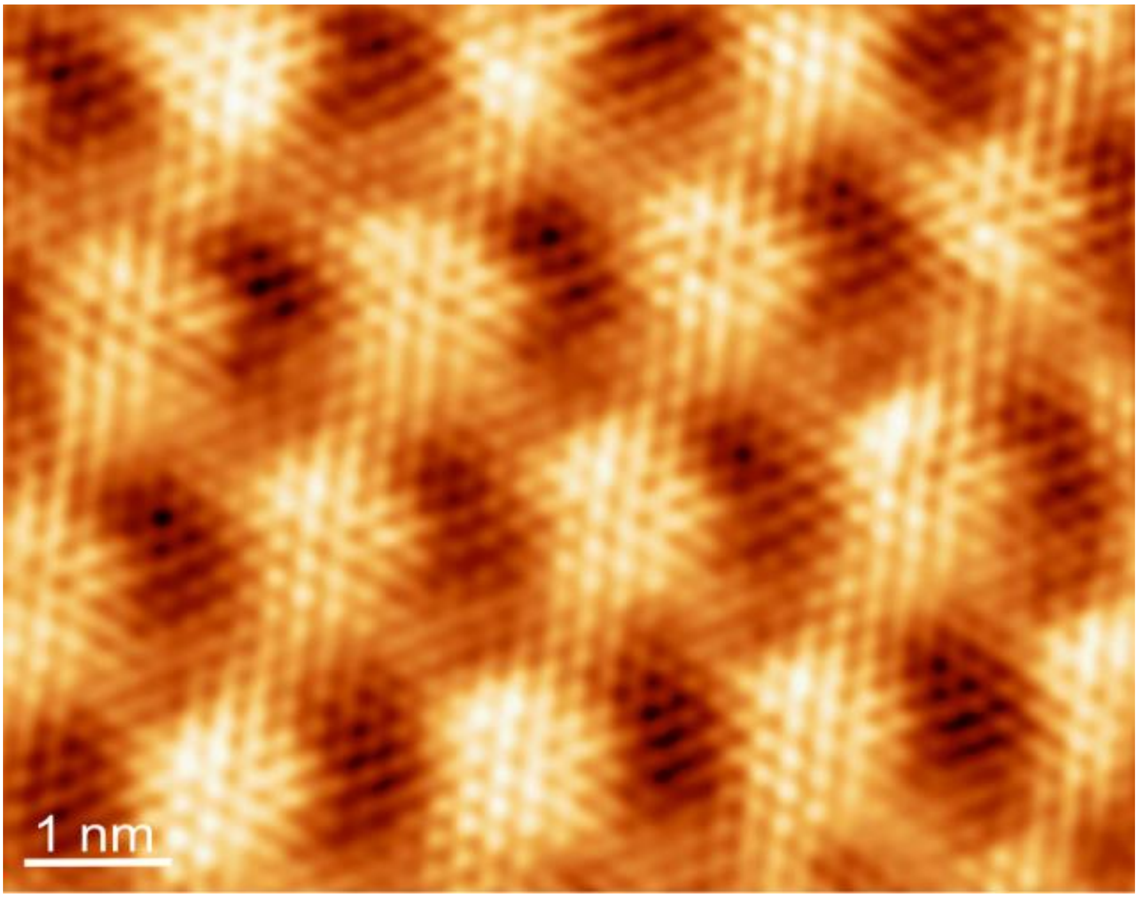
GDR PHYSIQUE QUANTIQUE MESOSCOPIQUE

SESSION PLENIERE 2019

2-5 December 2019 Aussois, France



Scanning Tunneling Micrograph of a Moiré pattern created by graphene on Rhenium, courtesy of C. Tonnoir

Programme :

lundi 2 décembre 2019

HEURES	ÉVÉNEMENT
12:30 - 13:30	Déjeuner
14:00 - 16:00	Supraconductivité et Topologie
14:00 - 14:35	› Real-Space Visualization of Majorana Edge Modes on the Nano-Scale Magnet-Superconductor Hybrid System - *Alexandra Palacio Morales, Université Paris Sud*
14:35 - 15:00	› Two-terminal conductance measurements in Selective Area Grown nanowires - *Gerbold Ménard, Service de physique de l'état condensé, Center for Quantum Devices and Station Q Copenhagen*
15:00 - 15:35	› Spin-Orbit induced phase-shift in Bi2Se3 Josephson junctions - *herve aubin, Centre de Nanosciences et Nanotechnologies*
15:35 - 16:00	› Engineering topological superconductivity with magnetic skyrmions - *Maxime Garnier, Laboratoire de Physique des Solides*
16:00 - 16:30	Pause café
16:30 - 18:20	Contrôle et Information quantique
16:30 - 16:55	› Quantum rifling: protecting a qubit from measurement back-action - *Daniel Szombati, ENS Lyon, University of Queensland*
16:55 - 17:30	› Exponential suppression of bit-flips in a qubit encoded in an oscillator - *Zaki Leghtas, LPENS*
17:30 - 17:55	› Multiplexed photon number measurement of a cavity using the fluorescence of a coupled qubit. - *Antoine Essig, Laboratoire de Physique*
17:55 - 18:20	› Photon detector resolving photon number in a microwave propagating mode - *Rémy Dassonneville, Laboratoire de Physique de lÉNS Lyon*
19:30 - 20:30	Dîner
21:00 - 23:00	Session poster

