1) Interference phenomena in superconductor - ferromagnet hybrids

Alexander Buzdin
University of Bordeaux, France

Abstract: The mismatch of the Fermi surfaces for the electrons with up and down spin orientation in the ferromagnets leads to the oscillatory behavior of the Cooper pairs wave function. In the ballistic regime the Cooper pair phase accumulation depend on its trajectory and the exchange field along it. The critical current of the superconductor-ferromagnet- superconductor Josephson junction results from the phases interference from different trajectory. We demonstrate how such interference may produce the long-ranged singlet proximity effect. The additional spin-orbit interaction provides a mechanism of the non-conventional Josephson junction formation, which may have an arbitrary phase difference in the ground state.

2) Trapping quasiparticles in superconducting qubits

Gianluigi Catelani
"Institute for Theoretical Nanoelectronics, Forschungszentrum Jülich Peter Grünberg Institut, Germany

Abstract: With quality factors of over one million, superconducting qubits are at the threshold for surface code error correction on one hand, and exquisitely sensitive to decoherence mechanisms on the other. Quasiparticles provide an intrinsic decoherence channel, which can however be suppressed by trapping them away from tunnel junctions. After a brief overview of quasiparticle effects, I will discuss how quasiparticles can be trapped in vortices and normal-metal islands. In the latter case, the proximity effect places weak constraints on the trap placement. Trapping provides a viable way of improving the device performance

3) Visualizing out-of-equilibrium superconductivity

Claude Chapelier
Laboratoire de Transport Electronique Quantique et Supraconductivité, CEA, Grenoble, France

Abstract: Highly disordered superconductors are predicted to provide non dissipative high impedances in the microwave domain. This makes them very promising materials for the realization of Kinetic Inductance Detectors (KIDs), an infra-red photon sensor. However, previous attempts to use them in KIDs have been hindered by anomalous electrodynamics which could be attributed to an inhomogeneous superconducting state and trapped quasi-particles. During the talk, I will review the experimental inputs of scanning tunneling spectroscopy in highly disordered superconductors in light of their anomalous behavior at high frequency and I will introduce the critical current scanning microcopy, a new experimental technique developed in the laboratory to probe their out-of-equilibrium properties.

4) Ultrasonic attenuation in a pseudogapped superconductor

A. V. Shtyk,[1,2] **Mikhail V. Feigel'man**[3,4]
[1] Physics Department, Harward University, USA
[2] Moscow Institute of Physics and Technology, Dolgoprudny, Moscow region, Russia
[3] L. D. Landau Institute for Theoretical Physics, Chernogolovka, 142432, Moscow region, Russia
[4] Laboratory for Condensed Matter Physics, Higher School of Economics, Moscow, Russia

Abstract: We develop a theory of ultrasound decay rate $\alpha(\omega, T)$ in a superconductor with a large pseudogap $\Delta_P \gg T_c$. We show that at low temperatures the magnitude of the decay rate $\alpha(\omega, T)$ is determined by collective excitations of the Higgs mode type, with the energy gap $2\Delta \gg \Delta_P$, where Δ is a superconducting gap. At $T \ll T_c$ we find that decay rate $\alpha \propto \exp(-2\Delta/T)$. Thus our results can be used to develop a new method to measure the collective gap Δ in a situation when strong pseudogap is present.
Ref: A. V. Shtyk, M. V. Feigel'man arXiv:1609.01683 (2016).

5) How many quasiparticles can be in a superconductor?

Manuel Houzet
INAC/PHELIQS, CEA Grenoble and Univ. Grenoble Alpes, France

Abstract: Experimentally, the concentration of quasiparticles in gapped superconductors always largely exceeds the equilibrium one at low temperatures. Since these quasiparticles are detrimental for many applications, it is important to understand theoretically the origin of the excess. We demonstrate in detail that the dynamics of quasiparticles localized at spatial fluctuations of the gap edge becomes exponentially slow. This gives rise to the observed excess in the presence of a vanishingly weak non-equilibrium agent.

Ref: A. Bespalov, M Houzet, J. S. Meyer, and Yu. V. Nazarov, PRL **117**, 117002 (2016).

