Session 21DP

Full Counting Statistics of a Superconducting Beam Splitter **21DP1**

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The complete information about a charge transfer process is contained in the so called *full counting statistics*. We study the statistics of charge transport in a mesoscopic three-terminal device with one superconducting terminal and two normal-metal terminals. We calculate the full distribution of transmitted charges into the two symmetrically biased normal terminals. In a wide parameter range, we find large positive crosscorrelations between the currents in the two normal arms. We also show that the third cumulant provides additional information on the statistics not contained in the current noise.

Excitonic condensation in a symmetric electron-hole bilayer **21DP3**

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Using Diffusion Monte Carlo simulations we have investigated the ground state of a symmetric electron-hole bilayer and determined its phase diagram at $T = 0$. We find clear evidence of an excitonic condensate, whose stability however is affected by in-layer electronic correlation. This stabilizes the electron-hole plasma at large values of the density or inter-layer distance, and the Wigner crystal at low density and large distance. We have also estimated pair correlation functions and low order density matrices, to give a microscopic characterization of correlations, as well as to try and estimate the condensate fraction.

21DP4 Oscillations of Magnetoconductance in semiconductor-superconductor junctions with a laterally potential barrier isolator inside semiconductor region

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Magnetoconductance(MC) in junctions of a superconductor and a semiconductor(Sm) consisting of two parallel quantum waveguides coupled through a potential barrier under a perpendicular applied magnetic field in the semiconductor region is studied theroretically. The results of MC showing a series of oscillations with stepwise platform and spikes may be understood well within the phenomenological argument similar to Y. Asano (Phys. Rev. B 61, 1732 (2000)) proposed. Also, MC spectrum may be tailored by changing height, width, position, and the number of the isolating barrier layers in Sm .

21DP5 Response Times of a Thermometer Based on Normal Metal - Insulator - Superconductor (NIS) Tunnel Junctions

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Thermal effects in a thin film NIS structure fabricated by electron beam lithography are studied by heating electrons in the normal metal island in the frequency range 0.1 Hz - 80 MHz. This is done by applying an ac-bias to one pair of junctions, and measuring the dc response of the additional junctions connected to same N metal. Unexpectedly, the response shows a cut-off frequency well below the one corresponding to the electron-phonon interaction. The effect does not seem to be a simple equilibrium phenomenon of the electrons and quasiparticles, since the measured differential conductance curves indicate non-trivial changes in the superconducting density of states at the high frequency side of the cut-off.

21DP6 Magnetic-field-tuned Superconductor-Insulator-Metal Transition in ultrathin TiN films

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We report the experimental observation of a magnetic-field-tuned superconductor-insulator transition (SIT) in ultrathin TiN films. The low temperature transport properties of these films show scaling behavior consistent with a transition driven by quantum phase fluctuations in two-dimensional superconductor. The magnetoresistance reveals peak and a subsequent decrease in fields higher than the critical field. The temperature dependences of the isomagnetic resistance data on the high-field side of the SIT have been analyzed and the transition from insulating to metallic phase is found, with at high fields the zero-temperature asimptotic value of the conductivity being approximately equal to e^2/h.

Inductive Coupling of Two Superconducting Loops with Three Josephson Junctions **21DP7**

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A superconducting loop with three Josephson junctions can behave as a macroscopic quantum two-level system, which could be used as a flux qubit. Coupling of qubits is necessary to realize a quantum computer. We have been measuring on two such loops which are inductively coupled. Antiferrromagnetic ordering of the two loops is expected when the magnetic flux in each loop is around half a flux quantum. The quantum coherence of two-qubit states will be discussed.

Long–range coherent transport in macroscopic NS systems **21DP8**

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In the system Aluminium-Indium, the metals being in a mechanical contact of different area, the temperature-dependent transport in normal single-crystal bulk Aluminium has been investigated over the temperature interval included the superconducting transition temperature for Indium. One of the normal voltage leads was located on Aluminium at a macroscopic distance either from the Al-In interface or from the other, superconducting, voltage lead. After In went into the superconducting state the change in normal Al conductivity over helium temperatures exceeded by an order of magnitude or more that change in case when the NS boundary was absent.