mardi 3 décembre 2019

HEURES	ÉVÉNEMENT
09:00 - 10:35	Contrôle et Information quantique
09:00 - 09:35	› Phonon-mediated quantum state transfer between remote superconducting qubits and phonon interferometry - *Audrey Bienfait, University of Chicago, Laboratoire de Physique de lÉNS Lyon*
09:35 - 10:10	› Understanding the electrical manipulation of hole spins in silicon - *Yann-Michel Niquet, Interdisciplinary Research Institute of Grenoble, Modeling and Exploration of Materials Laboratory*
10:10 - 10:35	Electronique quantique
10:10 - 10:35	› Single-photon emission mediated by single-electron tunneling in plasmonic nanojunction - *Quentin Schaeverbeke, Donostia International Physics Center - DIPC (SPAIN), Laboratoire Ondes et Matière d'Aquitaine*
10:35 - 11:05	Pause café
11:05 - 12:20	Electronique quantique
11:05 - 11:30	› Transmitting the quantum state of electrons across a metallic island with Coulomb interaction - *Hadrien Duprez, Centre de Nanosciences et de Nanotechnologies*
11:30 - 11:55	› The electron radar - *Pascal Degiovanni, Laboratoire de Physique*
11:55 - 12:20	› Measure of the absorption and emission noises of a non-linear out-of-equilibrium quantum conductor - *Iftikhar Zubair, CEA SPEC*
12:30 - 13:30	Déjeuner
15:00 - 15:35	Electronique quantique
15:00 - 15:35	› Tunneling time probed by quantum shot noise - *Julien Gabelli, Laboratoire de Physique des Solides*
15:35 - 17:00	Graphène
15:35 - 16:00	› Coherent manipulation of the valley in graphene - *Paul Brasseur, CEA saclay/spec*
16:00 - 16:25	› Strain tuning and mobility enhancement by reduction of random strain fluctuations - *Simon Zihlmann, Department of Physics and Astronomy [Basel]*
16:25 - 17:00	› Helical quantum Hall phase in graphene on SrTiO3 - *Benjamin Sacépé, Institut Néel*
17:00 - 17:20	Pause café
17:20 - 19:00	Matière topologique
17:20 - 17:55	› A hydrogen atom reveals the Berry phase of graphene - *C. Dutreix, Université Bordeaux, CNRS, LOMA, UMR 5798, F-33405 Talence, France*
17:55 - 18:20	› Topological pumping: from the Quantized Hall Effect to circuit QED - *David Carpentier, CNRS - Laboratoire de Physique de l'ENS de Lyon*
18:20 - 18:55	› Dynamical conductivity of the Fermi arc and the Volkov-Pankratov states on the surface of Weyl semimetals - *Dibya Mukherjee, Systèmes élastiques : du désordre à la plasticité*
19:30 - 20:30	Dîner
21:00 - 23:00	Posters session

mercredi 4 décembre 2019

HEURES	ÉVÉNEMENT
09:00 - 10:00	Graphène
09:00 - 09:35	› Imaging work and dissipation in the quantum Hall state of graphene - *Arthur Marguerite, Weizmann Institute of Science*
09:35 - 10:00	› Imaging Ballistic and Topological Transport in Graphene/Hexagon Boron Nitride Heterostructures - *Ziwei Dou, Laboratoire de Physique des Solides*
10:00 - 10:30	Pause café
10:30 - 11:30	Supraconductivité mésoscopique
10:30 - 11:05	› Nonadiabatic dynamics in strongly driven diffusive Josephson junctions - *Julien Basset, Laboratoire de Physique des Solides*
11:05 - 11:30	› Dynamically induced 0-Pi transition in a carbon nanotube-based Josephson junction - *diana watfa, Laboratoire de Physique des Solides*
11:30 - 12:20	Matière topologique
11:30 - 11:55	› Topological phases of polaritons in a cavity waveguide - *Guillaume Weick, Institut de Physique et Chimie des Matériaux de Strasbourg*
11:55 - 12:20	› Quantised Fermi-arc-mediated transport in Weyl semimetal nanowires - *Vardan Kaladzhyan, Royal Institute of Technology [Stockholm]*
12:30 - 13:30	Déjeuner
14:30 - 16:20	Supraconductivité mésoscopique
14:30 - 15:05	› Multi-gap superconductivity in LaAlO3/SrTiO3 interfaces - *Nicolas Bergeal, Laboratoire de Physique et dÉtude des Matériaux*
15:05 - 15:30	› Superconductor-insulator transition in Josephson junction chains by Quantum Monte-Carlo - *Denis Basko, Laboratoire de physique et modélisation des milieux condensés*
15:30 - 15:55	› Modulation of superconducting nanowires critical current driven by tunneling quasiparticle injection - *Thomas Jalabert, CEA-IRIG-PHELIQS*
15:55 - 16:20	› Photonic heat flow modulation using charge quantization - *Olivier Maillet, PICO group, Low Temperature Laboratory, Aalto University*

