Session 23DP

Continuous Transformation from Skyrmion- to Pseudospin-type Excitation **23DP1**

A. Sawada[a], D. Terasawa[a], N. Kumada[a], Z.F. Ezawa[a], K. Muraki[b], T. Saku[b], Y. Hirayama[b]

[a] *Department of Physics, Faculty of Science, Tohoku University, Sendai 980-8578, Japan*
[b] *NTT Basic Research Laboratories, 3-1 Morinosato-Wakamiya, Atsugi 243-0198, Japan*

We measured the activation energy of bilayer $\nu = 1$ quantum Hall states by changing the bias voltage and tilting samples in the magnetic field. By changing the density difference, the tilting behavior of the pseudospin(PS)-type activation energy at the equal density point gradually transforms into the Skyrmion(S)-type one at the monolayer density point. At the intermediate density difference, by increasing the tilting angle the activation energy starts to decrease as a PS-type excitation gap and then increase as a S-type excitation gap. It is impossible to explain this behavior in terms of the level crossing of the PS- and S-type excitations. The result of the overall behavior indicates the excitation in bilayer system possesses the both properties of the PS-type and S-type excitations.

Explanation of the tunneling phenomena between the edges of two lateral quantum Hall systems **23DP2**

Shinji Nonoyama[a,b], George Kirczenow[a]

[a] *Department of Physics, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6*
[b] *Faculty of Education, Yamagata University, Yamagata 990-8560, Japan*

We use computer simulations to identify the physics behind the surprising results of recent measurements by Kang *et al.* [Nature **403**, 59 (2000)] of electron transfer between the edges of two two-dimensional electron systems (2DES). We find that a consistent explanation of all of the observed phenomena is possible only if the barrier between the 2DES is surrounded by a strong potential well that supports quantum railroads of edge channels that, in the presence of disorder, exhibit directed localization. This together with the onset of electrical resistance as the system exits the perfectly conducting quantized Hall regime accounts for every aspect of the data. We propose direct experimental tests of our theory.

23DP3 Neutral Collective Excitations in Striped Hall States

Nobuki Maeda, Takahiro Aoyama, Yumiko Ishizuka, Kenzo Ishikawa

Department of Physics, Hokkaido University, Sapporo 060-0810, Japan

In the absence of disorder and edges, the quantum Hall system has the magnetic translation and rotation symmetry. In the striped state, a magnetic translation in one direction is spontaneously broken to the discrete translation and the rotation is also spontaneously broken to the π-rotation. Using the conserved current, the property of the neutral collective excitations is studied. The spectrum of the neutral collective excitation is obtained in the single mode approximation numerically. The spectrum has a multiple line node structure and cusps. Furthermore, the spectrum has anisotropic feature, that is, in one direction the spectrum resembles the liquid Helium spectrum with the phonon and roton minimum, and in another direction it resembles the FQHS spectrum.

23DP4 Goldstone Mode Kink-Solitons in Double Layer Quantum Hall Systems in the Absence of Tunneling

Ramaz Khomeriki[a], Kieran Mullen[b]

[a]*Department of Physics, Tbilisi State University, Chavchavadze Ave. 3, Tbilisi 380028, Republic of Georgia.*
[b]*Department of Physics and Astronomy, University of Oklahoma, 440 West Brooks, Norman, Oklahoma 73019, USA*

It is shown that in charge unbalanced double layer quantum Hall system with zero tunneling pseudospin Goldstone mode forms moving kink-soliton in weakly nonlinear limit. This charge-density localization moves with a velocity of gapless linear spin-wave mode and could be easily observed experimentally. We predict that mentioned Goldstone mode kink-solitons define diffusionless charge transport properties in double layer systems, where mentioned kink-solitons could be considered as transport carriers.