6) Nonlocality and dynamic response of Majorana states in fermionic superfluids

Alexander S. Mel'nikov
Institute for Physics of Microstructures, Russian Academy of Sciences, Russia;
Lobachevsky State University of Nizhny Novgorod, Russia.

Abstract: We suggest a microscopic model describing the nonlocal ac response of a pair of Majorana states in fermionic superfluids beyond the tunneling approximation. The time-dependent perturbations of quasiparticle transport are shown to excite finite period beating of the wavefunction between the distant Majorana states. We propose an experimental test to measure the characteristic time scales of quasiparticle transport through the pair of Majorana states defining, thus, quantitative characteristics of nonlocality known to be a generic feature of Majorana particles.

7) Maxwell's Demons and quantum heat engines in superconducting circuits

Jukka Pekola
Aalto University, Finland

Abstract: I present experiments on superconducting nano-circuits, which test the role of information in thermodynamics. Two types of Maxwell's demons (MD), a Szilard's Engine and an autonomous MD, were realized based on single electrons. Ideally they extract heat and do work equal to kT log(2) per operation cycle, in accordance with the Landauer principle for the cost of erasing a single bit in computation. In our experiments we achieve 75% of this bound per cycle, and the missing efficiency can be quantitatively accounted for by assigning the entropy of mutual information, due to incomplete measurement, on the same footing as other contributions of entropy. In the second part of the talk I present quantum heat engine (refrigerator) based on a superconducting qubit.

8) The magnetic field-induced insulating state in amorphous superconductors

Benjamin Sacepe
Nano-Spectroscopy and Quantum Electronics, NEEL Institute CNRS / UGA, France

Abstract: When a highly disordered superconducting film is subjected to a strong magnetic field it can undergo a transition to an insulating state. In recent years this insulator drew significant interest due to the body of experimental work that indicates that charge carriers in it are localized Cooper-pairs. In this talk we show that, at low temperature (T<0.2K), Cooper-pairs undergoing a localization transition are decoupled from the host-material phonons. This allows us to experimentally investigate an interacting, many-body quantum system of localized Cooper-pairs in a disordered potential.

9) Mode engineering with a one-dimensional superconducting metamaterial

Frank Hekking*, in collaboration with Denis Basko* and Masahiko Taguchi[$]
*Laboratoire de Physique et Modélisation des Milieux Condensés, Université Grenoble Alpes & CNRS, Grenoble – France
$ Theoretical Chemistry Group, University of Kyoto, Kyoto –Japan

Abstract: We propose a way to control the Josephson energy of a single Josephson junction embedded in one-dimensional superconducting metamaterial: an inhomogeneous superconducting loop, made out of a superconducting nanowire or a chain of Josephson junctions. The Josephson energy is renormalized by the electromagnetic modes propagating along the loop. We study the behaviour of the modes as well as of their frequency spectrum when the capacitance and the inductance along the loop are spatially modulated. We show that, depending on the amplitude of the modulation, the renormalized Josephson energy is either larger or smaller than the one found for a homogeneous loop. Using typical experimental parameters for Josepshon junction chains and superconducting nanowires, we conclude that this mode engineering can be achieved with currently available metamaterials.
Reference: Phys. Rev. B 92, 024507 (2015)

10)

Lev Ioffe
, France

Abstract: a

11) Superconductivity suppression in disordered films: 3D vs 2D

Daniil Antonenko, Mikhail Skvortsov

Skolkovo Institute of Science and Technology, Russia;

Moscow Institute of Physics and Technology, Russia;

L. D. Landau Institute for Theoretical Physics, Russia.

Abstract: We revisit the problem of superconductivity suppression in homogeneously disordered thin films. Anderson's theorem stating that the critical temperature is insensitive to the degree of disorder is violated in the vicinity of the Anderson localization transition. For strongly disordered films, the interplay between disorder and interaction effectively suppresses the BCS coupling constant, thereby reducing the critical temperature. For strictly 2D films, superconductivity suppression is coming from large scales (similar to the 2D localization), and summation of the leading logarithms can be performed with the help of Finkelstein's renormalization group. For thicker and sufficiently dirty films, there exists an additional effect originating from small scales (similar to the 3D localization). We calculate the corresponding contribution to the shift of the critical temperature and discuss its importance in the context of experimental situation.