Unusual Quantum Magnetoresistance Oscillations in the Superconducting Microstructure with a Small Loop **21DP9**

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The magnetoresistance R(H) of a small thin film aluminum loop connected to a large Al contacts by Al narrow lines is measured near the superconducting transition temperature. We find quantum oscillations in R(H) which is different from Little-Parks ones. In low magnetic fields the oscillations are superposed on the anomalous background of negative magnetoresistance. We also find the oscillation amplitude versus the applied current to be nonmonotonic and differentiated in low and high fields. We attribute this behavior to non-local effects, to contributions of phase-coherent paths that passed through the loop as well as large contacts, so the contacts isn't ideal reservoirs.

21DP10 Using vortex pumps to control the motion of flux-quanta in superconductors

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We have studied several types of pumps to control the motion of flux-quanta in superconductors. These systems consist of superconductors with pinning sites shaped either: (a) as triangles, (b) as boomerangs, or (c) as two overlapping square arrays of round blind holes. These systems rectify (in different ways) an applied electrical alternating current, transforming it into a net DC motion of fluxons. The asymmetry of the pinning potential induce this diode effect. This type of control of the motion of fluxons can have important applications in devices, like SQUID magnetometers, where the removal of trapped flux would greatly help the reduction of noise in these devices.

21DP11 Superconducting SET with Tunable Electromagnetic Environment

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Small-capacitance superconducting tunnel junction is a promising candidate for solid-state realizations of quantum computing. In solid-state systems, a major obstacle is decoherence resulting from coupling to the electromagnetic environment. We have studied the environmental effect on superconducting single-electron transistors (S-SETs), which are building blocks of nano-circuits, by biasing with 1D arrays of small-capacitance dc SQUIDs. The advantage of this SQUID configuration is that the effective impedance of the array can be varied *in situ* by applying an external magnetic field, i.e., the arrays are tunable environment to the S-SET. As the zero-bias resistance of the arrays is increased, Coulomb blockade in the S-SET becomes sharper. Furthermore, the dependence on the gate voltage changes from e-periodic to $2e$-periodic. These results imply that the SQUID arrays are effective on-chip noise filters.

21DP13 Critical current distributions in ballistic Andreev junctions

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We have measured swithing-current histograms for different Andreev based Josephson junctions made of niobium – InAs two-dimensional electron gas – niobium. From the histograms we extract both the escape temperature and the "real" critical current. Measurements are presented as a function of temperature, magnetic field and applied gate voltage.
By comparing the effects of temperature versus those of magnetic field and gate voltage we can evaluate the nature of the escape process and its dependence on different parameters.

Mesoscope interference effects in ultrathin Bi films **21DP14**

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The resistance of continuous quantum size Bi films as a function of magnetic field (5 T) was investigated. The films thickness (below than 25 nm) was less than the de Broglie wavelength of the electrons on the Fermi surface. The oscillation of the resistance periodic in magnetic field were observed, that could be interpreted as the result of the electron interference on the occasionally arised local films regions of the mesoscope size with better conductivity. The area of this local regions define the period of oscillations.

Dynamical Conductivity and Localization Corrections in Small and Large Quantum Dots and Disordered Systems **21DP15**

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Localization effect on the dynamical conductivity $\sigma(\omega)$ is examined in quantum dots and disordered electron systems. For the small volume limit (0D limit), which is well described by the random matrix theory, $\mathrm{Re}[\sigma(\omega)]$ is known to be proportional to the DOS correlator $\langle\nu(E)\nu(E+\omega)\rangle$, hence to the two-level correlator $R_2(\omega/\Delta)$. Looking on localization effect, however, should reveal the discrepancy between $\mathrm{Re}[\sigma(\omega)]$ and $\langle\nu(E)\nu(E+\omega)\rangle$, because only the former, not the latter, is consistent with the weak localization result and its RG treatment of conductivity. We investigate and clarify the issue by evaluating the linear response $\sigma(\omega)$ directly from the nonlinear sigma formulation.

