Session 26DP

Kondo Effect in Quantum Dots Coupled to Ferromagnetic Electrodes **26DP1**

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The Kondo effect in a quantum dot (QD) coupled to metallic leads is related to the formation of a spin singlet state of the unpaired localized electron and delocalized electrons of the leads. When the dot is coupled to ferromagnetic electrodes a key question is how the spin polarization of the ferromagnetic electrodes affects the QD magnetic state, and whether the Kondo effect still survives. We show that the Kondo effect appears in such systems, it is still strong but significantly modified. The zero-bias anomaly in the differential conductance split by a magnetic field, are also greatly modified.

Suppression of the Kondo Effect in T-Shaped Double Dots System **26DP2**

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We investigate electron transport through a system with double dots in parallel geometry, in which only the first dot is connected to the leads whereas the second dot to the first one. We evaluate the tunneling conductance and the local density of states by means of Green's function method with the non-crossing approximation. It is shown that transport properties are considerably affected by tunable parameters of the second dot. In the Kondo regime, we find anomalous suppression of the conductance, which results from the interplay of the Kondo effect and the Fano-type interference effect.

26DP3 Ab initio calculation of molecular conductance

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We report first principles calculations for the conductance of organic molecules that have been studied experimentally by J. Reichert *et al.* (PRL **88**, 176804 (2002), see also talk by H. Weber, 22aD5). Our calculations are based on the nonequilibrium Greens function formalism and the quantum chemical software package TURBOMOLE. After relaxation of the system's geometry, molecule plus leads (55 gold atoms per contact), we find a conductance of approximately $0.1e^2/h$ which is about two orders of magnitude larger than the experimental result. In order to address this puzzle, results from a detailed study of the conductance change upon modification of the microscopic conditions (e. g. the nature of the sulfur-gold bonding) are presented.

26DP5 Stabilization of ground-state minimal spin in disordered quantum dots

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We investigate the ground-state spin and energy of disordered quantum dots using spin-density-functional theory. With increasing interaction strength, the even-odd alternation of addition energies (Coulomb-blockade peak spacings) disappears, and the probability of non-minimal spin increases, but never exceeds 50%. Within a two-orbital model which takes screening into account, we show that the off-diagonal Coulomb matrix elements help stabilize a ground state of minimal spin by creating a low-energy hybridization of the various minimal-spin basis states. We also show that fluctuations of addition energies scale proportional to level spacing, not proportional to the average addition energy.

26DP6 Current-spin density-functional theory of magnetic-field-induced transitions in quantum dots and quantum rings

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The chemical potential, spin magnetization, orbital angular momentum, and persistent current in quantum dots and quantum rings under a magnetic field have been calculated within the framework of current-spin density-functional theory (CSDFT). With increasing magnetic field, a rich variety of transitions between the ground states with different angular momentum and spin configuration have been predicted. The features in the calculated field-dependent chemical potential spectra of the quantum dots, which reflect the many-electron state transitions, are in good agreement with those observed in the experiments. This suggests that CSDFT is a useful tool for studying the combined effects of confinement, Coulomb interaction, spin polarization and magnetic field for a realistic quantum dot or ring.

Singlet-triplet and Triplet Kondo effects in a two-electron quantum dot **26DP7**

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We experimentally study the crossover of the Kondo effect when the ground state of a two-electron quantum dot is changed from a spin-singlet via a singlet-triplet (ST) crossing to a spin-triplet by sweeping the magnetic field. We only observe a Kondo zero-bias peak in the differential conductance in the ST and triplet regions, being most pronounced at the ST crossing. Away from the ST crossing, the Kondo temperature decreases at the triplet side. In the linear conductance as a function of the gate voltage, a bump in the Coulomb valley is observed at the ST crossing, which splits apart at the triplet side. This feature is ascribed to the influence of Hund's coupling. Our findings agree with recent theory.