12) A New View of the Superconductor-Insulator Transition

Idan Tamir

Department of Condensed Matter Physics, Weizmann Institute of Science. Israel

Abstract: The insulating phase bordering superconductivity is now believed to be comprised of localized Cooper-pairs termed CPI (Cooper-pair insulator). These CPIs, being a different manifestation of superconductivity, inherit weak electron phonon coupling. I will review some of the resulting phenomena: current instabilities under an

applied bias voltage, non-trivial noise spectral density, transport catastrophe and strong (phonon independent?) insulating behavior.

13) Spin correlation functions and quasiparticle decay

Igor Poboiko,[1,2,3] Mikhail V. Feigel'man[2,3]

[1] Skolkovo Institute of Science and Technology, Russia;

[2] Laboratory for Condensed Matter Physics, Higher School of Economics, Moscow, Russia

[3] L. D. Landau Institute for Theoretical Physics, Russia.

Abstract: We study the decay of bosonic quasiparticles in the one-dimensional anisotropic XXZ spin-1/2 chain. By means of the bosonization approach and Keldysh diagram technique we calculate the damping of excitations with energies much smaller compared to the temperature due to their scattering from thermal excitations, taking into account the non-zero curvature of the excitation spectrum. We also calculate the longitudinal spin-spin correlation function near the «light cone».

14) Fluctuation conductivity in superconducting films at arbitrary disorder strength

Nikolai Stepanov,[1,2,3] M.A. Skvortsov[1,2,3]

[1] Skolkovo Institute of Science and Technology, Russia;

[2] Laboratory for Condensed Matter Physics, Higher School of Economics, Moscow, Russia

[3] L. D. Landau Institute for Theoretical Physics, Russia.

Abstract: We study the effect of superconducting fluctuations on the conductivity of metal films at arbitrary temperatures and impurity scattering rates. Using the standard diagrammatic technique in the Keldysh representation, we obtain the general expression for fluctuation conductivity applicable both for dirty and clean superconductors. We observe that the usual classification in terms of the Aslamazov-Larkin, Maki-Thompson and density-of-states diagrams is to some extent artificial since these contributions produce similar terms, which partially cancel each other. In the diffusive limit, the results are compared with known predictions of early approaches. In the clean case, we demonstrate that the correction does not contain a divergent term $(T\tau)^2$ attributed previously to the DOS-type contribution. The crossover between the diffusive and ballistic regimes is also studied.

15) Admittance of a long diffusive SNS junction

Konstantin Tikhonov

L. D. Landau Institute for Theoretical Physics, Russia

Abstract: The dynamical properties of hybrid normal metal/superconductor structures have recently come into research focus both experimentally and theoretically. Recent experimental studies of the coherent admittance $Y(\omega)$ of SNS rings as function of the phase difference φ are still not fully understood. Here we concentrate on the linear response regime, calculating $Y(\omega)$ by solving Usadel equations, linearised in electric field. Although partially reproducing previously known results, we find qualitatively different behaviour in the collisionless regime of $\tau_{in}^{-1} \ll \omega \ll E_{Th}$ and high temperature $T \gg E_{Th}$ and low temperature $T \ll E_{Th}$ near the minigap closing $\varphi_0 \sim \pi$. We find that the dissipative part Re $Y(\omega)$ peaks when the minigap closes (at a phase difference of π) even at high temperatures, when the equilibrium supercurrent is fully suppressed.

16) Heat transport in a metallic single-electron transistor

Joonas Peltonen

Aalto University, Finland

Abstract: We are investigating experimentally the low-temperature thermal transport in metallic single-electron transistors. We probe the thermal conductance of a normal-conducting transistor using local electron thermometry and temperature control based on normal metal - insulator - superconductor tunnel junctions. I present results from measurements of high-resistance samples where the observations can be compared with sequential tunneling models.