Session 25DP

The Anderson transition due to random spin-orbit coupling in two-dimension — 25DP1

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Recently we proposed the SU(2) model which represents random spin-orbit coupling and estimated the critical exponent of the Anderson transition in the 2D symplectic universality class. The advantage of the SU(2) model is that corrections to scaling due to irrelevant scaling variables can be neglected permitting an accurate estimate of the critical exponent.
In the present work we examine the critical phenomena of the SU(2) model without on-site random potential. The Hamiltonian without on-site random potential has chiral symmetry. We estimate the critical exponent and compare it with the one in the system with on-site random potential.

Non-universal Exponents at the Anderson Transition — 25DP2

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We have numerically calculated the correlation dimension D_2 describing fractality of critical wave functions at the two- and three-dimensional Anderson transition points by employing the forced-oscillator method and the box-counting procedure. It is shown that values of the exponent D_2 distribute over realizations of disorder and the width of the distribution remains finite even in the thermodynamic limit. Similar results have been obtained for the exponent α which characterizes the decay of wave packets at criticality. This implies that these exponents are not universal. We have also shown that the scaling relation $D_2 = d\alpha$ (d is the spatial dimension) does not hold for individual samples, but is the case in a statistical sense.

25DP3 Metal-insulator transition in quasicrystalline AlPdRe

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Quasicrystals of AlPdRe can be made in phase pure form over wide ranges of conductivities σ, at low T. It has long been expected that samples with small σ should be insulating, but this has been difficult to prove from σ(T), which saturates at very low T. We have found that a metal-insulator transition, MIT, can be inferred from the magnetoresistance with a behavior characteristic for weakly disordered metals in samples with σ(4.2 K) $>$10$(\Omega\text{cm})^{-1}$, while insulating behavior with variable range hopping is observed for smaller σ(4.2 K). The estimated σ(0 K) decreases with increasing R=σ(295 K)/σ(4.2 K) over four orders of magnitude and across the MIT. This behavior indicates that σ(0 K) > 0 is an intrinisc property also of insulating AlPdRe and suggests quantum tunneling in such quasicrystals at low T.

25DP4 Coulomb-correlated hopping near a 2D Metal-insulator Transition

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We investigated the temperature dependence of resistivity of a high mobility Si MOSFET in the insulating regime near a 2D metal-insulator transition. Coulomb hopping in a wide range of temperature and carrier density was found. Quantitative analysis of the results suggests that electron-electron interaction is screened by the metal-gate as the localization length increases. The hopping is highly correlated, i.e. the observed hopping energy is one order of magnitude smaller than the expected value from a single-particle hopping picture. Our data agree with a percolation model which consists of electron puddles and quantum point contacts.

25DP5 Single parameter scaling of the conductance distribution in mesoscopic conductors

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The distribution of conductance g in phase coherent mesoscopic conductors is investigated near the Anderson transition. The distribution function $P(g)$ in 3D orthogonal systems shows single parameter scaling, which reconciles the phenomenon of the universal conductance fluctuation with the scaling theory of localization, i.e., the scaling theory of conductance. We also study the conductance distribution for 2D system with spin-orbit interaction near the Anderson transition.

One-particle model of the metal-insulator transition at $T = 0$ **25DP6**

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A method is proposed for calculating the ground-state conductance of weakly disordered quantum wires, which is based on the reduction of a transport problem for the electron propagator in a bounded system of arbitrary dimension to a set of exactly one-dimensional non-Hermitian problems for mode components of that propagator. In systems with more than one extended mode, it is the inter-mode scattering by disorder that leads to dephasing of *many-electron* states, thus keeping the electron system in the metallic state. With reducing the conductor thickness, while the bulk electron concentration being kept constant, the number of open channels is successively lowered to zero ultimately leaving evanescent modes only in the "electron waveguide". This is interpreted as a metal-insulator phase transition widely observed in 2D systems, whose origin is unrelated to the degree of disorder and thus to Anderson localization of carriers.

