Interactions, disorder and dephasing in superconducting films and Quantum Hall systems.

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It is shown that a large class of two dimensional Superconductor to Insulator (SC-I), and Quantum Hall to Insulator (QH-I) transitions can be understood by assuming that the thermodynamic transition in the clean system is *first order*. The finite correlation lengths at the transition yield a natural separation of the disorder into short and long wavelengths which are then straightforward to incorporate perturbatively and semiclassically respectively.
This approach reduces problems of disorder+interactions to puddle network models, whose studies have alrealy yielded insight into experiments of QH-I and SC-I. For theQH-I, the difference between Landauer-Buttiker and Boltzman theories highlights effects of dephasing.

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Mixed-valent regime of the two-channel Anderson impurity as a model for $U_{1-x}Th_xBe_{13}$

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In recent years, a new class of f-electron materials has emerged featuring log(T) enhancements of the specific heat and susceptibility, and a low-temperature resistivity that varies either linearly or as the square root of the temperature. Such behaviors are incompatible with Landau's Fermi-liquid picture of metals. One primary example is $U_{1-x}Th_xBe_{13}$, in which uranium ions fluctuate between two different charge configurations. In this talk I will show that the non-Fermi-liquid behavior of $U_{1-x}Th_xBe_{13}$ is best understood in terms of a novel mixed-valent state in which the ionic fluctuations undergo an exotic many-body screening. By considering realistic crystalline electric field splittings, this scenario successfully explains the linear and nonlinear susceptibility data for UBe_{13} which thus far appeared incompatible, and accounts for their variation upon doping with thorium. It also supports a small many-body energy scale, as found in $U_{1-x}Th_xBe_{13}$. These results were obtained using extensive Monte Carlo, non-crossing approximation, and numerical renormalization-group calculations.

Strong Bulk–Edge Coupling in the Compressible Half–Filled Quantum Hall State

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We studied analytically static correlators in the compressible half–filled quantum Hall state, which characterize the nature of charged excitations in the bulk and on the edge of the system. We employ a modified version of the plasma analogy - namely, a mapping to a classical two–dimensional system of interacting particles - similarly to what has been done in studies of the incompressible (Laughlin) states. However, the 'fake plasma' corresponding to the half–filled state is found to have *anomalously weak* screening properties. As a consequence, the correlations along the edge do not decay algebraically as in the incompressible case, thus indicating the breakdown of Wen's edge theory. On the other hand, the bulk correlator (which parallels the Girvin–MacDonald algebraic off–diagonal long range order) decays algebraically in a similar way as in the incompressible states, signifying the presence of some kind of bosonic order even in the compressible state.
The above results suggest that due to the strong coupling between charged modes on the edge and the neutral Fermions (dipoles) in the bulk, the (attractive) correlation hole is not well defined on the edge. Hence, the system there can be modeled as a free Fermi gas of *electrons* (with an appropriate boundary condition). A possible experimental indication of a strong bulk–edge coupling at half–filling has been indeed observed in non–local resistance measurements [1]. We also suggest, that while our results contradict the validity of an effective one–dimensional description of the edge excitations on the *static* level, the *dynamics* may decouple the edge and bulk so as to recover the Laughlin–like behavior apparent in the experiment of Grayson *et al* [2].

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Waves in Random Media: Intensity Distributions and non-Rayleigh Statistics

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A wave propagating in a random medium produces a complicated, irregular intensity pattern (speckle pattern). It is described in statistical terms, with the help of various correlation functions and probability distributions, such as the intensity distribution $P(I)$ at some point in space. In many cases $P(I)$ is well approximated by the Rayleigh distribution, $\exp(-I)$, as long as the intensity I, normalized to its average value, is not too large. Recently Mirlin *et. al.* [1] considered quasi-one-dimensional geometry and, using the supersymmetry formalism, derived a close expression for $P(I)$, valid for any value of I. In particular, it turned out that $P(I)$ developes a log-normal tail for assymptotically large values of I. The treatment of Mirlin *et. al.* will be briefly reviewed and extended to the three dimensional case. In that case the the supersymmetry formalism is not applicable and the far tail of the distribution is obtained by using the method of optimal fluctuation [2].

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Transmission Phase and Electron-Electron Interactions in Mesoscopic Systems

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In a series of beautiful experiments by Yacobi, Schuster, Heiblum, Buks, Mahalu, Umansky and Shtrikman, the (relative) phase of an electron beam transmitted through a quantum dot has been measured. A high degree of correlation of this phase has been observed as consecutive transmission resonances through the dot were scanned (by varying a gate voltage). Notwithstanding a considerable theoretical effort, this result has not yet been accounted for. In particular, an independent electron picture cannot provide such correlations.
We propose a model combining the effects of disorder and charging energy which results in generic phase correlations. We identify a large dimensionless parameter in the theory which provides for such correlations. Possible experimental tests are proposed.
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FERMI ENERGY ANOMALY IN HIGHLY Sn DOPED InGaAs

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We show that I-V characteristics of thermionic current from a semiconductor with the Fermi energy E_{f_1} into a semiconductor with the Fermi energy E_{f_2} over a ballistic barrier exhibits strong maximum in dI/dV at $eV=\Delta E_f \equiv E_{f_2}$-$E_{f_1}$. It could be a simple method for Fermi energy measurement in one of the semiconductors provided that the Fermi energy of the second one is known. However, in order to meet the ballisticity requirement the barrier has to be so thin that tunneling contribution could not be ignored. We demonstrate that even for thick non-ballistic barrier with build-in positive charge dI/dV has a well pronounced maximum at the same point, namely at $eV=\Delta E_f$. Our calculations were successfully tested in n-GaAs/AlGaAs/n-GaAs sandwich where AlGaAs barrier was artificially charged by introducing Si δ-doping in the middle of the barrier. In heavily Sn doped sandwiches there is no need to charge the barrier artificially since the diffusion of a small amount of Sn into the barrier during a growth provides charge sufficient to observe the above described feature. We grew by molecular-beam epitaxy (MBE) a set of n-InGaAs/AlInAs/n-InGaAs heterojunctions with fixed low $n_1 \approx 5 \times 10^{17}$ cm^{-3} carrier concentration in the first InGaAs, fixed chemical composition of the barrier and a variable doping concentration n_2 in the second InGaAs layer in the range $n_2 : 10^{18} \div 4 \times 10^{19}$ cm^{-3}. The carrier densities in each layer were measured by standard Hall effect technique and were found to be consistent with the doping levels confirmed by SIMS measurements. The dI/dV of the I-V characteristics of the junctions exhibit sharp peak for all samples. It's position on the voltage axes, being interpreted as ΔE_f allows us to extract the dependence of E_{f_2} on carrier density, n_2. This dependence strongly deviates from standard theoretical predictions. The most striking observed anomaly is the near saturation of the Fermi level at a value $E_f \simeq 130$ meV when the mobile carrier concentration exceeds 10^{19} cm^{-3}. Photoluminescence measurements on the same set of samples allow independent evaluation of E_{f_2}, which is consistent with the data obtained from the transport experiments. In addition a pronounced discrete peak appears in the photoluminescence spectrum just above E_{f_2} in the heavily doped samples which show the saturation behaviour. Our results call for a thorough re-examination of the existing theory.

