to an oscillatory behavior in Anderson overlap as a function of filling of the PQD levels. In particular, we find a pronounced AOC, related to the quasi-degeneracy of levels, whenever a new shell is opened up. This inherent shell structure survives in the presence of mesoscopic fluctuations, when we observe the Anderson overlap to remain unchanged despite adding several electrons to the system. A similar bunching phenomenon has been observed in transport measurements on quantum dots by Zhitenev et. al.[PRL,79, 2308 (1997)].

TT 24.15 Wed 18:00 H 2053
Konkurrenz von Coulomb-Abstoßung und Elektron-Phonon-Wechselwirkung in einem eindimensionalen Elektronen-Phonon-System — Gérard Zschaler, Steffen Sykora and Klaus W. Becker — Institut für Theoretische Physik, TU Dresden, Germany


TT 24.16 Wed 18:15 H 2053
Entanglement percolation at quantum phase transitions in random quantum magnets — Yu-Cheng Lin¹, Ferenc Iglòs²,³, and Heiko Rieger — Institut für Theoretische Physik, Universität des Saar- landes, 66041 Saarbrücken, Germany — ²Research Institute for Solid State Physics and Optics, H-1525 Budapest, Hungary — ³Institute of Theoretical Physics, Szeged University, H-6720 Szeged, Hungary

We study the scaling of the entropy quantifying the degree of quantum entanglement between two regions in a bipartite random quantum Ising model in two dimensions, using an asymptotically exact renormalization group treatment [1]. This system undergoes a quantum phase transition at a certain transverse field strength, at which point the von Neumann entanglement entropy of a subsystem violates the "area law", providing evidence for non-trivial and long-range quantum entanglement in the ground state. The entanglement entropy per surface area of a subsystem diverges in a double logarithmic form, arising from a type of percolation of the critical ground state that is fundamentally different from classical percolation. The latter can be found in an analogous quantum system with random bond dilution; here the area law is valid at the quantum critical point, which implies that entanglement cannot be regarded as an indicator of quantum criticality for higher dimensional systems in the way as for one-dimensional cases. [1] Y.-C. Lin, F. Iglòs and H. Rieger, Phys. Rev. Lett. 99, 147202 (2007).

TT 24.17 Wed 18:30 H 2053
Spin-orbit coupling and electron correlations in quantum wires — Jens Eho Bircholz² and Volker Meden¹ — ¹Institut für Theoretische Physik, Universität Göttingen, D-37077 Göttingen, Germany — ²Institut für Theoretische Physik A, RWTH Aachen, D-52056 Aachen, Germany

We investigate the influence of the spin-orbit coupling on the transport properties of mesoscopic quantum wires. For a continuum model we discuss the effect of the spin-orbit interaction resulting from the lateral potential necessary to confine the two-dimensional electron gas, occurring at a semiconductor hetero junction, to a quasi one-dimensional wire geometry. The spin polarization at a potential step in the presence of a magnetic field is analyzed. We introduce a lattice model which shows similar low-energy physics. For this lattice model we use the functional renormalization group method to investigate the role of the two-particle interaction (Coulomb interaction). The interplay of spin-orbit coupling, potential barriers, and electron correlations leads to interesting phenomena in the low-energy physics regime.

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

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 predicted [1] and experimentally verified [2]. Another interesting 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.


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 Andreev 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 NOWAK1, HARTMUT ZABER1, BORIS NEMOV2, and KURT WESTERHOUT2

1Experimentalphysik / Festkörperphysik, Ruhr - Universität Bochum, Germany — 2Department 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 KOMISSINSKY1,2, JENS MEYER2, IGOR BORISNOG2, YULII KISLINSKI2, SANDRA HEINZ2, DAG WINKLER3, and LAMBERT ALFF1

1Department of Materials Science, Darmstadt University of Technology, 64287 Darmstadt, Germany — 2Institute of Radio Engineering and Electronics Russian Academy of Sciences, 125009 Moscow, Russia — 3Department of Microtechnology and Nanoscience, Chalmers University of Technology, 41296 Gothenburg, Sweden.