Suppression Of Universal Conductance Fluctuations By An Electric Field In Doped Si (P,B) Near The Metal-Insulator Transition **25DP7**

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We present results of 1/f noise meausurement (10^{-3}<f<10 Hz) at low temperatures(1K<T<20K) in single crystals of Si doped with P and B. The doping concentration n is close to the critical composition n_c of metal-insulator transition (MIT). Measurements in a magnetic field shows that universal conductance fluctuation(UCF) is at the origin of the observed noise. We show that an electric field can induce suppression of noise and this is more pronounced than that seen in a magnetic field. Near n = n_c the suppression even in a moderate field can be as large as 90%. We show that such an effect is not due to heating. We propose that the origin of this phenomena is the presence of electron-electron interactions.

Spectral Statistics of a Spin-1/2 Particle in Coupled Quartic Oscillator Potentials **25DP8**

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The quantum spectral statistics, i.e. the nearest neighbor level spacing distribution(NNSD) and the mode fluctuation distribution(MFD), etc. of a spin-1/2 particle in coupled quartic oscillator potentials are numerically studied. Selecting the coupling constants to make the system chaotic, three kinds of the Gaussian ensembles GOE, GUE, GSE can be realised. Our interpolation formulae can be fitted with the numerical NNSDs in the intermediate regions, which are between chaotic and intergrable regimes, as the Brody distribution is. The system with the external magnetic field is also discussed.

25DP9 Energy level spacing distribution at the quantum Hall transition

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We apply the real-space renormalization group approach to the Chalker-Coddingtion network model to study the energy level statistics at the integer quantum Hall transition. To assess the level statistics we analyze the *phases* of the transmission coefficients. We find that, at the transition, the level spacing distribution (LSD) exhibits well-pronounced level repulsion. We emphasize that a metal-like LSD emerges when the *fixed point* distribution $P(T)$ is used. Away from the transition the LSD crosses over towards the Poisson distribution. Studying the change of the LSD around the transition we observe scaling behavior. By a finite-size scaling analysis we obtain the critical exponent $\nu = 2.3 \pm 0.2$ of the localization length.

25DP10 Pulsed-mode operation of nuclear spin polarization in integer quantum Hall systems

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We present resistively detected nuclear magnetic resonance (NMR) in integer quantum Hall systems. A pulse-mode radio frequency magnetic field is applied through local metallic wire fabricated on top of $Al_{0.3}Ga_{0.7}As$/GaAs Hall bars. The change of dynamic nuclear polarization is detected by increase/decrease of differential Hall resistance. This pulse-mode NMR will open up a new way of utilizing nuclear spins in solid state devices.

25DP11 An Improved Far-infrared Microscope with Quantum Hall Detectors

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Optical system of far-infrared (FIR) microscope with quantum Hall detectors is improved in order to obtain enhancement of the detectivity and high-resolution images. In this microscope, FIR emission from the focal point of solid immersion lens is effectively concentrated on the small detector of 400μm $\times 400\mu$m. Spatial images of cyclotron emission due to non-equilibrium electrons are demonstrated in quantum Hall devices.

Role of DX^--centers in High Frequency Hopping Conductivity of the Si-doped heterostructures GaAs/AlGaAs in the Quantum Hall regime **25DP12**

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Long-term effects, i.e. dependence both on *cooling procedure*, and *IR illumination*, are observed in the HF hopping conductivity in the Si doped heterostructures GaAs/AlGaAs near the middle points of quantum Hall plateaus when studied acoustically at T=1-4.2K. It can be attributed to deep-donor centers, DX^--centers, which are localized two-electron states bounded by local lattice distortion, and HF hopping is due to tunneling of electron pairs between the center and its empty neighbor. RFFI 01-02-17891.

Gauge Theory of Composite Fermions **25DP13**

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We explain the success of Jain's composite fermion theory for quantum Hall systems at the filling factor $\nu = p/(2pq \pm 1)$ by applying the gauge theory of particle-flux separation previously studied for the case $\nu = 1/2$.[1] At temperatures $T < T_{\rm PFS}(\nu)$, the charge and Chern-Simons flux degrees of freedom of electrons separate. We call the corresponding quasiparticles chargeons and fluxons, respectively. Bose condensation of fluxons justifies the (partial) cancellation of external magnetic field. Fluxons describe correlation holes, while chargeons describe composite fermions. We calculate that $T_{\rm PFS}(\nu = 1/2) = 4 \sim 4.5$K and the mass of composite fermion is $(6.5 \sim 4.7) \times m$ (m: the effective electron mass).