Many Body Relaxation Induced By an External Alternating Field in Strongly Disordered Media **21DP16**

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In papers [1] a concept of resonant pairs was put forward to explain low temperature relaxation properties of glasses. Then it was established [2] that strong external field gives rise to a new nonlinear relaxation mechanism in disordered systems. In the present communication we combine the ideas of both papers [1,2] to describe many body relaxation in glasses affected by strong external alternating field what allows to eliminate the quantitative discrepancy between the experiment and the theory.
[1] A. L. Burin, Yu. Kagan, L. A. Maksimov, I. Ya. Polishchuk, Phys. Rev. Lett. **80**, 2945 (1998).
[2] A. L. Burin, Yu. Kagan, I.Ya. Polishchuk, Phys. Rev. Lett. **86**, 5416 (2001).

21DP17 Is weak temperature dependence of electron dephasing possible?

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A first-principle theory of the electron dephasing by disorder-induced two-state fluctuators is developed. Two channels of the dephasing can be discriminated. They are, respectively, due to (i) direct transitions between the defect levels caused by inelastic electron-defect scattering, and to a "breathing" scattering potential produced by the fluctuators which breaks the symmetry with respect to the time reversal. Both mechanisms predict weak temperature dependence of dephasing rate at low temperatures. The quantitative estimates based on the experimental data concerning the fluctuators density show that the disorder-induced dephasing can dominate at low enough temperatures. It is capable to explain the experimental low-temperature behavior of magnetoresistance of two-dimensional electron gas.

21DP18 Disorder and Its Effect on the Electron Tunneling and Hopping Transport in Semiconductor Superlattices

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We study theoretically vertical electron transport in semiconductor superlattices subject to an electric field. A disorder is introduced into the layer parameters. Both, disordered superlattices with a strong electron scattering and those with a weak scattering, are considered at low temperatures. The interwell hopping transport is simulated for the former structures, and the tunneling approach is adopted for the latter superlattices. In both models the current–voltage characteristics are calculated for various types and degrees of the disorder. The superlattice transport properties can be controlled by the disorder.

21DP19 Variable Range Hopping Conduction in Copper Ternary Compounds

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We report on the temperature dependence of the resistivity in single crystals of the Cu-III_3-Te_5 systems. A crossover from Mott variable range hopping (VRH) to Efros-Shklovskii VRH conduction is observed below 15 K in some of the samples. Although both types of conduction mechanisms have been found previously in several different materials, they have been seen rarely in the same sample at different ranges of temperature. The crossover has been observed mainly in highly insulating 3D films, and only recently in a weakly insulating single crystal of the $CuInTe_2$ semiconductor. As it happens in the 3D films, the predicted temperature for the crossover is significantly below the one found in experiments.

Magnetic Freeze-Out and Impurity Band Conduction in n-InSb **21DP20**

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Effective Bohr radius of the donors of InSb is very large (a*=65nm) on account of its small electronic effective mass (m*=0.014m) and the metallic impurity band is formed due to the overlap of wave functions. Metal-nonmetal (M-N) transition in the impurity band of n-InSb can be induced in a moderate magnetic reflecting the shrinkage of the donor wave functions due to magnetic field, and the magnetic freeze-out as well as conspicuous non-ohmic behavior shows up with increasing magnetic field at low temperatures. In this contribution, the non-ohmic conduction in magnetic fields of n-InSb with the different donor concentration at low temperatures is demonstrated systematically and the temperature- and magnetic-field dependence of the impurity band mobility is discussed as well as the magnetic-field induced M-N transition, extracted from the analysis based on the two-band model for the non-ohmic conduction.