On the Transient and Stationary Parametric Excitation of Spin Waves

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There is a time delay between the switch on of the pumping and the time when parametric excitation of spin waves [1] becomes stationary. This time delay is critically dependent on the pumping field, h, and exhibits a "critical slowing down" behavior near the threshold field hc. It is very short for pumping fields far beyond the threshold and it approaches infinity as $h \rightarrow h_c$ from above. We name this time delay as the buildup time. Buildup times and stationary values of spin wave excitations near the instability threshold are calculated numerically. The study is done in the framework of the two-mode model. It is shown that if a finite medium correction term is introduced to the equations of motion [2] the threshold of the pumping field amplitude is below γ/v where γ is the spin wave relaxation rate and v is the coupling of the spin wave to the pumping field. The time evolution of the excitation may approach the steady state via oscillations that may last for a very long time. The stationary excitation N_0, and the buildup time τ_b depend on the pumping power p, and the pumping field h via power laws: $N_0 = B(p/p_c - 1)^{\delta}$ and $\tau_b = A(h/h_c - 1)^{-\Delta}$. $\delta = 0.5$ for the case of an infinite medium and no de-tuning of the mode frequencies from $\omega_p/2$. For modes that are de-tuned from $\omega_p/2$, it is 0.37 for an infinite medium and 0.42 for a finite medium. $\Delta = 0.98$ for the case of an infinite medium and no de-tuning of the mode. For modes that are de-tuned from $\omega_p/2$, it is 1.06 for an infinite medium and 0.98 for a finite medium. The power law dependence is consistent with experiments but the numerical results for δ and Δ do not agree with experiments.

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Current noise in an irradiated point contact.

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Current fluctuations in ballistic quantum point contacts (PC) attract now much attention, both in theory and experiment partly because of the assumed possibility to measure fractional charges in shot-noise and to probe other non Fermi liquid properties. We are interested in current fluctuations in a ballistic PC biased by applied voltage and irradiated by external field. *Time averaged* current in microstructures under such conditions (photon-assisted current) was investigated experimentally in point contacts and quantum dots.

We consider a classical field which can be coherent (e.g. microwave radiation) or incoherent (e.g. representing the environment at high enough temperature or a heat phonon pulse). We assume that the field does not irradiate the leads between which the bias is applied. Which means e.g. modulated gate voltage, not modulated bias voltage. We model this situation considering a 1D channel with a time-dependent barrier potential $U(x,t)$. The d.c. part of the potential $U_0(x)$ is due to the squeezing of the PC while the a.c. part $\delta U(x,t)$ is due to the field.

We suggest a new approach to calculate current and current correlations in such a system. The approach is based on the concept of scattering states for a *time dependent* Hamiltonian.

Consider the 1D Schrödinger equation $i(\partial/\partial t)\psi = H\psi$ for one particle with a time dependent Hamiltonian $H = -\nabla^2/2m + U(x,t)$, where the barrier potential $U(x,t) = 0$ at $x \to \pm\infty$ for all t. For any energy $\epsilon_k \equiv k^2/2m > 0$ (with $k > 0$) we define *time dependent* scattering states $\chi^\sigma_k(x,t), \sigma = \pm$, as solutions of the Schrödinger equation with the following boundary conditions: the only incoming waves are $e^{-i\epsilon_k t + ikx}$ for χ^+_k and $e^{-i\epsilon_k t - ikx}$ for χ^-_k. The outging parts of χ^σ_k contain waves with $k' \neq k$, describing inelastic scattering in transmission and reflection by the a.c. barrier.

The *time-dependent* electron field operator can be calculated in the following way: $\Psi(x,t) = \sum_{k,\sigma} a^\sigma_k \chi^\sigma_k(x,t)$, where a^σ_k are Fermi operators of electrons in the left lead and the right lead at $x = \pm\infty$, respectively. Electrons in different leads do not correlate, while averages for operators belonging to the same lead can be calculated as for a free Fermi gas with chemical potentials $\mu^\pm$ introducing the bias voltage $V = (\mu_+ - \mu_-)/e$.

Using this approach we calculated the spectra of the current noise in a biased contact irradiated by a weak random field. Considered examples demonstrate that the nonequilibrium noise excited by irradiation differs essentially from nonequilibrium noise excited by bias.

The First Superconductivity Experiment in Space.

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One of the most promising applications of high T_c superconductors is in the field of satellite communications. In view of the rapidly increasing demand for satellite communication channels due to the formation of global networks of cellular phones, internet, etc., one needs to develop more efficient ways of dividing the finite frequency band into more and more channels without paying for it with excessive interference or an increasingly large weight of conventional filters. Superconductive components can save an order of magnitude on the weight and volume of such filters, a very important factor in satellite design. Yet, up to now superconductors were never tested in space. We present the design and performance of the first such experiment to reach space. The experiment consists of a thin film HTSC device integrated with a miniature cryocooler. It was launched into space in July 1998 aboard the TECHSAT-II microsatellite[1]. We will present data obtained from this experiment until the present time. Long term survivability of HTSC devices in space would be discussed.

[1] The TECHSAT satellite is built and operated by the Asher Space Institute at Technion.

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Direct Identification of Atomic-Like Electronic Levels in InAs Nanocrystal Quantum Dots

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The size dependent level structure of InAs nanocrystals in the range 2-7 nm in diameter is investigated using both tunneling and optical spectroscopies. The tunneling measurements are performed using a cryogenic scanning tunneling microscope on *individual* nanocrystals that are attached to a gold substrate via dithiol molecules. The tunneling I-V characteristics manifest an interplay between single electron charging and quantum size effects. We are able to directly identify quantum confined states of isolated InAs nanocrystals having s and p symmetries. These states are observed in the I-V curves as two and six-fold single electron charging multiplets. Excellent agreement is found between the strongly allowed optical transitions [1] and the spacing of levels detected in the tunneling experiment. This correlation provides new information on the quantum-dot level structure, from which we conclude that the top-most valence band state has both s and p characteristics. The interplay between level structure and single electron charging of the nanocrystals obeys an atomic-like *Aufbau* principle of sequential electron level occupation.

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Localization and Dephasing Driven by Magnetic Fluctuations in Colossal Magnetoresistance Materials

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The recent discovery of "colossal magnetoresistance" (CMR) in Mn oxides has generated great interest in these materials. Due to the co-existence of conduction electrons and local magnetic moments, with strong interaction between them, and interplay between spin, charge, orbital and lattice degrees of freedom, these materials exhibit rich physical behavior. In particular, the phenomena of magnetic transition and simultaneous metal-insulator transition has emerged as an active area of experimental and theoretical studies. To describe the transition we apply the conception of Anderson localization of conduction electrons caused by the scattering on spin fluctuations and temperature dependent position of the mobility edge. We consider separately two cases:

- the double-exchange model, which describes magnetic perovskites and narrow conduction band magnetic semiconductors [1];
- the s-d model, which describes magnetic pyrochlores and wide conduction band magnetic semiconductors [2].

