FRONTIERS IN CONDENSED MATTER PHYSICS

International conference in honor of G.M. Eliashberg and V.F Gantmakher

PROGRAM AND ABSTRACTS

October 8-10, 2010 Chernogolovka

CONFERENCE PROGRAM

Friday, October 8

9:00 - 9:05	Opening
9:05 - 9:25	Isaak Khalatnikov. Historical talk
9:30 - 10:10	Herbert Capellmann. Anomalous Rare-Earths (i.p. Cerium) and metallic RE-compounds
10:15 - 10:45	**Coffee-break**
10:45 - 11:25	Vladimir Mineev. Polarization Effects in Superfluid ^{4}He
11:30 - 12:10	Efim Kats. Physics of annealed and quenched copolymers
12:15 - 14:00	**Lunch**
14:00 - 14:40	Yuli Nazarov. Towards Josephson laser
14:45 - 15:25	Ernst Pashitskii. Vortex dynamics in open nonequilibrium systems
15:30 - 16:00	**Coffee break**
16:00 - 16:40	Evgenii Maksimov. Eliashberg and HTSC
16:45 - 17:25	Mikhail Skvortsov. Time-dependent random matrices: Quantum interference effects

Saturday, October 9

9:00 - 9:05	Opening
9:05 - 9:25	Historical talk
9:30 - 10:10	Vadim Gurevich. Two problems of the theory of amorphous systems and their interrelation - Two-level systems and boson peak
10:15 - 10:45	**Coffee-break**
10:45 - 11:25	Leonid Levitov. Nonlocal Transport and Flavor Currents at the Dirac Point in Graphene
11:30 - 12:10	Grigory Volovik. Topological superfluids, superconductors and insulators
12:15 - 14:00	**Lunch**
14:00 - 14:40	Teun Klapwijk. Microwaves and superconductors (for space)
14:45 - 15:25	Andrey Chubukov. Eliashberg theory of spin-fluctuation mechanism of superconductivity
15:30 - 16:00	**Coffee break**
16:00 - 16:40	Alexander Golubov. Application of Eliashberg theory to novel superconductors
16:45 - 17:25	Alexei Byalko On Possible Climatic Instability

Sunday, October 10

9:00 - 9:05	Opening
9:05 - 9:25	Valerii Dolgopolov. Historical talk
9:30 - 10:10	Vladislav Timofeev. Coherence of bose condensate of dipolar excitons in GaAs/AlGaAs heterostructures
10:15 - 10:45	**Coffee-break**
10:45 - 11:25	Sergei Iordanski. Skyrmion lattices and fractional quantum Hall effect
11:30 - 12:10	Valerii Dolgopolov. Some experimental methods and tricks
12:15 - 14:00	**Lunch**
13:15 - 13:55	Mikhail Trunin. Microwave response of multizone and organic superconductors
14:00 - 14:40	Alexei Ioselevich. Hot electron in a disordered wire: distribution of transmission coefficients
14:45 - 15:15	**Coffee break**
15:15 - 15:55	Vadim Khrapai. Shot noise measurements in a wide-channel transistor near pinch-off

ABSTRACTS

Anomalous Rare-Earths (i.p. Cerium) and metallic RE-compounds

Herbert Capellmann

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Just in time for the celebration in honour of Prof. Eliashberg, recent experiments have confirmed claims which Eliashberg and Capellmann made (some 12 years ago) for the the anomalous phase diagram of Cerium, in particular the gamma-alpha phase transition. The consequences for anomalous RE-compounds, usually described as "heavy-fermion"or "Kondo"systems, will be discussed.

Polarization Effects in Superfluid ^{4}He

Vladimir Mineev

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A theory of thermoelectric phenomena in superfluid ^{4}He is developed. It is found an estimation of the dipole moment of each helium atom arising due to electron shell deformation caused by pushing forces from the side of its surrounding atoms in presence of accelerated motion of liquid. In correspondence with the experimental findings made for accelerated relative motion of normal and superfluid components the derived ratio of the amplitudes of temperature and electric polarization potential was proved to be practically temperature independent. Its magnitude is in reasonable correspondence with the observations. The polarity of electric signal is determined by the sign of temperature gradient in accordance with the measurements. The roton excitations dipole moment is also discussed.

Physics of annealed and quenched copolymers

Efim Kats

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The Insitute Laue-Langevin, Grenoble, France

We propose simple mean-field model and perform Monte Carlo simulation of annealed copolymers of solvophobic/solvophilic monomers. Such copolymers show collapsed globular states having dynamic core-shell structures. In these, the core is mostly solvophobic while the core boundary contains an excess of solvophilic monomers. This two-state model, where each monomer undergoes interconversion between solvophilic and solvophobic state, is a minimal version of models of neutral water-soluble polymers. The reduced surface tension of such core-shell structures suggests an explanation of the stability of "protein-like" globules as observed in the experiments. The statistics of monomeric states along the chain vary with degree of chain swelling. They are differ from those of quenched copolymers designed to create water soluble globules, though both systems involve a core-shell structure.