Sizeable Enhancement of Anti-Weak Localization Effect in In_2O_{3-X} Thin Film caused by H_2 Gas Mixing in N_2 Gas Atmosphere on Heat Treatment **21DP21**

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Through magneto-conductance (MC) measurements, we have observed sizeable enhancement of anti-weak localization effect (AWLE) in In_2O_{3-X} thin film (60nm) caused by H_2 gas mixing (10%) in N_2 gas (90%) atmosphere on heat treatment (HT). In case of the HT in pure N_2 gas atmosphere, the AWLE is recognized, but very small. The MC is obtained as functions of the magnetic field, the temperature, the sample thickness and the azimuth between the film surface direction and the magnetic field direction. By H_2 gas mixing in N_2 gas atmosphere on the HT, we consider that interstitial In atoms in In_2O_{3-X} are effectively generated and the sizeable enhancement of the spin-orbit (SO) interaction is caused.

Localized Phonon Assisted Electron Tunneling in DBRT structure in Quantizing Magnetic Field **21DP22**

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A calculation of confined and interface optical phonon assited electron tunneling in GaAs/AlAs double barrier resonant tunneling (DBRT) structure in the presence of quantizing magnetic field, along the growth direction, is presented. The excess current is calculated employing transfer matrix method. Confined optical phonon modes are described by the microscopic lattice dynamic model due to Huang and Zhu. Interface modes are described following the work of Lassnig. Numerical results obtained, based on Huang and Zhu model, for GaAs/AlGaAs DBRT structure are in good agreement with experimental observations. Calculations are presented for the variation of excess current with well and barrier width, temperature and magnetic field.

21DP23 Effects of Disorder on the Conductance through Small Interacting Systems

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We consider a two-dimensional Hubbard model of finite size connected to two noninteracting leads, as a model for the superlattices of the quantum dots or the atomic networks of nanometer size. To study the effects of disorder on the transport through this kind of small interacting systems, we introduce the randomness into the hopping matrix element, which preserves the electron-hole symmetry. We calculate the conductance at zero temperature by using the order U^2 self-energy, which is obtained numerically by taking the random potential into the unperturbed Hamiltonian. Our preliminary results show that the conductance is sensitive to the randomness when a number of the eigenstates of an effective Hamiltonian exist near the Fermi energy[1] and contribute to the transport.

[1] Y. Tanaka, A. Oguri, and H. Ishii, J. Phys. Soc. Jpn. **71**, 211 (2002).

21DP24 Tunneling Picture of Interlayer Magnetotransport in Multilayer Systems

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Interlayer magnetotransport of multilayer systems has been generally studied theoretically and experimentally. In multilayer systems with weak interlayer coupling, interlayer conduction is mainly dominated by single tunneling process between neighboring layers. The selection rule and probability of single interlayer tunneling are controlled by orientation and strength of magnetic fields. This tunneling model gives the most general explanation of several kinds of angular dependent magnetoresistance oscillation (AMRO) phenomena observed in Q2D or Q1D layered conductors. The existence of the Fermi surface is not necessary for appearance of AMRO's. This model can also be applied to the interlayer cyclotron resonance or AMRO's under strong electric fields. The experimental results of GaAs/AlGaAs superlattices and low-dimensional organic conductors are also presented.

21DP25 Numerical Study of the Sideband Quenching in Driven Mesoscopic systems

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Coherent electron transport through a system driven by a time-varying potential is theoretically studied by employing a transfer-matrix method which enables us to investigate not only dc but also ac transport of dynamical mesoscopic systems. It has been found that dc and ac currents in the driven mesoscopic system vanish if the strength of the time-varying potential coincides with certain values α^*, namely, the sideband quenching. We have clarified the frequency dependence of α^* and discussed the origin of this phenomenon.

Polarization of Bloch electrons and Berry phase in the presence of electromagnetic fields **21DP26**

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We consider Bloch electrons in the presence of the electromagnetic field. We show that the macroscopic electric polarization are written in terms of the Berry phase, which is induced by the adiabatic change of the time-dependent vector potential. The relation between the macroscopic polarization and the Berry phase is analogous to that in the crystalline dielectrics, which is mentioned by King-Smith and Vanderbilt, and Resta.