23DP5 Anomalous Metallic Phase and Magnetism in a High-Mobility and Strongly Correlated 2D Electron System

Mitsuaki Ooya, Tohru Okamoto

Department of Physics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

We report the transport properties of a low disorder ($\mu_{\max} \sim 30\mathrm{m}^2/\mathrm{Vs}$) two-dimenstional electron system in the Si/SiGe heterostructure, where the strong electron-electron interaction ($U/\varepsilon_{\mathrm{F}} \sim 10$) causes the anomalous metallic temperature dependence of resistivity. We found a sharp kink in the resistivity ρ vs parallel magnetic field $B_{//}$ curve which corresponds to the complete spin polarization. The observed critical magnetic field B_c is smaller than that expected for the free electron system by a factor of 2 or 3. The metallic temperature dependence of ρ was observed even for $B_{//} > B_c$ where spin degree of freedom is frozen, while the metallic phase in Si-MOSFET's is suppressed by the parallel magnetic field (cf. Okamoto et al. PRL 82 (1999) 3875). $B_{\perp}$-dependence of ρ are also investigated systematically.

Quantum Hall Ferromagnets in Magnetic Quantum Wells **23DP6**

Jan Jaroszyński[a,b], Tomasz Andrearczyk[a,b], Grzegorz Karczewski[a], Jerzy Wróbel[a], Tomasz Wojtowicz[a], Ewa Papis[c], Eliana Kamińska[c], Anna Piotrowska[c], Dragana Popović[b], Tomasz Dietl[a]

[a] *Institute of Physics, Polish Academy of Sciences, PL 02–668 Warsaw, Poland*
[b] *National High Magnetic Field Laboratory, Florida State University, Tallahassee, Florida 32310, USA*
[c] *Institute of Electron Technology, PL 02–668 Warsaw, Poland*

We report transport studies in a (Cd,Mn)Te/(Cd,Mg)Te:I heterostructure. Due to s-d coupling in this novel quantum Hall system, giant exchange Zeeman splitting strongly depends on magnetic field. Thus, even in moderate, perpendicular magnetic fields crossings of Landau levels occur. This makes it possible to probe for the first time formation of quantum Hall ferromagnetism in a magnetic quantum well. Magnetic ions not only dramatically modify electronic energy levels but also strongly enhance many body effects of the system. This makes ferromagnetic critical temperature as high as $T_c \approx 2$ K in this heterostructure.

Spin Peierls Effect in Polarization of Fractional Quantum Hall States **23DP7**

Shosuke Sasaki

Shizuoka Institute of Science and Technology

The magnetic dependence curve of the electron spin polarization in the fractional quantum Hall effect has many plateaus. Some of the plateaus have very small widths, and the others have wide widths. In the Landau gauge, the single electron orbitals are like straight lines with equal intervals. For a filling factor of 2/3, the electron-configuration with minimum energy is the sequence (filled, filled, empty, ...), which produces spin exchange interactions. When, we take the spin-Peierls effect into consideration, the intervals in the first sequence are changed to be wide, and the ones in the second sequence are changed to be narrow, ... This modulation creates energy gaps. The energy-decreasing by the gap is superior to the Coulomb energy increasing. Therefore, the gap really appears. Then, the magnetic dependences of the calculated spin polarization are well in accord with the experimental data after Kukushkin et al.

Negative Differential Conductance in a Benzene-Molecular Device **23DP8**

Maarten R. Wegewijs[a], Matthias Hettler[b], Wolfgang Wenzel[b], Herbert Schoeller[a]

[a] *Institut für Theoretische Physik A, RWTH Aachen, 52056 Aachen, Germany*
[b] *Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021 Karlsruhe, Germany*

We predict a *negative differential conductance effect* in the nonlinear transport through a molecular device containing a *weakly* coupled benzene ring. The effect is based on (1) the symmetry properties of the molecule with respect to the transport direction, (2) the strong local e-e interactions and (3) the coupling of electrons to photons. The effect is generic: other molecules may have similar current-switching properties. The flow of current is blocked by the spontaneous decay of the molecular anion from an *excited* state to a lower lying, stable state of the anion which does not couple to the electron tunneling. An effective *interacting* Hamiltonian for the π-electrons (derived from an electronic structure calculation) serves as input for the transport calculation.