Spin Accumulation in Ferromagnetic Single-Electron Transistors **26DP8**

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We propose a new method of direct detection of spin accumulation, which overcomes difficulties met in earlier measurements. A spin dependent current in a single-electron transistor with ferromagnetic electrodes leads to a nonequilibrium spin accumulation on the metallic island. Owing to the charging energy, the resulting spin-splitting of the electrochemical potential of the island can be detected from the spacing between two resonances in the current-voltage characteristics. The results were obtained in the framework of real-time diagrammatic technique, taking into account higher order (cotunneling) processes.

Kondo effect variety in an artificial atom laterally coupled to two-dimensional electron gas **26DP10**

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We fabricated a vertical dot coupled to a lead of two-dimensional electron gas separated by split gates. The coupling strength between the dot and lead can be controlled by applying the vertical magnetic field to the surface. The conductance shows large broad peak in which the number of electrons in the dot changes through even and odd. When the magnetic field is applied, the broad peak changes the even-odd rectangular oscillations because the orbital degenerate Kondo effect disappears. The conductance also shows a chessboard behavior in the magnetic field-gate voltage plane.

26DP11 Two-stage Kondo effect in a semiconductor quantum dot

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A Kondo effect (Kondo temperature $\sim$ 4K) is observed at high magnetic field in a selective area growth semiconductor quantum dot, which is ascribed to a singlet-triplet transition in the ground state of the dot. The low-temperature conductance approaches the unitary limit at the transition, whereas away from it, the conductance is sharply reduced for low bias voltage and temperature. The observations are explained in terms of a two-stage Kondo effect, related to the single-channel character of the leads.

26DP12 Transmission Spectra for an Interacting Electron System of Finite Size

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We consider the transmission spectra $\mathcal{T}(\epsilon)$ through small interacting systems connected to noninteracting leads. Based on the Kubo formalism, the conductance can be expressed in a Landauer-type form as,[1] $g = (2e^2/h) \int d\epsilon \, (-\partial f/\partial \epsilon) \, \mathcal{T}(\epsilon)$, where $f(\epsilon)$ is the Fermi function and $\mathcal{T}(\epsilon)$ is defined in terms of a three-point current vertex. We have applied this formula to a series of Anderson impurities of size N ($= 1, 2, 3, 4$) and calculated $\mathcal{T}(\epsilon)$ using the order U^2 self-energy and current vertex.[1] In this presentation, we will discuss some extensions of the general formulation and give a simplified expression of $\mathcal{T}(\epsilon)$ in terms of the retarded products. We will also present numerical results of $\mathcal{T}(\epsilon)$ for the series of N Anderson impurities for various parameter values.

[1] A. Oguri, J. Phys. Soc. Jpn. **70**, 2666 (2001).

26DP13 Strings and Stripes in Condensed Matter

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We demonstrate that there are strings in narrow band ionic insulators due to Froelich electron-phonon interaction alone. The system is in an inhomogeneous state in a wide range of physically interesting parameters. We show that conditions for string existence, the string length and the number of particles self-trapped into depend on the electron(hole) conduction bandwidth, on the ratio of high frequency and static dielectric constants.

Collective charge modes in a 1D electron liquid **26DP14**

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A new behavior of the collective mode in a 1D electron liquid is found. In the wave number region close to $2k_F$ (k_F is the Fermi wave number) the mode frequency goes to zero. This means that the soft mode appears in addition to common long-wave plasmons. This mode is related to dynamic short-range electron correlations that are adequately described in the frame of the Luttinger model. The soft mode is immanent in 1D and is absent in higher-dimensional systems. The results are valid for both Coulomb and short-range electron-electron interaction.

Correlation analysis for the Calogero-Sutherland model **26DP15**

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Exploiting the results of the exact solution for the ground state of the one-dimensional spinless quantum gas of Fermions with μ/x_{ij}^2 particle-particle interaction, the Hellmann-Feynman theorem and the available analytical pair densities for $\mu = -1/4,\ 0,\ \mathrm{and}\ 2$ allow to analyze particle-number fluctuations. They are suppressed by repulsion, enhanced by attraction, and may therefore measure the kind and strength of correlation. Other recently proposed purely quantum-kinematical measures of the correlation strength arise from the small-separation behavior of the pair density or — for Fermions — from the non-idempotency of the momentum distribution and its large-momenta behavior. They are compared with each other and with reference-free, short-range correlation-measuring ratios of the kinetic and potential energies.