Rashba precession in quantum wires with interaction **21DP27**

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One of the realizations of a spin transistor uses the precession of spins when moving along a lateral electric field. This effect usually is explained, assuming noninteracting electrons, by spin splitting caused by the spin-orbit interaction. Here, this 'Rashba precession' along a one-dimensional quantum channel is calculated accounting for Coulomb interactions. The Tomonaga–Luttinger model is solved by Bosonization with the spin-orbit term included. Apart from the strength of the lateral electric field the spin velocity (compared with the Fermi velocity) is identified as the crucial parameter to influence the Rashba precession [1]. Spin velocities have been found [2] to decrease with increasing interaction strength at decreasing carrier density which *enhances* spin precession and the nominal Rashba parameter.
[1] Wolfgang Häusler, Phys. Rev. B **63**, 121310(R) (2001)
[2] C.E. Creffield, Wolfgang Häusler, and A.H. MacDonald, Europhys. Lett. **53**, 221 (2001).

Clustering of the electron-hole liquid **21DP28**

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Free excitons created in semi-metals and semiconductors under irradiation of light may condense into an electron-hole liquid when their density is large enough. This quantum phenomenon has been intensively studied theoretically and experimentally. The exciton gas undergoes Mott's metal insulator phase transition at much smaller density. This mismatch between the critical value of the density for the instability of the free excitons and the threshold value of the density for the appearance of the electron–hole liquid stimulated a controversial dispute over a decade of what arises in the range of densities between these two critical values. We show that a new structural liquid consisting of the charged clusters can be formed where each cluster is like a molecule consisting of different numbers of electrons and holes.

21DP29 Quantum Nyquist Temperature Fluctuations

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We consider fluctuations of a temperature of a small object. Classical fluctuations of the temperature have been considered for a long time. Using the Nyquist approach, we show that the temperature of an object fluctuates when in a thermal contact with a reservoir. For large temperatures or large specific heat of the object C_v, we recover standard results of classical thermodynamic fluctuations $\langle \Delta T^2 \rangle = \frac{k_B T^2}{C_v}$. Upon decreasing the the size of the object, we argue, one necessarily reaches the quantum regime that we call quantum temperature fluctuations. At temperatures below $T^* \sim \hbar / k_B \tau$, where τ is the thermal relaxation time of the system, the fluctuations changes the character and become quantum. For a nano-scale metallic particle in a good thermal contact with a reservoir, T^* can be on a scale of a few Kelvin.

21DP30 Acousto-Electric Effect in Bounded Metal

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We consider vibrations of electric scalar potential, accompanying the longitudal ultrasonic wave in metal at low temperatures, when the wavelength is less than free path of conducting electrons, L. It is shown that in bounded sample, aside from item similar to a field of deformations, the potential contains non-local part due to ballistic motion of carriers; it is essential at a distance $\sim$L from border. In general case of nonhard fixed border we calculate the temperature and frequency dependencies of magnitude and phase of surface potential, and find a qualitative agreement with experimental data measured in monocrystals Al, Ga and W. In pulsed mode a non-local part of potential takes form of quasi-wave impulse passing through the sample (of thickness D$\sim$L) with Fermi velocity, maximal for given crystal direction.

21DP31 Flow equation renormalization of a spin-boson model with a structured bath

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The spin-boson model is a standard model for dissipative quantum systems. We will discuss the dynamics of a spin coupled to a damped harmonic oscillator. This system can be mapped to a spin-boson model with a structured bath, i.e. the spectral function of the bath has a resonance peak. We diagonalize the model by means of infinitesimal unitary transformations (flow equation method [1]) and calculate spin-spin correlation functions for low temperatures and all energy scales. Structured baths were discussed in connection with electron transfer processes [2] and quantum measurement processes [3].

[1] S.K. Kehrein and A. Mielke, Ann. Phys. (Leipzig) **6**, 90-135 (1997); [2] A. Garg, J.N. Onuchic, and V. Ambegaokar, J. Chem. Phys. **83**, 3391 (1985); [3] F.K. Wilhelm, submitted to PRL.