In the latter case we also take into account spin dynamics, which leads to dephasing and partial delocalization of the electrons. In this case we claim the existence of the "mobility edge", which separates the states with fast diffusion and the states with slow diffusion; the latter is determined by the dephasing time. When the "mobility edge" crosses the Fermi energy a large and sharp change of conductivity is observed. The theory provides an explanation for the observed temperature dependence of conductivity in several classes of the CMR materials.

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Haldane Gap and Fractional Oscillations in Gated Josephson Arrays.

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An analogy between the twisted quantum xxz model and a gated Josephson junction array is used to predict sharp structure in the critical currents versus gate voltage, and fractional ac Josepphson frequencies. We prove selection rules for level crossings which imply fractional periodicities of ground states with varying Aharonov-Bohm flux. On infinite ladders they distinguish between different thermodynamic phases related to the magnetization plateaus of reference [1]. In particular, extrapolated numerical diagonalization on narrow ladders indicate a Haldane gap at moderate easy-plane anisotropy with vanishing superfluid stiffness. The Haldane phase is explained by mapping to an O(2) classical field theory in two dimensions with an inverse temperature that scales assymptotically as the ladder width. This suggests a Kosterlitz-Thouless transition to a phase with vanishing gap and finite superfluid stiffness above a critical ladder width. Physical parameters for experimental realization of these novel effects are proposed.

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Dodecagonal square-triangle tiling — growth simulation

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Some alloy systems such as NiCr and VNiSi have quasicrystalline phases with twelvefold symmetry [1,2]. These can be interpreted in terms of dodecagonal tilings by squares and equilateral triangles [3–5]. The formation of quasicrystals may be due to a number of mechanisms such as local growth rules, cluster covering, etc., which may act separately or in synergy. This research focuses on the growth of such dodecagonal quasicrystals as well as the abundancy of their vertex configurations, both regular and defective. We have simulated growth from the melt under various conditions in order to find the minimal constraints necessary to produce realistic patterns as well as realistic vertex statistics. We have also calculated the exact vertex frequencies of the ideal square-triangle tiling by relying on inflation symmetry. The simulation showed that unrestricted random growth typically results in phase separation of triangles from squares. Favoring triangles to attract squares and vice versa brings about nearly perfect patterns with nearly perfect vertex abundancies and very realistic defect concentrations.

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Cluster covering of octagonal MnSiAl quasicrystals

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A likely mechanism for the formation of quasicrystals is by maximally covering space with overlapping stable atomic clusters. This presumably minimizes the energy and also creates long-range correlations and order [1]. The purely geometric aspect was studied by Gummelt [2] who proved that the Penrose tiling could be produced by covering the plane with overlapping copies of a single decagonal patch. Octagonal quasicrystalline phases closely related to the β-Mn structure have been observed in the CrNiSi, VNiSi, MoCrNi and MnSiAl systems [3,4]. Jiang, Hovmöller and Zou [5] have experimentally determined the structure of $Mn_{80}Si_{15}Al_5$. It is a layer structure composed of octagonal layers A alternating with tetragonal layers B' and B'' (mutually rotated by 45° with an 8_4 screw axis. The layers can be described as decorations of the octagonal Ammann-Beenker tiling (ABT) [6.7]. The edge decoration is imposed by the structure itself in a natural way, thus, together with the maximal covering condition, enforcing the ABT [8]. We represent the decoration abstractly by a novel two-color version of ABT, which, incidentally, has also considerable aesthetic appeal. The covering atomic cluster of the quasicrystal corresponds to an octagonal patch of the colored tiling. The patch appears in two variants with complementary colors. Our construction yields in a natural way also the translation module (the generalization of the lattice concept) and the correct space group of the complete 3D quasicrystal. They are the centered octagonal module and the space group $I8_4/mcm$, respectively.

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Near the Onset of Superconductivity in Eccentric Mesoscopic Samples

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We consider a superconducting sample embedded in a magnetic field. For perfect axial symmetry, the winding number of the order parameter is a good quantum number and its equilibrium value increases with the flux. There are fluxes Φ_m^* at which the order parameters with winding numbers m and $m+1$ are degenerate. If the sample is eccentric and the flux is close to Φ_m^*, mixing of these order parameters occurs and interesting phenomena appear. One of them is the presence of a vortex, even if the sample is thinner than the coherence length. For small values of m this vortex appears at the thin side of the sample; for large m, it appears at the opposite side. An additional phenomenon is the existence of a critical point. There is a temperature $T_2^{(m)}$ such that below it there is a first order transition when the flux crosses Φ_m^*; above $T_2^{(m)}$, the passage is continuous. At the critical point, the ac magnetic susceptibility diverges. There is some experimental evidence for this behavior.

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Onset of Self-Assembly in Polymer-Surfactant Systems

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Amphiphilic molecules (surfactants) consist of two opposing parts — a water-soluble moiety and a water-insoluble one — which are chemically bonded. Consequently, above a certain threshold concentration in aqueous solution (*critical micellar concentration, cmc*) surfactants self-assemble into aggregates. Aqueous solutions containing linear, flexible chain molecules (polymers) and surfactants exhibit self-assembly at much lower surfactant concentrations. This feature offers a delicate control over the physical properties of the solution, which is used in numerous applications. We study theoretically the onset of self-assembly in such polymer-surfactant systems. Focusing on the effect of the surfactant on polymer conformation and using a conjecture of local instability of the polymer at the onset of self-assembly, we obtain several simple predictions: (i) the threshold concentration required for polymer-surfactant self-assembly (*critical aggregation concentration, cac*) is always lower than the cmc; (ii) in charged systems the cac increases with the concentration of added salt and is almost independent of polymer charge; (iii) in weakly interacting systems the cac follows changes in the cmc roughly linearly. We further use the special case of interactions between surfactants and amphiphilic polymers to demonstrate the crucial role of chain conformation in the self-assembly. The predictions are supported by available experiments.

Localization of Two Interacting Particles in One and Quasi one– Dimensional Disordered System

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Recently it has been shown that the interaction enhances the localization length for coherent propagation of two particles [1-3]. We investigate this problem using a new approach based on the introduction of an effective Hamiltonian for which the strength of the interaction **U** is the energy of the corresponding effective system. The localization properties of the two interacting particles are then deduced directly from the eigenstates of this effective Hamiltonian. Our results are then compared to the existing ones. The dependence of the localization length on the sign of interaction is also investigated and a general formulae is given.