23DP9 Molecule-Based Single Electron Transistor

Hye Mi So[a], Jinhee Kim[b], Wan Soo Yun[b], Jong Wan Park[a], Ju-Jin Kim[a], Do-Jae Won[c], Yongku Kang[c], Changjin Lee[c]

[a]*Department of Physics, Chonbuk National University, Jeonju 561-756, Korea*
[b]*Electronic Device Group, Korea Research Institute of Standards and Science, Daejeon 305-600, Korea*
[c]*Korea Research Institute of Chemical Technology, Daejeon 305-600, Korea*

We have fabricated molecular electronic devices combining Au nanoparticles and an organic self-assembled monolayer, and investigated their electrical transport properties. Current-voltage characteristic curves were nonlinear at temperatures below 70 K. Gate modulated current exhibited a periodic oscillation, attributed to the Coulomb oscillation, up to 40 K. The resonance peaks in differential conductance curves shifted with the increase of magnetic field, due to the Zeeman splitting of the electronic states of the Au nanoparticle.

23DP10 Current-Voltage Characteristics for Point Contact Composed of Two Peierls Conductors at Finite Temperature

Kazuo Sano

School of Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo, 169-8555, Japan

Current-voltage (J-V) characteristics are numerically investigated at finite temperature for a point contact consisting of two Peierls conductors (P) separated by an insulator in the conventional tunnel Hamiltonian approach. Here P is a conductor with a charge density wave (CDW). The J-V characteristics depend on the CDW phases in the mean field approximation where the phases (φ) and energy gaps (Δ) in both Peierls conductors are assumed to be equal, respectively. The current J is a periodic function of the phase φ with a period π, and has a discontinuous jump at $eV = 2\Delta$ ($\varphi \neq 0$). The jump increases as the phase φ increases. For $0 < eV < 2\Delta$ the current J decreases as the phase φ increases, but while for $eV > 2\Delta$ the current J increases as the phase φ increases.

23DP11 Electron Transport Properties of C_{60} Single Electron Transistor

Norihiko Nishiguchi

Department of Applied Physics, Hokkaido University, Sapporo 060-8628, Japan

Electron transport of a C_{60} single-electron transistor is studied theoretically, postulating the shuttle mechanism (L. Y. Gorelik *et al.*, Phys. Rev. Lett.**80**, 4526(1998)) that the vibrating nanoparticle carries charges between the electrodes. Two types of gate voltage effect on the transport properties are demonstrated: one is direct modulation of the current via modification in the tunneling rate, giving rise to modifications in Coulomb staircase. Another is an indirect effect due to a shift in the range of the C_{60} molecule vibration induced by the gate voltage. The latter effect stops the shuttle mechanism at a large gate voltage, leading to the conduction gap which widens in proportion to the gate voltage. The findings of this work are consistent with those of the experimental study on the C_{60} single-electron transistors.(H. Park *et al.*, Nature **407**, 57(2000))

Longitudinal Magnetoresistance of Bismuth Nanowires **23DP12**

Tito E. Huber[a], Michael J. Graf[b]

[a]*Laser Laboratory, Howard University, Washington, DC20059*
[b]*Department of Physics, Boston College, Chestnut Hill, MA 02467*

We study the electrical transport properties of 200-nm diameter and 30-nm single-crystal bismuth nanowire arrays embedded in an alumina matrix. Measurements have been carried out over a wide range of temperatures (1.8 K -300 K) and magnetic fields (0-18 T). The longitudinal magnetoresistance (B//I) is found to be negative at low fields, which is consistent with the model of size efects due to R.G. Chambers. The experiments have been carried out in our laboratories and in the U.S. National High Magnetic Field Lab. Support by NSF and ARO is acknowledged.

Rectifying diodes made of individual gallium nitride nanowires **23DP13**

Jae-Ryoung Kim[a], Hwangyou Oh[a], Hye Mi So[a], Ju-Jin Kim[a], Jinhee Kim[b]

[a]*Department of Physics, Chonbuk National University, Jeonju 561-756, Korea*
[b]*Electronic Device Group, Korea Research Institute of Standards and Science, Daejeon 305-600, Korea*

We have fabricated Schottky diodes with individual gallium nitride nanowires synthesized by chemical vapor deposition method. High quality rectifying diodes have been fabricated by using Al as the Schottky barrier and Ti/Au for the ohmic contact. The measured current-voltage characteristics showed clear rectifying behaviors and no reverse bias breakdown was observed up to the measured voltage, -5 V. The forward bias threshold voltage decreases linearly as the temperature was lowered from about 0.4 V at 280K to 1 V at 10 K.