[1] I.Ichinose and T.Matsui, Nucl.Phys.B468, 487 (1996); B483, 681 (1997).

Noise Performance of the Radio Frequency Single Electron Transistor **25DP14**

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We have operated a Single Electron Transistor (SET) in the radio frequency mode. In this way both the bandwidth and the sensitivity of the traditional SET can be increased several orders of magnitude. By optimizing the system we reached a best sensitivity of $3.2 * 10^{-6} e/\sqrt{Hz}$. The main noise contribution was found be coming from the cold amplifier but by further improvements it could be possible to reach the intrinsic shot noise limit of the transistor.

25DP15 The current and the charge noise of a single-electron transistor at large charge fluctuation out of equilibrium

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By using the Schwinger-Keldysh approach, we calculate the current noise and the charge noise of the single-electron transistor (SET) at large charge fluctuation caused by large tunneling conductance. Our result interpolates between two results of previous theories; "orthodox theory" and "co-tunneling theory". We found that the life-time broadening effect suppresses the Fano factor in the whole range of the sequential tunneling regime below the value estimated by the previous theories. We also show that large tunnel conductance does not spoil the energy sensitivity so much at threshold bias voltage. Our results suggest that SET electrometer has a potential for the high-sensitivity and high-speed device for quantum measurements.

25DP16 Non-Equilibrium Quantum Interference in Metallic Mesoscopic Systems

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A DC bias voltage V is used to increase the amplitude of the quantum interference corrections to the differential conductance in metallic mesoscopic wires and rings. The amplitude of both universal conductance fluctuations (UCF) and Aharonov-Bohm effect (ABE) can be enhanced several times for voltages larger than the Thouless energy and persists even in the presence of inelastic electron-electron scattering up to $V \sim 1$ mV. For larger voltages electron-phonon collisions lead to the amplitude decaying as a power law for the UCF and exponentially for the ABE. We obtain good agreement of the experimental data with a model which takes into account the decrease of the electron phase-coherence length due to electron-electron and electron-phonon scattering.

25DP17 Transport via a Quantum Shuttle

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We investigate the effect of quantisation of vibrational modes on a system in which the transport path is through a quantum dot mounted on a cantilever or spring such that tunnelling to and from the dot is modulated by the oscillation. We consider here the implications of quantum aspects of the motion. Peaks in the current voltage characteristic are observed which correspond to avoided level crossings in the eigenvalue spectrum. Transport occurs through processes in which phonons are created. This provides a path for dissipation of energy as well as a mechanism for driving the oscillator, thus making it easier for electrons to tunnel onto and off the dot and be ferried across the device.

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ac Current due to Photon-Assisted Tunneling in Driven Mesoscopic Systems **25DP18**

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Nonlinear ac transport induced by coherently oscillating potentials in mesoscopic resonant tunneling devices have been theoretically studied by employing a transfer-matrix method. This method enables us to calculate quantitatively ac currents of nonequilibrium quantum systems within a short computing time. We found that photon-assisted tunneling (PAT) affects not only dc but also ac transport. First, we calculate the ac current in a driven double-barrier system which is the simplest model of an irradiated quantum dot. Results show that there exist distinct sideband signals in the incident electron energy dependence of the zero-biase ac current. In the case of a driven mesoscopic ring, namely, a Mach-Zender electron interferometer with a time-varying potential, photon-assisted ac current exhibits acute cusps at sideband energies. We also discuss the possibility of experimental observations of these PAT signals.