Towards Josephson laser

Yuli Nazarov

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We have recently suggested a Josephson light-emitting diode: a setup involving quantum dot in a semiconductor nanowire where visible light is emitted from a voltage-driven superconducting contact. This initial work indicated a path to realize the long-standing dream: Josephson generation of visible light. The device combines optical coherence

of lasing light with the coherence of the superconducting Cooper pair condensate. Electron transfer between the superconductors results in photon emission into an optical cavity which enables further stimulated emission. At the same time, the light accumulated in the cavity will coherently couple the superconducting electrodes. This provides new opportunities for coherent transfer and manipulation of superconducting and optical phases.

Vortex dynamics in open nonequilibrium systems

Ernst Pashitskii

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Based on a general model of nonlinear vortex dynamics in open thermodynamically nonequilib rium systems with bulk or surface mass losses, an analysis is presented of the mechanism of generation of violent atmospheric vortices (tornadoes, typhoons, cyclones) associated with the formation of deep cloud systems by intense condensation of water vapor from moist air cooled below the dew point. Simple particular solutions to the Navier–Stokes equations are found that describe both axisymmetric and nonaxisymmetric incompressible vortex motions involving radial and vertical flows with viscous dissipation vanishing identically everywhere except for a thin shear layer at the boundary of the condensation region. It is shown that the nonlinear convective and local Coriolis forces generated by radial inflow in the presence of a background vorticity due to a global Coriolis force (the Earth's rotation) accelerate the solid body rotation in the vortex core either exponentially or in a nonlinear regime of finite time blow up. Due to updrafts, such a vortex is characterized by a strong helicity. This mechanism explains a number of observed properties and characteristics of the structure and evolution of tornadoes and typhoons.

Eliashberg and HTSC

Evgenii G. Maksimov

I. E. Tamm Theoretical Department, P.N.Lebedev Physical Institute, Moscow, Russia

We shall discuss experimental evidence related to the structure and origin of the bosonic spectral function $\alpha^2F(\omega)$ in high-temperature superconducting (HTSC) cuprates at and near optimal doping. Global properties of $\alpha^2F(\omega)$, such as number and positions of peaks, are extracted by combining optics, neutron scattering, ARPES and tunnelling measurements. These methods give evidence for strong electron-phonon interaction (EPI) with $1 < \lambda_{ep} \approx 3.5$in cuprates near optimal doping. It will be clarified how these results are in favor of the modified Migdal-Eliashberg (ME) theory for HTSC cuprates near optimal doping.

Time-dependent random matrices: Quantum interference effects

Mikhail Skvortsov

Landau Institute for Theoretical Physics, Russia

It is well established that the energy level statistics in disordered mesoscopic samples is universal and can be described by random matrices of an appropriate symmetry. The random matrix theory studied in great detail provides complete information about the spectral statistics. However, much less is known about time-dependent random matrices, which appear in studying, e.g., a quantum dot subject to a time-dependent gate voltage.

We review recent progress in time-dependent random matrices. On a semiclassical limit, the energy absorption rate can be calculated with the help of the Kubo formula. Quantum phenomena modify this result. We show that there are two type of interference effects. The first effect is controlled by the velocity of the perturbation and is responsible for the transition between Kubo and Landau-Zener regimes of dissipation. The second effect is operative for time-reentrant perturbations when dynamic localization in the energy space may take place. We demonstrate that these

effects can be described on the same footing within the Keldysh sigma-model formalism.

Two problems of the theory of amorphous systems and their interrelation - Two-level systems and boson peak

Vadim Gurevich

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The same physical mechanism is fundamental for such seemingly different phenomena as the formation of the two-level systems in amorphous dielectrics and the Boson peak in the reduced density of low-frequency vibrational states. This mechanism is the vibrational instability of a system of weakly interacting harmonic local vibrations. As a result, two most fundamental properties of amorphous systems are interconnected.

Nonlocal Transport and Flavor Currents at the Dirac Point in Graphene

Leonid Levitov

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While it is believed that many new electronic phenomena remain to be uncovered near the Dirac point (DP) in graphene, much of interesting physics is buried under the standard transport features and inhomogeneity. In this talk we discuss recent measurements of transport properties at DP demonstrating that they are essentially nonlocal and indicating presence of neutral currents associated with spin and valley flavors. This is seen as a giant nonlocal resistance sharply peaked at DP, observed at fields as low as 0.1T and even at room temperature. We attribute the nonlocality to long-range flavor currents arising due to the lifting of spin/valley degeneracy on top of the usual Hall effect. The flavor currents are expected to contribute strongly to all magnetotransport phenomena near the Dirac point.