Plasmons in weakly disordered array of quantum wires **26DP16**

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The paper deals with the theoretical investigation of intrasubband plasmons in weakly disordered array of quantum wires (QWs), consisting of finite number of QWs. The array of QWs is characterized by the fact that the density of electrons of one ”defect” QW was different from that of other QWs. The spectrum of plasmons has been calculated in zero-temperature approximation. It is shown that the amount of plasmon modes in weakly disordered array of QWs is equal to the number of QWs in array. The existence of the local plasmon mode, whose properties differ from those of usual modes, is found. We point out that the local plasmon mode spectrum is slightly sensitive to the position of ”defect” QW in array. At the same time the spectrum of usual plasmon modes is shown to be very sensitive to the position of ”defect” QW.

26DP17 The Effect of the Periodic Potential on the Stripe Formation in a Weak Magnetic Field

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We consider the influence of a weak external periodic potential on the stripes at half-integer filling fractions of the upper Landau levels. We find the ground state by analytically minimizing the cohesive energy in two cases: the stripes aligned perpendicular and parallel to the direction of the applied external modulation.

26DP18 Conductance renormalization and conductivity in quatum wires with multiple subbands

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Using a Tomonaga-Luttinger model, we studied the conductance renormalization and conductivity of a quantum wire with multiple subbands. As in a single-band system, the conductance of a quantum wire with an arbitrary number of subbands is not renormalized by the electron-electron interaction. We derived a formula for the conductivity of a quantum wire with multiple subbands and applied it to a simplified case. We found that inter-subband interaction enhances the conductivity, which is contrary to that expected from the intra-subband repulsive interaction, and that the conductivity increases with increasing number of subbands.

26DP19 Spinvelocities in quantum wires within the ladder approximation

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Spin transport properties of quantum wires or the g–factor depend crucially on the magnitude of the spin velocity v_σ [1] which is difficult to obtain for a given microscopic electron-electron interaction. Presently most trustworthy are extensive quantum Monte Carlo (QMC) calculations [2] while other techniques turn out to be considerably less reliable [3]. Here we present results obtained by means of a ladder approximation to the interaction vertex which yield promising estimates to v_σ in comparison with the QMC–data. The required effort does not exceed the one for selfconsistent Hartree-Fock calculations.
[1] W. Häusler, Phys. Rev. B **63**, 121310(R) (2001)
[2] C.E. Creffield, W. Häusler, A.H. MacDonald, Europhys. Lett. **53**, 221 (2001)
[3] W. Häusler, L. Kecke, A.H. MacDonald, Phys. Rev. B **65**, 085104 (2002).

Coulomb Blockade Effect in Collision of Two Acoustic Polarons **26DP20**

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Collision between two acoustic polarons, which are complexes of an electron near the band bottom and lattice distortions around it, is numerically studied by using Su, Schrieffer and Heeger's model extended to include extended Hubbard type electron-electron interactions. Particularly when the two polarons have opposite spins, their collision looks quite repulsive in the absence of electronic repulsive interaction. On the contrary to intuition, this effective repulsive interaction is found to be reduced by introducing relatively weak electronic interactions. Detailed analyses indicate that a kind of "Coulomb blockade effect" might explain this reduction of repulsion. The possibility to regard acoustic polarons as atomic scale self-organized quantum dots with a single bound state will also be discussed.

Fractional Conductance Plateau Near Subband Edge in Quantum Wires **26DP21**

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We study the anomalous conductance plateau in one-dimensional quantum wires with the bosonization technique. By symmetry arguments, we are able to show that the only instability due to electronic correlations is the formation of the Luther-Emery spin liquid. In contrast to the scenario of spontaneous spin polarization, we propose that the anomalous plateau is driven by the singularity located near the edges of one-dimensional subbands and the ground state changes from the Luttinger liquid to the spin liquid. Comparing with experiments, our theory explains the peculiar behavior of conductance plateau versus gate voltage and source-drain bias. In addition, we also predict the ground state has a spin gap that can be probed by applying an in-plane magnetic field.