Quantum wire arrays and dot arrays in mesoporous silica thin films. **23DP14**

Noriaki Sugimoto[a], Koji Tsukada[a], Yoko Kumai[a], Atsushi Fukuoka[b], Masaru Ichikawa[b]

[a]*TOYOTA Central R &D Labs.,Inc., Nagakute, Aichi, 480-1192, Japan*
[b]*Catalysis Research Center, Hokkaido University, Sapporo 060-0811, Japan*

The array of quantum metal wires and dots were synthesized by Ship-In-A-Bottle method with silica mesoporous thin films. The diameter of wire or dot can be designed from 2-6nm. The silica mesoporous film is self-assemble material with uniform diameter of mesopores like zeolite. The wire diameter and arrangement of wires are strictly controlled by Host materials. With the use of conventional semiconductor fabrication process, Host mesoporous film can cut under 500nm range. The electrical properties such as I-V characteristic and magneto-resistance were measured with sub-micron contact to wires. The UCF and electron wave interference effect will be discussed.

23DP15 Electron Transport through Quasi-1D Atomic Chains on a Silicon Surface

Takashi Uchihashi, Urs Ramsperger

National Institute for Materials Science, 1 - 2 -1, Sengen, Tsukuba, Ibaraki, 305-0047, Japan

The self-assembling technique is ideal to fabricate high-quality metallic nanowires with atomic-scale dimensions on a semiconductor surface. We clarify electron conduction through quasi-one-dimensional (1D) indium atomic chains self-assembled on a silicon surface (the Si(111)-4×1-In reconstruction). Both incomplete structural growth of indium chains at surface steps and intentionally introduced defects in the middle of the chains are found to suppress conduction through the surface reconstruction. The surface conductivity, extracted from the total including the contribution of the subsurface space charge layer, decreases rapidly below 130 K, indicating a metal-insulator transition. The behavior is consistent with the recently found phase transition accompanying structural and electronic modulations. The validity of the Peierls transition picture is discussed based on the temperature dependence of conductivity below T_c.

23DP16 Consistent size dependency of core-level binding energy shifts and single electron tunneling effects in supported gold nanoclusters

Taizo Ohgi, Daisuke Fujita

Nanomaterials Laboratory, Institute for Materials Science, 1-2-1, Sengen, Tsukuba, Ibaraki 305-0047

We report that the kinetic energy shift of the photoelectrons from the supported metal clusters has the origin in chemical potential of a cluster $\mu(-1 \leftrightarrow 0)$ determined by the capacitance between the cluster and substrate. Au deposited ocatnedithiol/Au(111) samples provide homogeneous Au nanoclusters, well defined tunneling barriers and atomically flat substrate, which enables us to compare experimental results with simple physical model and also minimizes the fluctuation of macroscopic data in photoelectron spectroscopy. We examined the prepared samples by photo-electron and tunneling electron spectroscopy independently and found that the results from both spectroscopies show consistent cluster-size dependency in the charging effect of supported metal clusters.

23DP17 Transport and Magnetic Properties of Magnetic Alloy Atom Bridges

Hiroshi Nakanishi[a], Hideaki Kasai[a], Tomoya Kishi[a], Fumio Komori[b], Ayao Okiji[c]

[a]*Department of Applied Physics, Osaka University, Suita, Osaka 565-0871, Japan*
[b]*Institute for Solid State Physics, University of Tokyo, Chiba 277-8587, Japan*
[c]*Wakayama National College of Technology, Gobo, Wakayama 644-0023, Japan*

We have investigated the magnetic properties of the atom bridge made from magnetic materials, which is the atom-scale wire constructed between a scanning tunneling microscopy tip and a solid surface, and how these magnetic properties affect the quantum transport of electrons through the bridge with ab initio calculations. In the case of FeNi alloy bridge, the atom bridge can be designed to have significantly larger magnetic moment than that in the corresponding alloy bulk and to provide the highly spin-polarized electron current through it. At the conference, we report the magnetic properties and the spin-dependent transport properties of various magnetic alloy atom bridges.