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Enhancement of Thermoelectric Power Factor in Composite Thermoelectrics

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The analytical properties of macroscopic transport coefficients of two-component composites are first used to discuss the bulk effective or macroscopic thermoelectric power factor W_e of such a composite. It is found that the macroscopic power factor can sometimes be greater than the power factors of both of the pure components, with the greatest enhancement always achieved in a parallel slabs microstructure with definite volume fractions for the two components. This is in marked contrast with the bulk effective or macroscopic thermoelectric figure of merit of a composite Δ_e, which was proven some time ago to be bounded from above by the largest of the pure component values of the figure of merit [1,2]. Some interesting examples of actual mixtures are then considered, where the components are a "high quality thermoelectric" and a "benign metal", leading to the conclusion that considerable enhancement of the power factor is often possible, with but a modest reduction in the figure of merit, compared to those of the high quality thermoelectric component. Somewhat to our surprise, we found that the largest value of W_e is often attained in composites with a very small volume fraction of the high quality thermoelectric component. E.g., in a medium composed of the benign metal Al and the undoped high quality thermoelectric alloy $(Bi_2Te_3)_{.2}(Sb_2Te_3)_{.8}$, a maximal enhancement of W_e, by a factor of 20 over the power factor of the alloy, is achieved in a parallel slabs microstructure where the volume fraction of the alloy is only 0.013! At the same time, Δ_e is about 0.28, as compared to the value 0.46 for the figure of merit of the homogeneous high quality thermoelectric alloy.
Two possibilities for fabricating real composites with such improved thermoelectric properties emerge from this study: a parallel slabs microstructure of benign metal and high quality thermoelectric, and a sintered collection of benign metal grains, each of them coated by a thin shell of high quality thermoelectric. Sufficient conditions were found which enable us to determine in advance whether enhancement is achievable in any of those microstructures using a given pair of components.

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Orientation of N2 Molecules Adsorbed on Graphite Between 20 K to 150 K

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The nuclear resonance photon scattering (NRPS) technique [1] is unique in its exclusive ability to determine the molecular orientations of adsorbed N_2 on graphite surfaces. The photon beam is obtained from the Cr(n,γ) using thermal neutrons from the IRR-2 reactor where one of the γ lines is known to be resonantly scattered from the 6324 keV level in ^{15}N. By measuring the resonantly scattered intensities from the $^{15}N_2$ adsorbed on Grafoil with the planes of a graphite surface set parallel and perpendicular to the photon beam direction, the out-of-plane tilt angle of the adsorbed $^{15}N_2$ relative to the graphite surface was determined versus molecular coverage and temperature. Detailed measurements were carried out on the N_2+Grafoil system at high temperatures, well above the 2D tricritical point ($T_c \approx$85K), where the N_2 is in the vapor phase on Grafoil. We showed beyond any doubt that even at T = 140 K and submonolayer coverages, the molecules have on the average, a definite forward tilt with respect to the graphite surface and that the tilt angle increases with coverage. The results are compared with grand canonical Monte Carlo calculations (GCMC). AT low temperatures, T = 20 K, where the N_2 is in the solid phase, more measurements were carried out at coverages between n = 0.6 to 5.0 monolayers. The measured tilt angle of $^{15}N_2$ at 20 K was found to be in good agreement with calculations based on molecular dynamic simulations.

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Nuclear Spin-Lattice Relaxation and Spin Diffusion in the Mixed State of Type II Layered Superconductors.

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In the type II superconductors, an applied magnetic field $\vec{H}_0$, in the range between the lower and upper critical field , $H_{c1} < H_0 < H_{c2}$, penetrates in the bulk sample in the form of filaments (vortices) with quantum flux $\Phi_0 = \frac{c\hbar}{2e}$ which form a two-dimensional structure in the plane perpendicular to $\vec{H}_0$[1]. The internal magnetic field $\vec{H}_L(\vec{r})$ is generated by vortices , the spatially distributes over sample. The thermal motion of the vortices in the mixes state gives rise to time-varying magnetic field, perpendicular component of which to the applied magnetic field $\vec{H}_0$ can induce transitions between Zeeman levels[2]. Due to special dependence of the transition probability the local nuclear magnetization $\vec{M}(\vec{r},t)$ reaches its equilibrium value at a faster rate near the core of vortex. Therefore the nuclear magnetization will be a function of the position and the spatial diffusion of the nuclear Zeeman energy can be induced. This process can be important only under the condition that the difference of the internal local magnetic field (in units of a frequency) at the points occupied by the neighboring nuclei is of the order or lower with nuclear line width in order to fulfill energy-conservation law[3].This relaxation process very similarly to that induced by paramagnetic impurities[4].
We apply â well developed theory of the spin diffusion and spin lattice relaxation in the presence of paramagnetic impurities to the spin system in the mixed state of type II layered superconductors . The main goals of the present paper is to obtain the time dependence of the nuclear magnetization $M(t)$ and calculate the spin lattice relaxation time T_1. The main difference between the cases of vortices and PI, that the local transition probability has the different spatial dependences: in superconductor case its depends on the field distribution and can be expressed by various spacial functions, but in the PI-case only the inverse sixth power dependence on the distance between nuclei and the PI is realized.

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The Return Probability of N Strongly Repelling Classical Diffusing Particles in Quasi-1D, an Exact Solution.

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N classical particles diffuse inside the one-dimensional interval [0,L]. The particles interact through short-range repulsive interaction that prevents them from exchanging positions - they stay ordered in their initial ordering on the line. The probability that at time t, all the particles are back at the points they were at t=0 (up to a distance less than a mean free path), and the configuration space average of this probability, are calculated exactly.
There are semiclassical relationships between the above return probability and the two-point correlation function of the energy levels of the system. These relations are established for noninteracting systems, and supply information on the behavior of, for example, noninteracting electrons diffusing in a dirty metal. There are indications that the return probability, can provide information about the scales in the level correlation of interacting-particle systems.

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Local modes, phonons, and mass transport in solid ^{4}He.

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The highly quantum nature of solid Helium has been a long-standing theoretical problem. The experimental manifestations of quantum effects are highly anharmonic phonons and anomalous atomic self-diffusion and transport. Here we propose a model to treat the local motion of atoms in solid ^{4}He as a local mode. In this model, the solid is assumed to be described by the Self Consistent Harmonic approximation, combined with an array of local modes. We show that in the bcc phase the atomic local motion is highly directional and correlated, while in the hcp phase there is no such correlation. The correlated motion in the bcc phase leads to a strong hybridization of the local modes with the $T_1(110)$ phonon branch, which becomes much softer than that obtained through a Self Consistent Harmonic calculation, in agreement with experiment. In addition we predict a high energy excitation branch which is important for self-diffusion. Both the hybridization and the presence of a high energy branch are a consequence of the correlation, and appear only in the bcc phase. We suggest that the local modes can play the role in mass transport usually attributed to point defects (vacancies). Our approach offers a more overall consistent picture than obtained using vacancies as the predominant point defect. In particular, we show that our approach resolves the long standing controversy regarding the contribution of point defects to the specific heat of solid ^{4}He.

Mesoscopic Superconducting Disc with Short-Range Columnar Defects.

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The use of submicron Hall probe technique in the ballistic regime for studying individual submicron superconducting samples smaller than the probe size allowed Geim *et. al.* [1] to establish a link between the detected signal and the sample magnetization. These experiments show that the sample undergoes a sequence of phase transitions of the first kind, which manifest themselves as mesoscopic jumps of the magnetization curve [2]. The jumps are due to penetrations of additional vortices inside the superconductor as the applied magnetic field increases.