Anomalous Temperature and Disorder Dependence of the Electron-Phonon Scattering Time in Impure Metals **21DP33**

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We have measured the electron-phonon scattering time, τ_{ep}, in disordered metals at liquid-helium temperatures, using weak-localization method. The temperature and disorder dependence of τ_{ep} is determined for AuPd and AgPd thick films, and $V_{1-x}Al_x$ alloys. In all three cases, we find an anomalous temperature and disorder dependence of $1/\tau_{ep} \propto T^2 l$, where l is the electron elastic mean free path. This temperature and disorder behavior cannot be explained in terms of current theoretical concepts for the electron-phonon interaction in impure conductors. Current theory predicts a form of either $1/\tau_{ep} \propto T^4 l$ or $1/\tau_{ep} \propto T^2 l^{-1}$ in the dirty limit, depending on the (vibrating or static) nature of the defects.

Quantum oscillations of Bi and alloy BiSb magnetoresistance in magnetic fields up to 33 T **21DP34**

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The special quantum oscillations of bismuth magnetoresistance have been considered. In contrast to Shubnikov-de Haas (SdH) oscillations observed at temperature less than 4K, the oscillations were detected in the temperature range 6-65 K and were referred to as “high-temperature” oscillations (HTO). The results of joint studies of SdH oscillations and HTO of the magnetoresistance for pure Bi and alloy $Bi_{1-x}Sb_x$ (x=2.6 at.%) in stationary magnetic field up to 33 T are presented. The oscillations are measured for different magnetic field directions at temperature 4 - 30 K. It was found that SdH oscillations and HTO reached its quantum limit at the same value of magnetic field. The analysis of the experimental data verified one of two alternative models of HTO.

Pressure tuning of the quantum critical point in a CrV alloy **21DP35**

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The concept of a zero temperature quantum phase transition, which is characterized by quantum rather than thermal fluctuations, has been invoked to understand various kinds of strongly correlated systems. We report here a magnetotransport study of the quantum critical behavior of $Cr_{1-x}V_x$ as its spin-density-wave (SDW) transition is driven to zero temperature. In order to look for quantum critical behavior, we substitute a small amount of V for Cr which drives T_N to zero for $x = 0.035$. The effect of pressure on T_N is similar to that of V substitution, but permits continuous tuning of the magnetic transition. We focus on the issues of whether the charge carrier density changes discontinuously through the transition and how the fluctuation spectrum develops in the immediate vicinity of the quantum critical point.

21DP36 New Hamiltonians to calculate electronic states in strain fields

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Semiconductor strain structures are made from materials with different lattice constants. Recently attempts to use strain structures as the low-dimensional quantum confinement have become popular. The effect of strain was formulated by Pikus and Bir. However the Pikus-Bir Hamiltonian is invalid when the strain is spatially modulated in the low-dimensional quantum structures, and moreover it is invalid when the strain exists in a magnetic field. Another formulation of the strain effects is the theory of deformation potential, but I conclude that it is wrong. Hence in this paper I propose new Hamiltonians that generally describe the effects of strain. In conclusion, the new Hamiltonians are enough accurate, and they are very useful.

21DP38 Electron localization and replica symmetry breaking in the quasicrystal-like system

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The electronic properties in quasicrystals are quite unusual. That is, the resistivity is anomalously large at low temperature, and decreases with increasing temperature. Recently the present author [1, 2] has considered the transport property in the randomly distributed system of the correlated configurations(the aggregation), in which the nearest distance between each configuration is $\sim 2\pi/2k_F$ (the quasicrystal-like state). In this study, we shall consider the transport property in the randomly distributed system of the correlated unit-cell configurations such as the prolate and oblate rhombohedra, by using the effective Lagrangian of diffusion modes, taking into account the sp-d hybrization. [1] I.Kanazawa, Physica B284-288,1161(2000). [2] I.Kanazawa, J.alloys and compounds (2002), in press.