Electron-Phonon Interaction in Freely Suspended Quantum Dots **25DP19**

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We present work on single and double quantum dots which have been defined in the two-dimensional electron gas of a freely suspended GaAs/AlGaAs heterstructure. The dots are formed by pairs of etched constrictions or by gating electrodes and characterized in Coulomb blockade measurements. Due to their small overall dimensions the suspended dots constitute phonon cavities in which electron transport is strongly modified by electron-phonon interaction. Recent measurements have shown that the emission of phonons suppresses linear transport in the Coulomb blockade regime. Upon application of a perpendicular magnetic field Coulomb blockade oscillations reemerge, as well as under nonlinear transport conditions or an increased temperature.

Adiabatic Electron Pumping through a Quantum Dot with a Discrete Level **25DP20**

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We theoretically investigate an adiabatic electron pumping through a quantum dot with a discrete energy level and tunneling barriers coupled to leads under the Coulomb blockade effect. Adiabatic electron pumping is the device that produces a finite charge transfer through a quantum dot when the dot is modified slowly by two external time dependent sources and it is returned to its initial configuration after a certain period. We calculate pumping charge under time dependent tunneling barriers using scattering matrix method. The maximum pumping charge per cycle is a unit charge. The Coulomb blockade effect suppresses the pumping charge. We also discuss the effect of magnetic fields.

25DP21 Resonant Raman scattering in a spherical quantum dot in presence of an external magnetic field

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A theory of one-phonon resonant Raman scattering in spherical quantum dots (SQD) in presence of an external magnetic field B is developed. We consider the Fröhlich interaction for the electron-phonon coupling. The calculated Raman intensities as a function of incident light $\hbar\omega_l$ and B shows a set of incoming and outgoing resonances corresponding to different inter-band magneto-optical transitions. Selection rules and conditions of double resonance are deduced. Only confined–LO-phonons with angular momentum $l = 0$ are found to be active in the resonant Raman scattering. The role of the surface phonon modes in the Raman process is outlined. To our knowledge, the resonant Raman scattering calculation in a SQD under an applied magnetic field has never been reported before.

25DP22 Environmental influences on geometric phases in superconducting nanocircuits

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Interferometry based on Berry's phase has been proposed to realize quantum gates. Geometric quantum computation has been implemented in NMR (J. Jones et.al. Nature 403, 869, 2000), and proposals have been made to detect geometric phases in superconducting nanocircuits (G. Falci et. al. Nature, 407, 355, 2000). In the proposed implementations the adiabatic tuning of the parameters is achieved by coupling the qubit to exernal driving sources which undergo intrinsic thermal and quantum fluctuactions. The possibility to define a Berry's phase in the presence of the coupling to a dissipative environment has been discussed by Withney et.al. (cond-mat/0107359). Here we study the effect of environmental fluctuations on Berry's phases phocusing on implementations with superconducting nanocircuits.

25DP23 Voltage Proportionate to the Persistent Current on Segments of an Asymmetric Superconducting Loop

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A dc voltage changed periodically with magnetic field $V(\Phi/\Phi_0)$ which was observed recently[1] on segments of asymmetric mesoscopic loop without any external dc current at temperatures corresponded to superconducting transition is intended to consider. This experimental result conforms to an analogy with a conventional loop but according to it a segment of the loop is a dc power source because the $V(\Phi/\Phi_0)$ as well as the persistent current $I_p(\Phi/\Phi_0)$ are observed without the Faraday's voltage, i.e. at a constant magnetic field $d\Phi/dt = 0$. It will be discussed what energy is transformed to the observed power VI_p.

[1]http://xxx.lanl.gov/abs/physics/0105059.

Coherent phenomena in a normal conductor with a superconducting coating. 25DP24

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The thermodynamic properties of a mesoscopic-size simply connected cylindrical normal metal with a superconducting coating are studied. It is accepted that a vector potential field can be varied inside the normal layer. The quasiparticles move ballistically through the normal metal and undergo the Andreev scattering by the off-diagonal potential. We find the spectrum of the Andreev levels and calculate the density of states (DOS) of the system. It is shown that the Andreev levels shift as the trapped flux changes inside the normal conductor. At a certain flux value they coincide with the Fermi level. A resonance spike in the DOS appears in this case. As the flux is increased, the DOS behaves as a stepwise function of the flux. The distance between the steps is equal to the superconducting flux quantum $hc/2e$.