Electronic Transport in a 3-D Network of 1-D Bismuth Quantum Wires **26DP22**

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The resistance (R) and magnetoresistance (MR) of a high density network of 6 nm diameter Bi wires in porous Vycor glass (PVG) was measured in order to study the expected semiconductor behavior. R increases as T decreases from 300 K to 0.3 K. Below 4 K, where R varies approximately as ln(1/T), the order-of-magnitude of the resistance rise and the behavior of the MR are consistent with localization and electron-electron interaction theories of a one-dimensional disordered conductor in the presence of strong spin-orbit scattering. This behavior, along with the surface-enhanced carrier density, may mask the proposed semimetal-to-semiconductor transition for quantum Bi wires. We will also present the effects of Te doping on the resistance and MR.
Work supported through NSF and ARO.

26DP23 Coulomb Blockade of Phase Slip in Mesoscopic Charge-Density-Wave Systems

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Phase slip near electrical contacts is responsible for the nonlinear current-voltage characteristic in clean mesoscopic charge-density-wave systems. The thermal nucleation rate of the phase slip is calculated for both the vortex-ring model and the vortex-pair model, with particular attention to the influence of long-range Coulomb interactions. It is shown that due to a large charging energy associated with the nucleation processes, the phase-slip rate is greatly reduced when the applied voltage is smaller than a threshold voltage. This indicates that the collective conductivity vanishes below the threshold voltage.

26DP24 Carrier Drift Velocity in Semiconducting Strings

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The carrier drift velocity in a semiconducting wire with metal contacts is derived from the Luttinger model, where the electric field generated by image charges due to the metal contact, other than the external field, is taken into account. In the large limit of the electric field, the (saturated) drift velocity can be estimated as $(4e^2/h)(1/\varepsilon_s)$, where e, h, and ε_s represent the elementary charge, the Planck constant, and the dielectric constant of the semiconductor, respectively.

26DP25 A Theoretical Study on Orbital Magnetism of Mesoscopic Ring Systems

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Magnetization and spatial distribution of current of mesoscopic ring systems with finite width are investigated in various regimes of temperature and magnetic field. Mesoscopic ring systems with finite width are effectively expressed by confining harmonic and inverse square potentials. The width can be controlled by the number of electrons. When the width is relatively small, usual Aharonov-Bohm (AB) oscillation is observed at low temperatures; its amplitude is, however, suppressed as the magnetic field increases by effects of finite width. When the width is large enough, de Haas-van Alphen oscillation appears. In this case the AB oscillation disappears, since the coherence of electrons is destroyed by exchange of electrons between different channels.

Cyclotron Resonance for 2D Electrons on Liquid Helium in a Resonator **26DP26**

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An investigation of the microwave absorption for two-dimensional electron systems(2DES) on helium films and in the presence of a cyclotron resonance (CR) magnetic field B are presented. Measured data are explained by a recently proposed two-fraction model of the 2DES, which makes the general structure of the microwave absorption understandable. The fraction of localized and free electrons can be precisely determined. Furthermore, CR for 2DES in a resonator results in the occurrence of a crossing point between the resonator eigenmode ω_0 and the cyclotron frequency ω_c versus B. As anti-crossing phenomena near this point are expected, the eigenmode of the resonator is renormalized, $\omega_0(B) = \omega_0 + \Delta\omega(\omega_0, B)$. Direct measurements of $\Delta\omega(\omega_0, B)$ for this system show the possibility to explain and fit such a shift.

Shubnikov-de Haas Oscillations and Fermi Surface of τ-Phase Conductors **26DP27**

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τ-phase organic Q2D conductors have a 4-fold single Fermi surface (FS) from band calculation. At low temperature, the resistivity turns into semiconducting, whereas Shubnikov-de Haas oscillations (SdH) have been observed. The SdH include two frequencies that are inconsistent with the band calculation. The reason of this contradiction may be explained by the deviation of the anion composition and/or the reconstruction of the FS. Recently, we found the super structure of this salt below 245 K by X-ray study.

