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 Elektron-Phonon-System — •Gerd Zschaler, Steffen Sykora und Klaus W. Becker — Institut für Theoretische Physik, TU Dresden, Germany

Wir untersuchen ein verallgemeinertes Su-Schrieffer-Heeger Modell mit zusätzlicher Coulomb-Abstoßung zwischen nächsten Nachbarn. Während die Elektron-Phonon-Wechselwirkung eine Dimerisierung auf den Bonds favorisiert, führt die Coulomb-Abstoßung zu einer Ladungsdichtewelle (CDW). Mit Hilfe der projektiven Renormierungsmethode (PRM) werden beide Wechselwirkungen sukzessive eliminiert, so dass ein renormiertes, entkoppeltes Elektron-Phonon-System resultiert. Der Einfluss der konkurrierenden Wechselwirkungen auf die renormierten Einteilchenenergien wird untersucht.

TT 24.16 Wed 18:15 H 2053

Entanglement percolation at quantum phase transitions in random quantum magnets — •Yu-Cheng Lin[1], Ferenc Igloi[2,3], and Heiko Rieger[1] — [1]Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken, Germany — [2]Research Institute for Solid State Physics and Optics, H-1525 Budapest, Hungary — [3]Institute 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. Iglói 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 Eiko Birkholz[1] and Volker Meden[2] — [1]Institut für Theoretische Physik, Universität Göttingen, D- 37077 Göttingen, Germany — [2]Institut 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, ocurring 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 24.18 Wed 18:45 H 2053

Single hole and vortex excitations in the doped Rokhsar-Kivelson quantum dimer model on the triangular lattice — •Hugo Ribeiro[1,2], Samuel Bieri[2], and Dmitri Ivanov[2] — [1]Institute of theoretical physics C, RWTH Aachen, Germany — [2]Institute of theoretical physics, EPF Lausanne, Switzerland

We consider the doped Rokhsar-Kivelson quantum dimer model on the triangular lattice with one mobile hole (monomer) at the RK point. The motion of the hole is described by two branches of excitations: the hole may either move with or without a trapped Z2 vortex (vison). We perform a study of the hole dispersion in the limit where the hole hopping amplitude is much smaller than the inter-dimer interaction. In this limit, the hole without vison moves freely and has a tight-binding spectrum. On the other hand, the hole with a trapped vison is strongly constrained due to interference effects and can only move via higher-order virtual processes.

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 $V_c = I_cR_N \sim 100-200\,\mu$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)

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 Brandt[1] and Grigorii Mikitik[1,2] — [1]Max-Planck-Institut für Metallforschung, Stuttgart — [2]B. Verkin Institute for Low Temperature Physics and Engineering, NUAS, Kharkov, Ukraine

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

[1] E. H. Brandt and G. P. Mikitik, Phys. Rev. B **76**, 64526 (2007).

TT 26.2 Wed 16:00 H 3010

Vortex Matter and Vortex Manipulation in Mesoscopic Superconducting Systems — •Roger Wördenweber[1], Eugen Hollmann[1], Jürgen Schubert[1], Rolf Kutzner[1], Konstantin Ilin[2], and Michael Siegel[2] — [1]Institute for Bio- and Nanosystems and cni - Center of Nanoelectronic Systems for Information Technology, Research Center Jülich — [2]Institute 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 Bothner[1], Matthias Kemmler[1], Konstantin Ilin[2], Michael Siegel[2], Reinhold Kleiner[1], and Dieter Koelle[1] — [1]Physikalisches Institut - Experimentalphysik II and Center for Collective Quantum Phenomena, Universität Tübingen, Germany — [2]IMS, Universität Karlsruhe, Germany

We study experimentally the critical depinning current I_c 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 T_c, the sample temperature is controlled and stabilized via an optical, very low noise heating system.