Mesoscopic fluctuations in interacting metallic grains: superconductivity, thermodynamics and interplay between pairing and exchange 25DP25

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We discuss ensembles of interacting metallic grains with statistical distribution of single particle energy levels. Signatures of pairing correlations in ultrasmall grains are found in the thermodynamic quantities.
The interplay of pairing and exchange is also studied, both analytically and numerically. They compete in stabilizing a nonzero spin ground state. The probability of nonzero spin ground state is found to show universal behavior as a function of distinctive scaling parameters.

Andreev Reflection in Ferromagnet/Superconductor/Ferromagnet Structures 25DP26

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Recently, many studies of the spin transport through magnetic nanostructures have been done. In a metallic ferromagnet(FM)/superconductor(SC) structure, there is a novel phenomenon of the Andreev reflection. To clarify the effect of the Andreev reflection on the magnetoresistance(MR), we calculate the MR in FM/SC/FM structures by solving the Bogoliubov-de Gennes equation. As a result, we find a strong dependence of the MR on the thickness of the SC and on temperature. These results are understood by considering the penetration of quasiparticles into the SC and give a good explanation for recent experiments of the MR in FM/SC/FM structures.

25DP27 Superconducting Correlation in Orbital Magnetism of Quantum Dots

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Anomalies of magnetic responses have been reported by Visani et al., Müller-Allinger and Mota. In their experiments, the Meissner diamagnetism is suppressed drastically in cylindrical samples with superconductor/normal metal junctions at low temperatures. To account for this, we consider a two-dimensional disk quantum dot with the above junction, and calculate the energy levels and then the orbital magnetization by solving the Bogoliubov-deGennes equation numerically. We find that characteristic energy levels appear below the superconducting gap due to the proximity effect and make a significant paramagnetic contribution to the magnetization. These energy levels have the novel dependence on the magnetic field and have a close relation to the "glancing state" proposed by Bruder and Imry. We also explain the field dependence of the energy levels by using the quasi-classical picture.

25DP28 Nonlinear shot noise in mesoscopic normal-superconducting structures

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We study differential shot noise in mesoscopic diffusive normal-superconducting heterostructures at finite voltages where nonlinear effects due to superconducting proximity effect arise. We apply a numerical scattering-matrix approach to calculate transmission coefficients through the sample. Two different systems are studied: a normal-superconducting (NS) junction and a NIS junction with a nonideal interface forming a potential barrier between the two regions.

25DP29 Electron Transport in Ferromagnet/Superconductor Nanostructures

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We report experimental study of electron transport in mesoscopic ferromagnet/superconductor structures. The ratio of the exchange energy, h, to the superconducting energy gap, Δ , was varied in a wide range from $h \gg \Delta$ in structures with Ni as a ferromagnet and Al as a superconductor to $h \approx \Delta$ in structures with ferromagnetic Ni/Cu alloys and Pb as a superconductor. Interface and bulk properties in both limits are compared.

Transmissivity of Electrons in a Quantum Wire Containing a Superconductor Ring Pierced Magnetic Flux

25DP30

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Transmissivity of electrons in a normal quantum wire tangentially attached to a superconductor ring pierced magnetic flux is calculated. A point scatterer with a $\delta-$function potential is placed at node. We find that the transmission probability spectrum of electrons in this structure strongly depends on the normal or superconducting state of the ring as well as scattering strength. In the case of superconductor ring threading one quantum magnetic flux, it emerges one deep dip, which originates from the superconductor state of the ring. Based on the condition of the formation of the standing wave functions in the ring, transmissivity of electrons in this structure can be well understood.

Proposal of a new type of a switching device using S-N-S suparlattice

25DP31

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We propose the way of separation of coherent region by spin exchange correlation without any dielectric materials. The method is based on the layer-by-layer anti-ferromagnetically spin arrangement in the system of S-N-S superlattice in the mesoscopic scale.