Topological superfluids, superconductors and insulators

Grigory Volovik

Landau Institute for Theoretical Physics, Russia

We discuss topological invariants describing the ground states (vacua) of condensed matter systems, topological quantum phase transitions between them, and topologically protected gapless fermionic states in the bulk and on the surface.

Microwaves and superconductors (for space)

Teun Klapwijk

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Detection of radiation is one of the most important topics in astronomical instrumentation. In recent years a great deal of attention has gone into the use of superconductors to detect radiation from 100 GHz to 5 THz. This range spans the energy gaps characteristic of the superconducting state leading to different solutions below and above the superconducting gap. In addition in some cases that absorption inside the superconducting material is most important

whereas in other cases the radiation-assisted tunnel-process is used as the critical process. The various processes and practical solutions will be summarized as well as connecting them with the use in the Herschel space telescope or the Atacama Large Millimeter Array.

Eliashberg theory of spin-fluctuation mechanism of superconductivity

Andrey Chubukov

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I review recent developments in the Eliashberg-type approach to superconductivity of itinerant fermions near a magnetic instability. The key idea behind the approach is that Landau-overdamped collective excitations that mediate the pairing are slow modes com- pared to fermions. This makes spin-mediated pairing similar in certain respects to phonon- mediated pairing – vertex corrections and the dependence of the fermionic self-energy on the deviations from k_F can be neglected, and the pairing problem reduces to a set of integral equations over frequency. much like Eliashberg theory for electron-phonon interaction. I consider in more details the pairing near antiferromagnetic instability and show that there exists two regimes on the phase diagram: the low-T regime, in which the pairing involves Fermi-liquid quasiparticles, and the high -T regime, in which the pairing involves incoherent fermions. I argue that Fermi-liquid pairing leads to a true d-wave supercon- ductivity, while the pairing of incoherent fermions produces spin-singlet pairs, which still remain incoherent over some range below the onset of pairing. I discuss various feedbacks from the pairing on both electronic and magnetic properties (e.g., the emergence of the resonance peak), and link spin-fluctuation approach to theories that depart from the Mott insulator/Heisenberg antiferromagnet at half-filling.

Application of Eliashberg theory to novel superconductors

Alexander A. Golubov

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Oleg V. Dolgov

Max-Plank Institute, Stuttgart, Germany

We present multiband extension of Eliashberg theory and applications to novel superconductors. As examples, two classes of new materials are discussed: magnesium diboride and iron pnictides.

Coherence of Bose condensate of dipolar excitons in GaAs/AlGaAs heterostructures

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Spatially indirect, dipolar, excitons photoexcited in quantum wells under electrical bias applied normal to heterolayers constitute a rather promising object for realization of excitonic Bose-Einstein condensation (BEC) [1-7]. When critical conditions for both temperature T and concentration N (or pumping intensity P) are achieved, BEC occurs spontaneously in a reservoir of rather long-lived interacting dipolar excitons collected in a lateral trap [3-7]. BEC is manifested by the abrupt appearance in the luminescence spectrum of a narrow line of dipolar excitons (FWHM at threshold ? 200 μeV) collected in a trap and condensed in the vicinity of $\boldsymbol{k} \approx 0$. This event is accompanied simultaneously by the formation of spatially-symmetric luminescent spot pattern within a perimeter of trap. Spatial pattern structure is directly related with luminescent line of condensed excitons and its visibility is strongly temperature dependent in accordance with found phase diagram. Dipolar exciton condensate accumulated in a ring trap exhibits large-scale spatial coherence confirmed by means of two-beam interference experiments with

the use of cw [4,5] and pulsed photoexcitation [6]. Statistics of photons emitted by exciton Bose-condensate have been studied at condensation threshold. Correlations of luminescence intensity (the 2-d order correlator $g^{(2)}(\tau)$, where τ is delay time between photons in registered photon pairs) under BEC of dipolar excitons have been studied in the temperature range of $(0.45 \div 4.2)$ K. Photon "bunching" has been observed near the Bose condensation threshold. The two-photon correlation function exhibits super-Poissonian distribution, $g^{(2)}(\tau) > 1$, at time scales of system coherence ($\tau < 1$ ns). At excitation pumping well above the threshold, when the narrow line of exciton condensate begins to grow in the luminescence spectrum, the photon bunching is decreasing and finally vanishes with further excitation power increase. In this pumping range, the photon correlation distribution becomes Poissonian reflecting the single quantum state origin of excitonic Bose condensate. Assuming that the luminescence of dipolar excitons collected in lateral trap directly reflects coherent properties of interacting exciton gas, the observed phenomenon of photon bunching nearby condensation threshold – where exciton density and hence luminescence intensity fluctuations are most essential – manifests the phase transition in interacting exciton Bose gas. It can be used as an independent tool for exciton Bose condensation detection.