Electronic Transport through Benzene Molecule: Effect of Gold Contacts **23DP18**

Amir A. Farajian, Hiroshi Mizuseki, Yoshiyuki Kawazoe

Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

Organic molecules are intriguing possible building blocks for nano-device applications due to their being self-assembled/abundant. In this work, we investigate electronic transport through one of the simplest possible organic molecules, i.e., benzene, which is attached to two Au(111) electrodes via sulfur clips. Ab initio model is used for both the organic molecule and the gold electrodes, by which the total Green's function of the system projected onto the molecule is determined. This will provide us with the transfer function across the benzene molecule, from which the conductance and current-voltage characteristics of the device are deduced. As our model takes into account the atomistic character of the electrodes, it provides a better understanding of the effect of electrodes on the transport properties of the device. The results are compared against the available experimental data.

A New Approach to Cooper Pair Pumping **23DP19**

José Aumentado[a], Mark W. Keller[a], John M. Martinis[a], Cristián Urbina[b]

[a]*National Institue of Standards and Technology, Boulder, CO 80305-3337*
[b]*CEA-Saclay, 91191 Gif-sur-Yvette CEDEX, France*

The ability to pump single electrons in gated arrays of tunnel junctions has already been well established in normal state devices with metrological precision.[1] However, similar attempts to pump Cooper pairs have not been so successful.[2] At NIST we are attempting to modify the Josephson coupling directly at the single and multiple junction levels using environmental resistors. We have shown discrete Cooper pair pumping at zero bias in pumps and are in the process of quantifying the effects of having these resistors present.

[1] M. W. Keller *et al.*, Appl. Phys. Lett. **69**, 1804 (1996)
[2] L.G. Geerligs *et al.*, Z. Phys. B **85**, 349 (1991)

Transport Properties of Quasiparticles in Semiconductor-Superconductor junctions with Magnetic Barrier at Interface **23DP20**

Ben-Yuan Gu[a], Young-Chong Hsue[b], Tzong-Jer Yang[b]

[a]*Institute of Physics, Academia Sinica, P.O. Box 603, Beijing 100080, China*
[b]*Department of Electrophysics, National Chiao Tung University, Hsinchu, 30050, Taiwan*

We present the numerical analyses of conductance of quasiparticles (QP's) in semiconductor-magnetic barrier-superconductor junctions. The total conductance as a function of the magnetic field strongly depends on the normal or superconductor state of the most right material and mismatch of Fermi energy and effective mass of QP's in different materials. It shows that the Andreev reflection plays a critical role. The conductance characteristics can be clearly interpreted by a phenomenological physical picture based on the classical cyclotron orbit of QP's under the magnetic field. We derive the explicit analytic expressions of the conductance and the analytic results coincide with numerical ones very well.

23DP21 General models of Josephson circuits in the presence of linear quantum noise

G. Falci[a], Elisabetta Paladino[b], Fabio Taddei[c], Gaetano Giaquinta[b]

[a]*DMFCI Universitá di Catania, Viale A. Doria 6, 95125 Catania, Italy*
[b]*NEST-INMF & DMFCI, Universitá di Catania, Viale A. Doria 6, 95125 Catania, Italy*
[c]*NEST-INMF, DMFCI Universitá di Catania, Viale A. Doria 6, 95125 Catania, Italy, & ISI, Torino Italy*

Single electron tunneling systems are influenced by noise coming from quantum and thermal fluctuations of the surrounding circuit. The coupling with this environment is usually described in phenomenological terms. We derive effective models by direct transformations of a bath of harmonic oscillators which describes an arbitrary LC line. We derive explicitely couterterms and discuss the Lamb shift induced by the environment, which is important in the multiqubit system dynamics.

23DP23 DC Josephson current through the nanographite ribbon junctions

Katsunori Wakabayashi

Department of Quantum Matter Science, Graduate School of Advanced Sciences of Matter (ADSM), Hiroshima University, Higashi-Hiroshima 739-8526, Japan

The DC Josephson currents through a nano-graphite ribbon sandwiched by two conventional superconductors are theoretically studied by using the thermal Green function techniques based on the tight binding model. It is found that the behavior of the DC Josephson current crucially depends on the electronic states of nano-graphite ribbons. Because the electronic states of nano-graphite ribbons strongly depend on their shapes of edges, it is shown that the temperature, Josephson junction length, and mangetic field dependence of the DC Josephson currents strongly depend on the edge structures of nano-graphite ribbons.