The relation of the magnetization jumps to the penetration of new vortices into the disc has been demonstrated in a series of theoretical works [3-7]. It was shown that S-N transition in mesoscopic disc could be of first or second order [3-5]. The conditions for multi-vortex states or a giant vortex state formation were analyzed [3-5]. It occured that above the upper critical field for an infinite sample the vortices always form a giant vortex located at the disc center [6].

In the present report we study the magnetic properties of a mesoscopic superconducting disc with disordered short–range columnar defects [8]. We show that the defects help the penetration of vortices into the sample, thereby decrease the sample magnetization and reduce its upper critical field. Even weak defects split a giant vortex state into a number of vortices with smaller topological charges. In a disc with a sufficient number of strong enough defects vortices are always placed onto defects. The presence of defects lead to the appearance of additional magnetization jumps related to the redistribution of vortices which are already present on the defects and not to the penetration of new vortices.

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A new view of the zero magnetic-field metal-insulator-transition in two-dimensions

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The realization of very high quality two-dimensional (2D) systems in semiconductor structures has enabled the study of numerous features associated with their reduced dimensionality. One of the more fundamental questions is whether a metallic phase exists in two dimensions. The absence of experimental evidence that supports the existence of such a phase, combined with a theoretical prediction [1] that non-interacting electrons in 2D systems are always localized at zero temperature (T) and at zero magnetic-field (B), generated a strong conviction that all 2D systems are insulating at B=0. However, recent experiments seem to reveal an unforeseen density-driven metal-insulator transition (MIT) at zero B, in low-density 2D systems [2,3]. Naturally the origins of these results are still unknown.
Unlike this puzzling B=0 transition, the insulator to quantum-Hall (QH) transition and the QH to QH transitions, also observed in 2D systems, are in accordance with existing theoretical models [4], and are considered to be well understood. To improve our understanding of the B=0 transition, we conducted a study of the insulator-to-QH transition in low-density 2D hole systems in GaAs near the B=0 MIT. We found that the value of the critical B of the insulator to QH transition (B_c) monotonically decreases to zero as the density is increased up to p_c and, at p_c, the insulator to QH transition *merges* with the B=0 MIT. By this we demonstrated that the two transitions share a common physical origin.

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How do holes destroy antiferromagnmetism in cuprates? A Variational Monte Carlo study.

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We study variational RVB wavefunctions with pair correlations between fermion holes using large scale Monte Carlo simulations on loop coverings. We find that while the two dimensional quantum Heisenberg model is resistant to destruction of magnetic order when doped with static or uncorrelated mobile holes, the addition of pair hopping terms induces concomitant superconductivity and a rapid reduction of the staggered magnetization at small dopant concentrations.

Stochastic parametric resonance in a weakly nonlinear system

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External or parametric perturbations of a system could lead to various resonant phenomena. The resonance in a system with randomly varying parameters is called a stochastic parametric resonance (SPR). It is known that relaxation leads to a particular lowest value of fluctuations necessary for the appearance of the SPR, whereas a nonlinear friction leads to the stabilization of the SPR.
Interactions of different harmonics increase with the increase of fluctuations. They are described by a weak nonlinearity. It is therefore interesting to study its influence on the SPR. We consider Düffing equation as a model

$$\frac{d^2x}{dt^2} + \omega_0^2(1 + z(t))x + \lambda x^3 = 0 \tag{1}$$

where $z(t)$ - is a Gaussian with a zero mean value and small intensity σ^2 ($\sigma^2 \ll 1$, $\lambda \ll \omega_0^2 < x^2 >^{-1}$. The most interesting case to consider is when the spectrum of the random process is limited by the frequency slightly larger then the double frequency of the system ($\omega - 2\omega_0 = \epsilon \ll 1$). We derive equations for the moments of the second order and disconnect them from the equations for the higher moments using approximation for the variational derivatives. We then obtain a system of three equations which we solve by Bogolubov-Krylov procedure. We derive an analytical solution for $< x^2 >$ and then find the following condition for the stabilization of the SPR

$$\lambda \gtrsim \omega_0^2(\sigma^2 + \epsilon\omega_0^{-1}) < x^2 >_0^{-1} \tag{2}$$

Therefore, a weak nonlinearity could stabilize the SPR, if double system frequency is close to the edge of the fluctuations spectrum. and the value of nonlinearity is higher or of the order of Eq. (2).

Anderson-Mott Delocalization of Charge Carriers and large paramagnetic Effect at high Pressure in glassy Semiconductors.

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Anomalous electron properties of glassy semiconductors (GSs) at ambient pressure ($p = 0$) have been attributed to the presence of a substantial concentration $c_2(0) \approx 10^{-3} - 10^{-4}$ of localized charge carriers, diamagnetic negative-U centres, in the mobility gap (see, e.g., [1]). Moreover, localized paramagnetic charge carriers of much lower concentration $c_1(0) \ll c_2(0)$ have been found in GSs at $p = 0$. Both kinds of charge carriers contribute to electrical conduction by only hopping, the contribution being negligible. Two pressure-induced phenomena are predicted for accessible high pressures p around a characteristic $p_c \approx 10^5$ bar, $10^4 < p < 10^6$ bar, which are associated with a theoretically revealed strong increase of both $c_2(p)$, up to $\approx 10^{-1}$,and $c_1(p)$, up to $\approx 10^{-2}$. The latter is due to both the theoretically established formation of the charge carriers in typical atomic configurations of the nanometer scale for the majority of atoms at the high p in question [2] and the earlier observed mobility-gap shrinking [3] . One of the predicted phenomena is the Anderson delocalization of the charge carriers at $p \geq p_c$, as the effective carrier-states overlap (for their average separation) increases with increasing $c_2(p)$ (or $c_1(p)$). Then, unlike the situation at $p = 0$, the non-localized charge carriers become current carriers determining a considerable metallic-type conduction, which actually predominates in the GS at the high p. In this sense, an "insulator-metal transition" is expected to occur at $p = p_c$ in the semiconductor phase (GS) of the material [4]. Another phenomenon is a large change in magnetic properties. In fact,the GS, a diamagnet at $p = 0$, has to exhibit a very large paramagnetic effect at the high pressures, which can predominate for appropriate values of the parameters involved, so the glass can transform to a paramagnet. Experimental testing of the predicted effects may give an extra information about the charge carriers and their characteristics for the materials.

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Dependence of the diamond type bonding on parameters of deposition from a $Ar + CH_4$ plasma.