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[3] A. V. Gorbunov and V. B. Timofeev, JETP Letters 83, 146-151 (2006); ibid 84, 329-334 (2006).
[4] V. B. Timofeev and A. V. Gorbunov, J. Appl. Phys. 101, 081708 (2007).
[5] V. B. Timofeev and A. V. Gorbunov, Phys. Stat. Sol. (c) 5, 2379-2386 (2008).
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Skyrmion lattices and fractional quantum Hall effect

Sergei V. Iordanski

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It is shown that in 2D electron gas the states obtained by projection to the lowest Landau level are unstable due to creation of vortex currents which reduce the thermodynamic energy. Vortex structure depends on the interaction. In the case of strong exchange (ferromagnetic) interaction it can be described as the periodic lattice of skyrmions with each elementary cell corresponding to the sphere of spin directions. The group of translations becomes the group of magnetic translations with additional change of a wave-function phase and a rotation in the spin space. Filling of the corresponding bands yields experimentally observed electron densitities for the fractional quantum Hall effect.

Some experimental methods and tricks

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Experimental methods developed for the investigation of high-mobility two-dimensional electron systems in magnetic fields are reviewed. These include measurements of the local transport, the Hall current pinch, the electron transfer under the Fermi level, the tunnel density of states, and thermodynamic measurements. Problems, advantages, and disadvantages of each method are briefly discussed.

Microwave response of multizone and organic superconductors f

Mikhail R. Trunin

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Results of recent investigations of the temperature dependences of the surface impedance $Z(T) = R(T) + iX(T)$ and microwave conductivity $\sigma(T) = \sigma'(T) - i\sigma''(T)$ in organic κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br and two-band MgB_2, V_3Si_{1-x} and $Ba_{1-x}K_xFe_2As_2$ single crystals are discussed. We have performed accurate measurements of the in-plane surface impedance $Z_{ac}(T) = R_{ac}(T) + iX_{ac}(T)$ on several single crystals of organic superconductor κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br in the temperature range $0.5\,K \leqslant T \leqslant 100\,K$ using a "hot-finger" cavity perturbation technique at a frequency of $28.2\,GHz$. In the normal state we find the temperature dependence of resistivity $\rho_{ac}(T)$. Just above $T_c = 11.5\,K$, we obtain $\rho_{ac}(13K) = 2R_{ac}^2(T)/\omega\mu_0 = 170\,\mu\Omega \cdot cm$ and $\Delta\rho_{ac}(T) \propto AT^5$ for $T_c \leqslant T \leqslant T^\star \approx 45\,K$. At $T > T^\star$ the normal skin-effect condition, $R_{ac}(T) = X_{ac}(T)$, is disturbed, and we observe $X_{ac}(T) > R_{ac}(T)$ due to appearance of the imaginary part of conductivity $\sigma''(T)$ within a smooth crossover from coherent Fermi liquid excitations at $T < T^\star$ to the density wave conditions at higher temperatures. In the superconducting state the in-plane penetration depth $\lambda_{ac}(0) = 0.7\,\mu m$ is determined. The observed linear temperature dependence $\Delta\lambda_{ac}(T) \sim T$ at $T < T_c/3$ indicates d-wave order parameter symmetry in this compound. The temperature dependences of the microwave complex conductivity of MgB_2, V_3Si_{1-x} and $Ba_{1-x}K_xFe_2As_2$ single crystals allowed us to observe a number of peculiarities of two-band superconductors, namely, a nonlinear metallic behavior of resistivity at $T > T_c$, a positive curvature of $\sigma''(T)$ curves close to T_c, and a coherent peak in $\sigma'(T)$ centered at $T \approx T_c/2$.

Hot electron in a disordered wire: distribution of transmission coefficients

Alexei Ioselevich

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We study a penetration of an electron with high energy through strongly disordered wire. Such an electron can loose, but not gain the energy, when hopping from one localized state to another. We have found a distribution function for the transmission coefficient. Its typical value remains exponentially small in the wures length, but with the decrement, reduced compared to the case of direct elastic tunneling: The distribution function has a relatively strong tail in the domain of anomalously high transmissions; the average transmission is controlled by rare configurations of disorder, corresponding to this tail.

Shot noise measurements in a wide-channel transistor near pinch-off

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We study a shot noise of a wide channel gated high-frequency transistor at temperature of 4.2K near pinch-off. In this regime, a transition from the metallic to the insulating state is expected to occur, accompanied by the increase of the partition noise. The dependence of the noise spectral density on current is found to be slightly nonlinear. At low currents, the differential Fano factor is enhanced compared to the universal value 1/3 for metallic diffusive conductors. We explain this result by the effect of thermal fluctuations in a nonlinear regime near pinch-off, without calling for the enhanced partition noise.