures and investigated as a function of temperature, magnetic field and applied millimeter-wave electromagnetic radiation [1]. Values of the Josephson characteristic voltage $V_c = I_c R_N \sim 100-200\,\mu$V were demonstrated in the Nb/Au/CSCO/YBCO junctions with up to 50 nm thick CSCO AF layer. The ac Josephson effect is manifested in multiple Shapiro steps, which are well fitted by the RSJ Josephson junction model. The magnetic field dependence of the supercurrent $I_c(H)$ exhibits anomalously rapid oscillations, which is the first experimental evidence of the theoretically predicted giant magneto-oscillations in Josephson junctions with antiferromagnetic interlayers.

[1] P. Komissinskiy, G. A. Ovsyannikov, I. V. Borisenko, Yu.V. Kislinskii, K.Y. Constantinian, A.V. Zaitsev, and D. Winkler, Phys. Rev. Lett. **99**, 017004 (2007).

TT 25.6 Wed 15:15 H 3010

Inhomogeneous vortex distribution and magnetic coupling in oxide superconductor-ferromagnet hybrids — •Joachim Albrecht[1,2], Märit Djupmyr[1], Soltan Soltan[3], Hanns-Ulrich Habermeier[3], Malcolm Connolly[2], and Simon Bending[2] — [1]MPI für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Department of Physics, University of Bath, Bath BA2 7AY, UK — [3]MPI für Festkörperforschung, Heisenbergstr.1, 70569 Stuttgart

Hybrid systems of thin films of oxide ferromagnets and high-temperature superconductors have been investigated by Scanning Hall Probe Microscopy to analyze the local magnetic flux density distribution at low temperatures [1]. In addition to the intrinsic properties of the films themselves such structures exhibit novel phenomena due to complex interactions arising at the interface between them. As a consequence the distribution of vortices in the superconductor is strongly influenced by the magnetic background arising from the ferromagnet. The local magnetic information obtained from Scanning Hall Probe Microscopy images provides clear evidence for the presence of a magnetic dipolar interaction between the magnetic domains of the ferromagnetic component and the vortex ensemble in the superconductor.

[1] J Albrecht et al., New Journal of Physics **9**, 379 (2007)