Electronic Property of the Conducting LB Film of BEDO-TTF and Stearic Acid in High Magnetic Field **26DP28**

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The transverse magnetoresistance (MR) was measured up to 15 T in the metallic Langmuir-Blodgett (LB) films of BEDO-TTF and stearic acid. The negative MR under 2 T below 20 K, coming from the quantum interference of carriers, gives an evidence of the first observation of weak localization in two-dimensional electronic system (2DES) in the organic LB films. The Thouless length is up to 580 Å at 1.7 K[1]. The MR increased linearly with the magnetic field above 2 T and exhibits a specific curve up to 15 T with respect to the formation of 2DES below 3 K.

[1] Ishizaki et. al., Phys. Rev. B 63 (2001) 134201

26DP29 Narrow Band Noise in the SDW State of (TMTSF)$_2$PF$_6$

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Narrow band noise has been studied in the SDW phase of (TMTSF)$_2$PF$_6$ under magnetic fields, when electric current larger than the threshold for non-ohmicity is passed parallel to the one-dimensional axis. Periodic large and small peaks are clearly observed and the spectrum largely changes around a certain current I_0, which depend slightly on magnetic field. Below I_0 the small peaks move to higher frequency as usually observed in the CDW state. Above I_0, on the other hand, the large peaks move to lower frequency. There are two kinds of fundamental frequencies for the periodic peaks. One of them comes from a sliding motion of the SDW condensate and changes drastically in frequency above I_0, and the other does probably from a CDW-like collective mode whose frequency is independent of the electric current. The observed periodic large peaks appear at both the harmonic frequencies of the two fundamental peaks.

26DP30 Charge Disproportionation and Weak Localization in θ-$(\mathrm{BEDT\text{-}TTF})_2\mathrm{MZn}(\mathrm{SCN})_4$ $[\mathrm{M} = \mathrm{Cs}, \mathrm{Rb}]$

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We studied low-temperature electronic state of the title materials by applying uniaxial strain as it suppresses the M-I transition that is associated with charge ordering. We extended the metallic region below ~ 5 K and found no superconductivity but phenomena due to the weak localization of charge carriers. We propose that the fluctuation of the charge ordering is responsible for the localization.

26DP31 De Haas-van Alphen and Shubnikov-de Haas oscillations under the conditions of magnetic breakdown in 2D organics

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A theory is developed for the dHvA and SdH effects in a Q2D organic conductors like $\kappa-(ET)_2CNCS_2$. The energy spectrum reorganized due to the magnetic breakdown (MB) and Landau bands develops whose bandwidth and separation between them oscillate in inverse magnetic field. The theory of dHvA and SdH oscillations display "forbidden" frequencies and well fit the magnetization pattern. The SdH oscillations depend on the layer stacking factor and on the MB factors which, in particular, are responsible for the temperature-independent SdH oscillations. The latter contain the so called slow oscillations, forbidden frequencies and combinations of these frequencies. The peaks in the SdH oscillations are splitting by the chemical potential oscillations. The possibility of the MB-Peierls phase transitions is discussed.

Optical Conductivity in Commensurate Spin-Density-Waves at Quarter-Filling **26DP32**

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A role of the commensurability has been examined for the optical conductivity of spin-density-wave (SDW) states using the extended Hubbard model with one-dimensional quarter-filled band. The conductivity coming from both single particle and collective excitations is calculated within the random phase approximation. A noticeable peak due to the collective mode exists at a finite frequency below the frequency corresponding to the single particle excitation gap. The mass enhancement estimated from the contribution of the collective mode is shown for the three kinds of mean-field ground states, i.e., charge uniform SDW state and two kinds of SDW states with different charge ordering, which are determined by on-site, nearest-neighbor and next-nearest-neighbor repulsive interactions.