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Variation of relative fractions of sp^3 and sp^2 bonds studies of amorphous diamond-like carbon (a-DLC) films, deposited on silicon from rf ($CH_4 + Ar$) RF plasma, is presented. The electrical, optical, morphological, and mechanical properties, were measured, and the results, discussed as a function of the partial Ar pressure in the mixture of $CH_4 + Ar$ gases, during the a-ArDLC deposition. The comparative study of properties of a-DLC films, using Auger electron spectroscopy (AES), to these of the ratio ($\Phi = sp^3/sp^2$ (sp_2 graphite-bonding) and (sp^3 diamond-bonding), have shown that Ar improves the diamond-like properties. Raman spectroscopy and FTIR were also used to determine the ratio sp^3/sp^2 bonds. For morphology investigation optical microscopy and Atomic Force Microscopy (AFM), were used. Electrical measurements, current-voltage (I-V) and current-temperature (I-T), were performed. Deposition of a-ArDLC films on substrates (sapphire, germanium) with average roughness (σ) of the order of (σ 1000$\mathring{A}$, have shown that a strong decrease of σ with increasing the thickness (d) is obtained. For d=0.8 μm the value σ was reduced to about 10$\mathring{A}$. The bonding ratio Φ remains constant with increasing d up to 0.4μm and decreases with further increasing d. This indicates that the influence of substrate and roughness is important for obtaining optimum value of Φ. The novel and important result obtained in this paper was that a high value of ratio ($\Phi \geq 50\%$) was achieved for the mixture of Ar/CH_4 30/70), which was proved, using the above mentioned types of characterization.

Fabrication of submicron bipolar transistor structures by scanning probe microscopy.

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Hemispherical p/n/p transistor structures ranging from 100 microns down to 0.05 microns are fabricated in $CuInSe_2$ by application of a high eletric field between a conducting diamond tip of an Atomic force Microscope and a $CuinSe_2$ crystal. This leads to electromigration of Cu ions in the bulk of the material. The structures are characterized by nm scale scanning spreading resistance and scanning capacitance microscopy to reveal the inhomogeneous doping profile which was created by the electric field. For such transistor structures there is a lower limit in size which is roughly 10L (where L is the Debye length). The size of our smallest fabricated structure is close to this limit.

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Anomalous Coarsening Process of Voids, Steps and Denuded Zones on a Si(111)7x7 Surface

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Annealing a silicon surface covered with a submonolayer of a - Si at 600^{O}C gives a surface with voids that undergo a ripening process. If the uncovered surface has steps, the deposition of the growing and diffusing voids at this high temperature on the step creates a coarsening of the step. The coalescence of the voids with the step creates a denuded zone (in which the density of voids is below the average) both at the upper and the lower terraces. It is shown here, that both the exact morphology and the scaling of the step width on one hand, and the density of voids near the step on the other hand, can be analyzed quantitatively. The scaling relations of the step width, the dynamic scaling of the voids, the denuded zones and the scaling of the diffusion constant with size, are shown to be interconnected. Using all these relations, it is possible to get a complete picture of all the characteristics of this anomalous diffusive coarsening phenomenon. So we prove that the void coarsening process is dominated by voids diffusion and coalescence and that void diffusion is dominated by boundary vacancy diffusion. Thus the diffusive models of coarsening (described in the mean field by Lifshitz Slyozov) are non - relevant in this case.

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AC loss problem in high-temperature superconductors.

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A number of technological applications of high-temperature superconductors (HTSC) as superconducting power transmission lines, current leads, inductive fault current limiters, magnetic shields and magnetic bearings are based on bulk components such as tubes, rings, rods, plates. The problem of AC loss reduction is a key issue at the development of superconducting devices operating in AC circuits. In a marked deference from low temperature superconductors, HTSC materials possess smooth voltage-current characteristics and very low thermal conductivity. These features can lead to the pronounced difference of the actual AC losses from the values predicted by Beanls critical state model. We propose the analytical approaches for AC loss evaluation in HTSC that take into account actual voltage-current characteristics and heating due to AC losses. The obtained expressions explain experimentally observed dependencies of AC losses on frequency and amplitude of the magnetic field. Cases of complete and incomplete magnetic field penetration have been distinguished. The AC losses per cycle decrease with increasing frequency in the case of incomplete penetration, the case relevant to thick slabs and low amplitude magnetic fields. In thin slabs and large magnetic fields, the case of complete penetration, the losses increase with frequency. It has been shown the manner in which the analytical solutions can be applied for various forms of voltage-current characteristics. The simple criteria for neglecting thermal activated flux creep and flux flow and ignoring thermal processes are deduced.

Observation of a Confinement Effect of He Adsorbed on Activated Carbon Fibers

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We studied the interaction between helium and the surface of Active Carbon Fibre (ACF) by measuring the momentum distribution of the adsorbed He atoms using the Neutron Compton scattering technique [1]. In the nano-scale regime, the structure of the ACF resembles that of graphite, hence the interaction energy of He with the ACF is close to that of He enclosed between two graphite surfaces. The data yields the effective temperature of adsorbed He atoms which is related to their total zero-point kinetic energy. Submonolayer coverage of He on ACF was employed, to ensure that the main part of the interaction is between a He atom and the adsorber and to reduce the relative contribution of the He-He interaction. In order to increase the signal/background ratio, we selected an ACF with a huge surface area of $3000m^2/g$ [2], which yielded a detectable He signal enabling us to measure the He effective temperature with good accuracy. The measured result at 10.2 K was $T_s = 36.2 \pm 2.0$ K to be compared with $T_s = 11.0 \pm 1.8$ K for He in the bulk. The effective temperature was calculated using the WKB approximation yielding: $T_s = 27$ K (for the case of He adsorbed on a single graphite surface); $T_s = 55.5$ K for He enclosed in a slit of width w = 0.52 nm varying to $T_s = 27.5$ K at w = 1.0 nm and a coverage of one monolayer. Here we used a 4-10 Lennard-Jones potential to describe the He-surface interaction. The relatively high measured value of T_s which is much larger than that of He in the bulk or that of He adsorbed on a single graphitic surface is indicative of a **confinement** effect of He atoms inside the micropores. This result also means that the dimensions of the pores are of the order of 0.55 nm, which causes the enhancement in the value of T_s.

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AIR OXIDATION OF COPPER IN AN APPLIED ELECTRIC FIELD

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Two copper disks were connected as dc capacitor electrodes, and were placed in a controlled temperature oven. An electric field in the range of $0 - 500\ V/mm$ was applied between the electrodes. The electrodes were oxidized by annealing in air for one hour at a temperature in the range of $100 - 500$ °C. After annealing, the plates were removed from the oven and allowed to cool to room temperature. Electrode masses were determined before and after each annealing run. A SEM, using the scattering electrons (SE), back scattering electrons (BSE) and energy discursive spectroscopy (EDS) modes examined the surface structure of the electrodes.
The leakage current between the electrodes was measured, and was found to depend on time, applied voltage and electrode temperature. After the annealing, electrode masses decreased probably due to the delaminating of oxide fragments. The decrease in the cathode mass depended weakly on the applied voltage, whereas anode mass loss depended strongly on it. SE images show that the oxide on the anode consisted of a dense, continuos and homogenous layer of CuO. On the other hand, oxide layer on the cathode consisted of disconnected $6 - 10\ \mu m$ grains of CuO distributed over a background of $1.5\ \mu m$ grains of Cu_2O. Similarly, the oxide layer on samples annealed without the applied voltage also consisted of disconnected $5 - 7\ \mu m$ grains of CuO distributed over a background of $1\ \mu m$ grains of Cu_2O.
Mechanisms for the applied voltage effect and the leakage current origin will be discussed.