23DP24 Quantum Fluctuations and Dissipative Phase Transition in One-Dimensional Josephson Junction Arrays

Hisao Miyazaki, Takahide Yamaguchi, Akinobu Kanda, Youiti Ootuka

Institute of Physics, University of Tsukuba, 1-1-1 Tennodai, Tsukuba 305-8571, Japan

In small Josephson junction arrays, the charging effect competes with the Josephson effect and makes the superconducting phases of islands fluctuate quantum-mechanically. On the other hand, the dissipation introduced by the resistance shunting the junction suppresses the fluctuation of the phases. We fabricated one-dimensional Josephson junction arrays in which each junction was shunted by an ohmic resistor and measured their transport properties at low temperatures. We observed a clear change of behavior from the insulating to the superconducting one as a function of the Josephson coupling and the shunt resistance, and obtained the phase diagram at $T \to 0$. The SI transition due to dissipation took place at the shunt resistance nearly equal to the quantum resistance $R_{\rm Q}(\simeq 6.5\ {\rm k}\Omega)$ when the Josephson coupling is weak.

Spin relaxation and tunnel magnetoresistance of a ferromagnet/ superconductor / ferromagnet single-electron tunneling transistor **23DP25**

Hiroshi Imamura, Yasuhiro Utsumi, Hiromich Ebisawa

Graduate School of Information Sciences, Tohoku University, Sendai 980-8579, Japan

We theoretically study the tunnel magnetoresistance(TMR) of ferromagnet / superconductor / ferromagnet single-electron tunneling transistors with a special attention to the parity effect. It is shown that in the plateau region, there is no spin accumulation in the island even at finite bias voltage. However, the information of injected spin is carried by an excess electron and thus the TMR exists. The spin relaxation rate of the excess electron can be estimated from the TMR. We also show that the TMR increases with decreasing the size of the superconducting island.

Scalable quantum computing using persistent current qubits with Josephson junctions **23DP26**

Mun Dae Kim, Dongkwan Shin, Jongbae Hong

School of Physics, Seoul National University, Seoul 151-747, Korea

We study quantum logic gates using two persistent current states as a qubit in the superconducting ring with Josephson junction. We use an rf SQUID as a single persistent current qubit. An effective double-well potential, where quantum tunneling is possible, exists in the single qubit. The degeneracy of the two persistent current states is lifted by tunneling. The coupling between qubits is performed by the inductive current connecting qubits. A scalable qubit is constructed by making quantum circuit connecting many qubits in a topologically same way. Switching each qubit is possible by inserting dc SQUID into the line coming out of qubit.

System-Size Dependences and Correlation Effects of Josephson current through One-Dimensional Josephson networks **23DP27**

Takeo Kato

Department of Applied Physics, Osaka City University, 3-3-138 Sugimoto, Sumiyoshi-ku, Osaka, 558-8585, Japan

Josephson junction networks have attracted interest for many years as interacting Boson systems. In order to clarify correlation effects in this system, I discuss Josephson junctions hybridized with an array of superconducting islands. Assuming large on-site Coulomb interactions, a particle number and a Josephson critical current are calculated as functions of voltages of two leads based on a hard-core Boson model, which is equivalent to a spin system with boundary fields. The size-dependences of Josephson current are discussed by studying resonant tunneling peaks in critical currents and phase-dependence of Josephson currents.

23DP29 Numerical study of unconventional superconductor / a quantum dot / unconventional superconductor junction

Koichi Kusakabe[a], Yukio Tanaka[b], Yasunari Tanuma[c]

[a]*Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan*
[b]*Department of Applied Physics, Nagoya University, Nagoya, 464-8603 Japan*
[c]*Graduate School of Natural Science and Technology, Okayama University, Okayama 700-8530, Japan*

We analyze numerically a Josephson junction with a quantum dot which is attached to two d-wave superconductors. Various interfaces including those made from a (100) surface and/or a (110) surface of a d-wave superconductor are considered. The DC Josephson current is evaluated by a quantum Monte Carlo method. Interplay of correlation effects in the dot, *i.e.* the Coulomb blockade and the Kondo effect, and effects from the surface geometry, *i.e.* formation of the zero-energy states, is seen in temperature dependence of the current, which is controlled by the gate voltage on the dot.