Current-Driven Insulator-to-Superconductor Transition

25DP32

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Quench-condensed ultrathin beryllium films can be driven through a superconductor-insulator transition by tuning either the film thickness or a magnetic field. Films in the vicinity of the thickness-tuned transition are particularly interesting. First, the magnetoresistance is positive and can varying as much as eight orders of magnitude in a field less than 1 tesla. Secondly, the superconducting phase coherence length of barely insulating films is found to decrease as the temperature is lowered. Of the most surprising is that such barely insulating films can be tuned into superconducting when a large-enough dc current is applied. The origins and the implications of these observations will be discussed.

25DP33 Temperature Dependence of Electrical Conductivity in 1D Electron System Formed on Liquid Helium Surface

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The electrical conductivity of 1D electrons confined in the channels created on the surface of liquid helium was measured as a function of temperature down to 50 mK. A peak around 0.2 K, which was the evidence for 1D character originating in the intersubband transitions, was observed for the first time. The result of the temperature dependence is in agreement with an existing theory for 1D electron system. Below 0.2 K, the electrons occupy the ground state and behave as a nealy ideal 1D system.

25DP34 Detecting electrons on helium with a single electron transistor(SET)

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Phil Platzman and Mark Dykman have suggested that surface state electrons on helium would be excellent candidates for qubits (quantum bits) and could form the basis of a quantum computer. The (0¿ and (1¿ states of the qubit would be represented by the ground and first excited state(Rydberg states) in the potential well of a trapped electron trapped over helium on a micro-structured substrate. A test qubit has been designed and fabricated, incorporating a single-electron transistor(SET) to detect the electrons.

25DP35 Magnetoresistance of the Q1D electron system formed on a superfluid 4-He surface

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The longitudinal magnetoresistance ρ_{xx} of the Q1D electron system on the helium surface has been investigated under the magnetic field B up to 2.6T within $T =$ 0.48-2.05K. The width of the conducting strips formed on a liquid surface between the dielectric fibers was 100-400 nm. It was established that ρ_{xx} is mainly an increasing function of B. The influence of the magnetic field on ρ_{xx} is the stronger the lower T and the larger width of the strips. The data were compared with theories of the magnetotransport SE for both Q1D and 2D. The negative ρ_{xx} has been observed at the low B for both vapor atom and ripplon scattering regimes. This effect is assumed to be caused by weak localization of Q1D carriers.

Electron-electron interactions in a weakly screened two-dimensional electron system **25DP36**

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We extract the strength of electron-electron interactions from magnetoconductivity measurements of two-dimensional non-degenerate electrons on liquid helium at 1.22 K. Our data extend to electron densities that are two orders of magnitude smaller than previously reported. We span both the independent-electron regime where the data are qualitatively described by the self-consistent Born approximation (SCBA), and the strongly-interacting electron regime. At finite fields we observe a crossover from SCBA to Drude theory as the electron density is increased. We obtain a quantitative value for the Landau level broadening due to electron-electron interactions.

Effect of screening on plasmons **25DP37**

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Plasmons are collective excitations observed in systems consisting of charged particles. Besides the usual (Debye) screening inherent in these systems, there may exist impurities, external sources, etc., that cause the Coulomb interaction to be screened. To better understand the effect of this screening on the plasmon spectrum, we calculate the dynamic structure function of a system of charged bosonic particles at various densities in two and three dimensions (3D) within the jellium model. The applicability of these results to the electron gas and measurements on metals and semiconductors is pointed out and discussed. Special attention is paid to the vanishing plasmon gap in the 3D spectrum and the emergence of an acoustic mode when screening is present, and the appearance of anomalous dispersion at low densities.

Levinson's theorem and a bound state of positrons in the electron gas **25DP38**

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Positrons embedded in metals annihilate predominantly with conduction electrons. The annihilation rate reduces with decreasing density for the whole range of metallic densities. Controversial suggestions have been made on the annihilation rates at very low electron gas densities. We calculate the effective screened interaction between the impurity and electrons within a simplified jellium model where the electrons are treated as bosonic particles and show that the electrons attracted to the positron can form a bound cluster. The resonance states of the effective interaction are analyzed by calculating the scattering phase-shifts. We find that the maximum of the phase-shift as a function of energy approaches π when $r_s \approx 14$. According to the Levinson's theorem this indicates that a bound state is formed.