NQR Study of Thiourea-Hexachloroethane Inclusion Compound

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Thiourea-hexachloroethane is a non-stoichiometric inclusion compound with the non-integer ratio of the numbers of host to guest molecules $r = 2.95 \pm 0.01$, in which guest molecules are entrapped within the unidirectional, non-intersecting channels of a hydrogen-bonded network. We present Cl-35 NQR study of thiourea-hexachloroethane inclusion compound in the temperature range from 7 to 90 K. Instead of a narrow NQR line usually observed in chlorine compounds, Cl-35 NQR spectra of thiourea-hexachloroethane in the temperature range from 77 to 90 K show a broad line with two maxima. These maxima have been assigned to the edge singularities of the NQR lineshape of incommensurate (IC) phase [1], suggesting that the incommensurability results from the different periodicity of the guest and host sublattices. Hahn echo measurements show a shortening of the echo decay with increasing temperature from 77 to 90 K, which probably indicates slow diffusion-like motion of the modulation wave. At temperatures higher than 90 K the NQR spectrum is not observed. We attribute this fact to the reorientational mobility of the molecules in the guest sublattice likely accompanied by order-disorder phase transition at 90 K. Lower temperature yields additional splitting of the NQR line, and at $T < 68K$ the spectra exhibit three resolved lines. Temperature dependent measurements show significant changes in NQR spectra at 60 and 68 K and in spin-lattice relaxation time at 60 K, likely attributed to phase transitions. However, spectrum transformation at 68 K may be caused by a reduction of the soliton density in the IC phase which also explains the appearance of new lines observed in the experiment.

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The Effective Coherence Length in Anisotropic Superconductors.

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If electrons are transmitted from a normal conductor(N) into a superconductor(S), common wisdom has it that the electrons are converted into Cooper pairs within a coherence length from the interface. This is true in conventional superconductors with an isotropic order parameter. We have established experimentally that the situation is rather different in high T_c superconductors having an anisotropic order parameter. We used epitaxial thin film S/N bilayers having different interface orientations in order to inject carriers from S into N along different directions. The distance to which these carriers penetrate were determined through their effect on the T_c of the bilayers. We found that the effective coherence length is 20Å only along the **a** or **b** directions, while in other directions we find a length of 250±20Å out of plane, and an even larger value for in-plane, off high symmetry directions. These observations can be explained using the Blonder-Tinkham-Klapwijk model adapted to anisotropic superconductivity. Several implications of our results on outstanding problems with high T_c junctions will be discussed.

Density of states and reflectionless tunneling in NS junction with a barrier.

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We consider mesoscopic structures containing normal metal-superconductor interfaces. The interplay between superconducting coherence effects (Andreev reflection) and mesoscopic effects known to occur in diffusive normal metal, give rise to various interesting phenomena in these structures. In particular, the effect of a barrier at an NS interface on the conductance of the system and on the local density of states (DOS) across it is different than what would be naively expected. We use scattering theory [1] to show that even if the barrier has transmission probability $\Gamma \ll 1$, it can be effectively transparent. Consider a physical property which is determined by a certain set of electron trajectories in the normal metal. If most of these trajectories hit the interface more than Γ^{-1} times before electron-hole coherence is lost then the barrier is ineffective [2] We show that from this criterion alone one can reproduce the different conditions for the barrier to be ineffective in both problems of the conductance of the system and the local DOS with and without magnetic field. We also apply this criterion to ballistic systems where the geometry allows multiple reflections from the NS interface. Another interesting phenomena is the nonmonotonic differential conductance of an NS junction as a function of energy (reentrance effect) [3] We use a scattering formalism to show that in the case of finite transmission through the normal metal part, at the Fermi energy, the different paths that contribute to the Andreev reflection process interfere destructively. Therefore, at finite energies the destruction of the electron-hole coherence results in an enhancement of the Andreev reflection probability, and therefore an enhancement of the differetial conductance of the NS system, which is the main feature of the reentrance effect.

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Two-dimensional hopping conductivity: experimental evidence for a novel electron transport mechanism.

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Results are presented of measurements of two-dimensional (2D) variable-range-hopping (VRH) conductivity and magnetoresistance (MR) in a delta-doped GaAs/AlGaAs heterostructure. It is shown that at zero magnetic field and low temperatures ($T < 1$ K) the longitudinal resistivity $\rho_{xx}(T)$ exhibits "Coulomb-gap behavior": $\rho(T) = \rho_0 \exp(T_0/T)^{1/2}$ with the prefactor $\rho_0 = (h/e^2)$ which is independent of temperature and electron density [1]. This value of ρ_0 exactly coincides with that observed by Mason *et al.* in a different material - Si-MOSFET [2]. Universality of the hopping prefactor is considered as evidence that in some interval of electron densities close to the metal-insulator transition, the 2D VRH is assisted by the electron-electron interaction (EEI), rather than by conventional electron-phonon interaction. Experimental data show that (i) existence of a delta-doped layer in the proximate vicinity of the 2D conducting plane favors EEI-assisted VRH, and (ii) a strong magnetic field parallel to the 2D plane leads to the suppression of the EEI-assistance and the restoration of the conventional phonon-assisted hopping. To interpret these experimental observations, a novel electron transport mechanism is suggested [3], according to which the current-carrying single electron move via quantum resonant tunneling between localized states, brought into resonance by fast electron hops in their environment. The last hops can be assisted by phonons; however, the phonon frequency does not appear in the final expression for the current-carrying transition rate.

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Enhancement of quantum dot peak-spacing fluctuations in the fractional quantum Hall regime

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The fluctuations in the spacing of the tunneling resonances through a quantum dot have been studied in the quantum Hall regime. Using the fact that the ground-state of the system is described very well by the Laughlin wavefunctions [1], we were able to determine accurately, via classical Monte Carlo calculations, the amplitude and distribution of the peak-spacing fluctuations (PSF). Our results clearly demonstrate a big enhancement of the fluctuations as the importance of the electronic correlations increases, namely as the density decreases and filling factor becomes smaller. In our analysis the PSF is determined by the addition spectrum $\Delta_2^{(N)} \equiv \left(E_g^{(N+1)} - E_g^{(N)}\right) - \left(E_g^{(N)} - E_g^{(N-1)}\right)$, where $E_g^{(N)}$ is the ground-state energy of the N-particle system. It is shown, using the fact that the edge structure for different particle number is identical, but relatively shifted, that for short range potentials and large N $< (\Delta_2^{(N)})^2 >_{1/m} \sim N^{-3/2}$. Here $< ... >$ denotes average over realizations of the random potentials and $1/m$ is the filling factor. This observation is confirmed numerically. The numerical analysis for m =1, 3 and 5 also shows the enhancement mentioned above : e.g. for short range potentials one gets that the ratio between $< (\Delta_2^{(N)})^2 >_{1/3}$ and $< (\Delta_2^{(N)})^2 >_1$ is 5.0 ± 0.3.
As the range of the random potentials, σ, increases, the PSF are reduced and the ratios decrease towards unity. However, once σ becomes of the order of the size of the dot, $R \propto \sqrt{N}$, the ratios increase again, leading to a nonmonotonic dependence on σ. In the limit of very smooth potentials, $\sigma \to \infty$, one can show that $< (\Delta_2^{(N)})^2 >_{1/m}$ / $< (\Delta_2^{(N)})^2 >_1 = m^2$ so there is an enhancement of the PSF also in this limit.
Lastly we have considered the full distribution of the PSF and have found that the distribution of the fluctuations approaches a Gaussian as one increases the density of random potentials. The gaussian behavior is in agreement with experiments [2-5].