23DP30 Quantum dynamics of underdamped current-biased Josephson junctions

O. Buisson[a], F. Balestro[a], J. P. Pekola[b], F. Faure[c], F. W. J. Hekking[c]

[a]*CRTBT-CNRS, 25 Av. des Martyrs, BP 166, 38042 Grenoble Cedex 9, France*
[b]*Department of Physics, University of Jyväskylä, P. O. Box 35, 40351 Jyväskylä, Finland*
[c]*LPM^{2}C-UJF-CNRS, 25 Av. des Martyrs, BP 166, 38042 Grenoble Cedex 9, France*

We have measured escape rate of a current-biased Josephson junction and of a hysteretic DC-SQUID using DC-pulses with duration between 100 ps and 1 ms. For longer pulses, with decreasing temperature, we observe first the thermally activated regime, then the thermally assisted macroscopic quantum tunnelling (MQT) and finally the pure MQT regime. We are currently performing one shot readout quantum measurements using MQT escape with ultra-short pulses on a current-biased DC-SQUID alone or capacitively coupled to a Cooper pair box.

23DP31 Electron tunneling in smal-area junctions

Alexander I. Khachaturov[a], Eiji Hatta[b], Vladimir M. Svistunov[a]

[a]*Donetsk A.Galkin Institute for Physics & Technnology, Academy of Sciences, Donetsk 83114, Ukraine*
[b]*Nanoelectronics Laboratory, Hokkaido University, Sapporo 060-0813, Japan*

Electron tunneling in small-area junctions has been treated. It is found that at appropriate successful sets of barrier parameters and electronic characteristics of electrodes quantization of the latteral component of the wave vector manifests itself in the differential conductance as quite noticeable minima at low temperature. The second derivative of the tunnel current versus applied voltage should contain dictinct periodic structure. The caracteristic feature of the effects is reduced sensetively to thermal smearing. It is pointed out that possibility of manifestation of size-quantum effect should be taken into spectroscopic studies.

Two quantum dots with three-electrons **23DP32**

Lomidze Archil[a], Archil Lomidze[a], Shalva Tsiklauri[b]

[a]*Department of Physics, Tbilisi State University, av.3 Chavchavadze, Tbilisi, 380028, Georgia.*
[b]*Department of Physics, Tbilisi State University, av.3 Chavchavadze, Tbilisi, 380028, Georgia.*

In this work two quantum dots (QD) with three-electron in 2D spaces using the method of hyperspherical functions have been investigated theoretically. To study the total wave function of three-electron QD in 2D spaces first of all we investigate to taken into account by invers square potential between particles. Harmonic oscillator was use as confinement potential. The term of interchanging interaction for two quantum dots with three-electrons has been obtained use the received expression for total wave function.

Tunneling Effects and Electron Transport in Quantum Dot Structures **23DP33**

Lukas Pichl[a], Juri Horacek[b], Vladimir Mitin[c], Victor Ryzhii[a]

[a]*University of Aizu, Aizu-Wakamatsu 966-8580, Japan*
[b]*Charles University Prague, Prague 18000, Czech Republic*
[c]*Wayne State University, Detroit 48202, USA*

We report the development of a theoretical model for low-temperature effects in multiple-array QD structures similar to those used in quantum dot infrared photodetectors. The model takes into account the peculiar features of the electron tunneling from QDs in realistic structures. These features are associated with a flattened (disk-like) shape of QDs resulting in a substantially anisotropic electric-field distribution around each QD that, in turn, leads to the electron tunneling primarily through the QD edges, a strong dependence of the tunneling rate on the QD charge (i.e., the number of electrons residing in the QD), and the character of the transport of unbound electrons limited by the QD space charge.