Theory of Surface Plasmons in Layered Conducting Crystals **26DP33**

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A microscopic description of surface plasma vibrations in anisotropic conducting crystal is developed using the kinetic equation for charge carriers distribution. Such theory leads to integral dispersion equation which can be solved (analytically or numerically) for any given electron energy spectrum to obtain both the spectral relations and lifetimes of surface waves. The theory is applied to layered "synthetic" metals with quasi-2D motion of electrons, i.e. of open Fermi-surface analytically modelled by weakly corrugated cylinder. The activation frequencies, wave velocities and damping decrements (in collisionless limit) of surface plasmons have been calculated in 3 main geometries. If wave vector or the normal to sample surface is orthogonal to layers, the results differ qualitatively from the case of isotropic metal. Partially, there is a strong deceleration of TM-wave in first case, that could be employed in HF delay lines.

Effects of Tungsten doping on the CDW states of η–Mo_4O_{11} **26DP34**

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The η–Mo_4O_{11} system shows successive CDW transitions due to its two–dimensional Fermi surface instability. We find that the lower temperature CDW–II transition easily disappears by doping a small amount of W atoms (less than 0.2%/Mo), though the higher temperature CDW–I transition is weakly depressed. Since the modulation of CDW–II state has an interlayer component, the doped atoms should be partly located on the interlayer MoO_4 sites and then destroy the interlayer coherence between the intralayer two–dimensional CDWs. The resistivity along the conducting plane follows "*log T*" dependence below 10 K, suggesting that the doped atoms should also exist within the conducting layer and induce the Anderson–type charge localization.

26DP35 High Field Fermi Surfaces Studied by ADMRO in η–Mo_4O_{11}

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The high field Fermi surface in η–Mo_4O_{11} at low temperatures has been studied by the Angular Dependent Magenetoresistance Oscillation (ADMRO) method. The Shubnikov de Haas oscillation measurements so far obtained show a change in the frequency of quantum oscillation above 9 T, and the higher field behavior is very complicated. The ADMRO result shows a clear change in the size of Fermi surface supporting the existence of field induced phase transition around 9 T. The size of Fermi surface above 9 T along the c^* direction is decreased to one half of that below 9 T. The anisotropy of the Fermi surface and the higher field results help to discuss the nature and origin of the transition. The transport results were obtained using the rectangularly shaped single crystals.

26DP36 FERMI-LIQUID ELECTROMAGNETIC MODES IN LAYERED CONDUCTORS

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The specifics of quasi-two-dimensional electron energy spectrum in organic conductors with layered structure gives rise to peculiar Fermi-liquid modes, which are absent in a gas of charge carriers and exist at relatively low frequencies. There are windows of transparency of the layered conductor for two electromagnetic waves with different polarization even at low intensity of the Fermi-liquid interaction. When magnetic susceptibility is close to $1/4\pi$ we have determined the spectrum and amplitude of waves near the electron phase transition followed by the formation of diamagnetic domains.

26DP37 CYCLOTRON RESONANCE IN ORGANIC LAYERED CONDUCTORS

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The propagation of electromagnetic and acoustic waves in organic layered conductors with Q2D electron energy spectrum of arbitrary form in a strong quantizing magnetic field **H** have been considered taking into account the Fermi-liquid correlation of charge carriers. By experimental studies of the cyclotron resonance for various orientations in the layers-plane of **H** the electron velocity distribution over the Fermi surface and the intensity of fermi-liquid interaction can be determined. The H-dependence of the rate of sound attenuation takes the form of giant resonance peaks, between which the regions of high acoustic transparency are situated.

Magnetoresistance oscillstions in an organic superconductor, $(TMTSF)_2FSO_3$ **26DP38**

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The Shubnikov-de Haas oscillations were observed for the first time in $(TMTSF)_2FSO_3$ under pressures. The oscillations with frequency ~130 T for $H//c^*$, appear only in pressure between 8 and 11 kabr without any indication of field-induced transition rising. Suprisingly, angular magnetoresistance oscillations (AMRO) follows the Yamaji formula instead of Lebed's for tilted mangetic fields. Although the family of $(TMTSF)_2X$ is known as Q1D, the SdH oscillations and AMRO confirm this salt as a 2D electron system. We will discuss angular dependence of the SdH oscillations, related with Fermiology of this compound.