Josephson coupling between an s- and d-wave superconductor through Cu1−xSrxCu2O2 antiferromagnetic layer was observed for the hybrid Nb/Nb−Cu1−xSrxCu2O2/YBaCuO−3 heterostructures and investigated as a function of temperature, magnetic field and applied microwave-power electromagnetic radiation [1]. Values of the Josephson characteristic voltage Vc = IcRc ≈ 100−200 μV were demonstrated in the Nb/Nb/SCSO/YBCO junctions with up to 50 nm thick YBCO 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 Ic(H) exhibits anomalously rapid oscillations, which is the first experimental evidence of the theoretically predicted giant magneto-oscillations in Josephson junctions with antiferromagnetic interlayers.


TT 26: Superconductivity: Vortex Dynamics, Vortex Phases, Pinning

Time: Wednesday 15:45–18:15

Location: H 3010

TT 26.1 Wed 15:45 H 3010

General critical state in type-II superconductors with longitudinal currents • ERNST HELMUT BRANDT1 and GREGOR MIKTIT2

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The concept of the Bean critical state has been very successful in superconductors with vortex pinning. It states that the current density |j| is either zero or jcr, the critical current density, and it thus predicts sharp spatial jumps of j. However, this usual critical state model applies only when j is perpendicular to the vortex lines everywhere. We generalize this model to the frequent situation where the vortex lines are aligned with the applied magnetic field at an arbitrary angle with respect to the induction B(r), by postulating that only the perpendicular component jz (which causes the Lorentz force) is critical, jz ≤ jcr. Surprisingly, even for the simplest example of a slab in rotating magnetic field such that no flux cutting occurs, the resulting spatial profiles of j(x) and B(x) in the critical state are now smooth, diffusion like, and do not exhibit the expected sharp fronts.


TT 26.2 Wed 16:00 H 3010

Vortex Matter and Vortex Manipulation in Mesoscopic Superconducting Systems • ROGER WÖRDENWEIER1, EUGEN HOLLMANN1, JÜRGEN SCHUBERT2, ROLF KUTZNER3, KONSTANTIN ILLIN2, and MICHAEL SIEGEL2

1Institute for Bio- and Nanosystems and cni - Center of Nanoelectronic Systems for Information Technology, Research Center Jülich — 2Institute for Micro- and Nano-Electronic Systems, University of Karlsruhe

The understanding of the properties of Abrikosov vortices in mesoscopic superconducting systems that are exposed to low and high frequencies electric fields is of interest for basic aspects of vortex matter and for potential application of superconductivity in fluxonic devices. We report on theoretical aspects and new experiments on vortex matter in patterned superconducting films. The impact of micropatterns on the vortex mobility and vortex manipulation is examined for frequencies ranging from dc to 20GHz. Conventional superconducting films (Nb and NbN) as well as HTS films (YBCO) are examined. The manipulation of the vortices in thin films is achieved either by patterning with various hole arrays (antidots of different size and geometry) or by adding nanodots. The mobility and the manipulation of the direction of vortex motion by the micro and nanostructures are analyzed as function of frequency. Vortex diodes are generated by asymmetric pinning or an additional vortex driving potential provided by a dc current. The diode effect is demonstrated for different frequency regimes.

TT 26.3 Wed 16:15 H 3010

Commensurability effects in Nb thin films with randomly diluted pinning arrays • DANIEL BOTHNER1, MATTHIAS KEMMLER1, KONSTANTIN ILLIN2, MICHAEL SIEGEL2, REINHOLD KLEINER3, and DIETER KORTELE1

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We study experimentally the critical depinning current Ic versus applied magnetic field B in Nb thin films, which contain 2D arrays of circular antidots arranged in randomly diluted triangular lattices. For measurements of electric transport close to the Nb transition temperature Tc, the sample temperature is controlled and stabilized via an optical, very low noise heating system.