Scattering Phase Approach for Energy Spectrums in Quantum Dots **23DP34**

Hsiu-Hau Lin, Wei Chen, Tzay-Ming Hong

Department of Physics, National Tsing-Hua University, Hsinchu 300, Taiwan, Republic of China

We present a semiclassical approach to evaluate quantum energy levels in asymmetrical quantum dots and wells, where the analytical solution for Schrödiger equation is not possible. In spatial regions where the potential profile is steep, the wave function is locally solved and gives rise to a momentum-dependent phase correction $\phi(k)$ as shown in the figure. For smooth profiles, the usual WKB approximation works. Combining scattering phases accumulated in both steep and smooth regimes, we arrive at a generalized EBK quantization rule that can be solved algebraically to obtain the energy levels. We present several examples and show that this semiclassical approximation actually works very well, even for low-lying excitations.

23DP35 Broadening of charge state transitions in a single-electron box

Roland Schäfer, Bernhard Limbach, Peter vom Stein, Christoph Wallisser

Forschungszentrum Karlsruhe, Institut für Festkörperphysik, Postfach 3640, 76201 Karlsruhe, Germany

We report on measurements on a sample consisting of two roughly identical single-electron transistors the islands of which are coupled capacitively. One transistor at a time is operated as electron box. The remaining transistor is used as an electrometer to measure the charge on the box gate. While ramping up the box gate voltage transitions between states occur periodically which differs in the charge on the box island by the elementary charge e. This shows up in jumps of the electrometer current. The coupling between the box and the measuring device causes a broadening of the transition width not included in the formulae for an isolated box. This is evident in our data as well as from a thorough analysis of the system in the framework of the sequential tunneling model. The sample is studied in the superconducting as well as in the normal state.

23DP36 Strong tunneling in metallic double island structures

Bernhard Limbach, Peter vom Stein, Christoph Wallisser, Roland Schäfer

Forschungszentrum Karlsruhe, Institut für Festkörperphysik, Postfach 3640, 76201 Karlsruhe, Germany

We report on measurements of metallic single electron tunneling systems in the intermediate and strong tunneling regime ($g \approx 0.1 \ldots 5$ with $g = G/G_K$, $G_K = e^2/h$), where significant deviations from the orthodox theorie can be observed. We studied single and double island structures with variations of the coupling between the islands and the leads, respectively. Our sample designs enable us to determine the conductance of each single tunnel junction, while in common layouts the ratio of conductances remains unknown.
Conductance and DC-current measurements were carried out at varying temperatures and the results are compared to different theoretical predictions (pertubation theory, nonperturbative semiclassical approach, Monte-Carlo simulation).

23DP37 Quantum Interference on Electron Wave Spreading over a Coupled Dot

Nobuyuki Aoki[a], Daisuke Oonishi[a], Yoshikazu Iwase[a], Kohji Ishibashi[b], Jonathan P. Bird[c], David K. Ferry[c], Yuichi Ochiai[a]

[a]*Department of Materials Technology, Chiba University, 1-33 Yayoi, Inage, Chiba 263-8522, Japan*
[b]*Semiconductors Laboratory, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*
[c]*Department of Electrical Engineering, Arizona State University, Tempe, AZ 85287-5706, USA*

The characteristics of the fluctuations, observed in the low-temperature magnetoconductance of an open quantum-dot molecule formed from a pair of split-gate quantum dots have been studied. The evolution of these fluctuations suggests a decrease in the typical area for coherent interference with decreasing the coupling strength between the two dot. We discuss this behavior in terms of a transition from multi- to single-dot interference as a function of the inter-dot coupling. Moreover, an existanve of interference trajectories independent of the dot coupling was also found in our analysis.

A model for ferromagnetic nanograins with discrete electronic states **23DP38**

Silvia Kleff, Jan von Delft

Sektion Physik and Center for NanoScience, Ludwig-Maximilians-Universität, Theresienstr.37, 80333 München, Germany

We discuss a simple phenomenological model [1-3] for an ultrasmall ferromagnetic grain, formulated in terms of the grain's discrete energy levels. We compare the model's predictions with recent measurements of the discrete tunneling spectrum through such a grain [3,4]. The model can qualitatively account for the observed features if we assume (i) that the anisotropy energy varies among different eigenstates of one grain, and (ii) that nonequilibrium spin accumulation occurs.

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