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Two Magnon Raman Scattering as Indicator for Superconducting to Antiferromagnetic Phase Transition Upon Hydrogenation of YBCO

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Raman spectra of Hydrogenated $YBa_2Cu_3O_{7-x}+H_y$, where y=0.45 and 0.19 is the number of Hydorogen atoms per units cell. The spectra exhibit important changes in the electronic scattering. Upon progressive doping with Hydrogen two magnon scattering features emerge. This coincides with the transition of $YBa_2Cu_3O_{7-x}+H_y$ from superconducting to antiferromagnetic phase. Exchange energy values were obtained from two magnon Raman scattering of the y=0.45 material. It has been found that for y=0.19 the sample has not lost its supercondactivity, and indeed two-magnon scattering has not been observed. However, the situation changed substentially when the doping of the Hydrogen atoms was 0.45. The two-magnon scattering has been observed at different temperatures down to 20^K. The two-magnon energy density exhibits two peak values around $2100cm^{-1}$ and $3000cm^{-1}$.

Superconductor-Insulator transition in a single Josephson junction

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For ultrasmall Josephson junctions, when quantum effects become important, *dissipative phase transition* (DPT) has been predicted [1]. The physical origin of this transition is the suppression of macroscopic quantum tunneling of the phase by the interaction with dissipative quantum-mechanical environment. Macroscopic quantum tunneling destroys superconductivity of a junction, whereas suppression of tunneling restores superconductivity. Hence, this transition is often called a superconductor-insulator transition (SIT). SIT was predicted for various systems, but its detection in a *single* Josephson junction is of principal importance since it is the simplest system where this transition is expected, without any risk of being masked by other physical processes, as is possible in more complicated systems like regular or random Josephson junction arrays.

In this Letter we present results of our measurements on $R = dV/dI$ vs. I curves, for a variety of single small isolated Josephson junctions, shunted and unshunted, with different values of capacitance C and normal state tunneling resistance R_T. We have detected a crossover between two types of RI-curves with an essentially different behavior at small currents. On the basis of this crossover, we are able to map out the *whole* phase diagram for a Josephson junction [2].

The position of the observed phase boundary did not agree with that expected from the original theory. However, the theory revised to take into account a finite accuracy of our voltage measurements (*viz.*, the minimum voltage which we are able to detect), explains well the observed phase diagram.

Our important conclusion is that the concept of *dissipative phase transition* (DPT) and *superconductor-insulator transition* (SIT) are not completely identical as assumed before. Both are accompanied by the sign change of the thermoresistance, which is traditionally considered as a signature of SIT. Thus any DPT is SIT, but not *vice versa*. We argue that the real signature of DPT is a modification of VI curves as observed in our experiment.

Our work is a strong demonstration of quantum effects in a single Josephson junction, especially, of the Josephson phase delocalization and the band picture of the phase motion.

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Optical Transmission Through Metal Films with a Sub-Wavelength Hole Array in the Presence of a Magnetic Field

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Quite recently it was reported that arrays of submicrometer cylindrical cavities in metal films display highly unusual transmission spectra at wavelengths larger than the array period, when no wavelength sensitive interference should occur [1]. This unusual behavior is apparently due to the coupling of light with surface plasmons in the film. Continuing this idea, we have studied such systems in the presence of a static, in-plane magnetic field $\mathbf{B}_0$. Treating the cylindrical holes as dielectric inclusions embedded in a conducting host, we can apply a general approach previously developed for the discussion of a metal/dielectric composite medium in the quasi-static regime [2]. We find that the precise frequencies of the sharp peaks in the transmission spectra should depend strongly on the magnitude of $\mathbf{B}_0$, as well as on its direction and on the polarization of the incident wave. The directional sensitivity results in a strong magneto-induced anisotropy of the optical properties. This is similar to the anisotropic magnetoresistance recently found in periodic conducting composites [3,4], and also to the anisotropic macroscopic dielectric properties recently predicted to appear in metal/dielectric composites in the vicinity of a sharp quasi-static resonance [2]. An experiment to observe this phenomenon would best be done using a mid-infra-red polarized light beam and a doped semiconducting film with a large Hall mobility.

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Defects in lamellar polymer and magnetic systems: chevron and Omega-shape tilt boundaries

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Modulated phases are found in a wide variety of physical and chemical systems, such as diblock copolymers, thin-film magnetic garnets and amphiphilic systems. The lamellar phase appears as a result of a competition between short- and long-range forces, selecting a preferred periodicity of the lamellae.
We focus on block co-polymer melts and, in particular, on the case where the lamellae meet symmetrically with respect to the interface. The angle θ is defined as the angle between their normals, and the form of the interface strongly depends on θ. Chevron morphology occurs when the angle is small. The lamellae transform smoothly from one orientation to the other, creating V-shaped rounded tips. A gradual transition to an Omega-shape tip is observed when θ is increased. This morphology is characterized by a protrusion of the lamellae along the interface between the two phases.
We present a theoretical approach to find these tilt boundaries in two dimensional systems, based on the free energy functional used previously [1]. In the mean-field approximation, the free energy of the melt is a functional of the polymer concentration $\phi(x, y)$. A Ginzburg-Landau expansion of the free energy successfully predicts the appearance of lamellae in the bulk. Close to the tips, these lamellae are distorted. The free energy can now be expanded to second order in this local distortion field, $\delta\phi$. An ansatz is used, utilizing the periodicity along lines parallel to the interface. Averaging the free energy along these lines and using the variational principle result in a linear fourth order differential equation, with proper constraints, similar to the Mathieu equation.
The analytical polymer concentration profile and line tension obtained agree with Transmission Electron Microscope (TEM) experiments [2], and with full numerical solution of the same problem [1].

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Ag/YBCO thin film growth by single resistive evaporation.

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It is commonly accepted that thin film formation of YBCO on conducting and flexibility substrate is one of the keys to further development of advanced devices in the microelectronic and high field applications. In this work we report on a preparation of superconducting YBCO thin film deposited on unbuffered silver substrate using a simple conventional vacuum system equipped with only one single resistively heated evaporation source. The subsequent heat treatment was carried out under a low oxygen partialA thick Ag film ($1\mu m$) was first deposited on a polished clean MgO substrate. A pulverized mixture of Y, Cu, and BaF2 was then inserted into resistive evaporation boat. The evaporation process lasted 15 minutes thus coating the Ag film on the substrate with a 500 nm thickness of amorphous film. Subsequently heat process under a low oxygen partial pressure was carried out. The results of the film evaluation are presented and discussed.

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