Abstracts by alphabetic order

Spin-charge relaxation in a Silicon MOS transistor

Agostino Aprà * [1], Alessandro Crippa [1], Marco Tagliaferri [1], Rami Ezzouch *

[1], Simon Zihlmann *

[1], Nicolas Piot *

[1], Iulian Matei [1], Louis Hutin [1], Maude Vinet [1], Xavier Jehl *

[1], Romain Maurand *

[1], Silvano De Franceschi *

1

[1] CEA – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble – France

Silicon spin qubits have recently emerged as a concrete option for the development of scalable quantum processors. They combine long spin coherence times (many ms) to a well-established technology, capable of delivering very large scale device integration. We will present our recent progress on a n-type silicon device based on silicon-on-insulator (SOI) technology. Our devices are realized in the 300mm fab-line of LETI. The multi-gate transistor we are currently studying has six gates, 3 on each side of an undoped channel. Using the two middle gates in accumulation, we create a double quantum dot (DQD) in the channel. Using one of the remaining gates we also accumulate a third dot coupled to a reservoir and capacitively coupled to the central double dot. The third dot acts as a charge detector and is read-out via a gate dispersive technic. Tuning the DQD in a Pauli spin blockade regime we measured a spin relaxation time between 100us and few ms depending on the external magnetic field. Our next goal is to demonstrate the coherent control of an electron spin via an electric dipole spin resonance.

Keywords: Spin, Gate reflectomery, Silicon, qubit

*Speaker

Superconductor-insulator transition in Josephson junction chains by Quantum Monte-Carlo

Denis Basko * [1], Markus Holzmann , Petr Adamus , Frederik Pfeiffer

[1] Laboratoire de physique et modélisation des milieux condensés (LPMMC) – CNRS : UMR5493, Université Joseph Fourier - Grenoble I – Maison des Magistères/CNRS 25 Av des martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

We study the zero-temperature phase diagram of a clean dissipationless Josephson junction chain. Namely, we determine the critical Josephson energy below which the chain becomes insulating, as a function of the ratio of two capacitances: the capacitance of each Josephson junction and the capacitance between each superconducting island and the ground. We use the imaginary-time path integral Quantum Monte-Carlo algorithm in the charge representation, which enables us to efficiently handle the electrostatic part of the chain Hamiltonian. We find that the large part of the phase diagram is determined by corrections which are subleading to the standard Kosterlitz-Thouless scaling.

Keywords: Josepson junctions, superconductor, insulator transition, quantum Monte, Carlo

*Speaker

Nonadiabatic dynamics in strongly driven diffusive Josephson junctions

Julien Basset * [1], Marko Kuzmanovic [2], Pauli Virtanen [3], Tero Heikkilä [4], Jerome Esteve [5], Julien Gabelli [6], Christoph Strunk , Marco Aprili

[1] Laboratoire de Physique des Solides (LPS) – CNRS : UMR8502, Université Paris Sud - Paris XI – Université Paris-Sud, Laboratoire de Physique des Solides 91405 Orsay, France
[2] Laboratoire de Physique des Solides (LPS) – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – Bat. 510 91405 Orsay cedex, France
[3] University of Jyväskylä – Department of Physics and Nanoscience Center, P.O. Box 35 (YFL) University of Jyväskylä, Finland, Finland
[4] University of Jyväskylä – Finland
[5] Laboratoire Kastler Brossel (LKB (Lhomond)) – Université Pierre et Marie Curie (UPMC) - Paris VI, CNRS : UMR8552, École normale supérieure [ENS] - Paris, Université Pierre et Marie Curie [UPMC] - Paris VI – 24 rue Lhomond, F-75231 Paris CEDEX 05, France
[6] Laboratoire de Physique des Solides (LPS) – CNRS : UMR8502, Université Paris XI - Paris Sud – Bat. 510 91405 Orsay cedex, France

By measuring the Josephson emission of a diffusive superconductor–normal metal–superconductor (SNS) junction we access the harmonic content of the current-phase relation (CPR). We experimentally identify a nonadiabatic regime in which the CPR is modified by high frequency microwave irradiation. This observation is explained by the excitation of quasiparticles in the normal wire induced by the electromagnetic field. The distortion of the CPR originates from the phase-dependent out-of-equilibrium distribution function which is strongly affected by the ac response of the spectral supercurrent. For a phase difference approaching π, transitions across the minigap are dynamically favored, leading to a supercurrent reduction. This finding is supported by a comparison with the quasiclassical Green's function theory of superconductivity in diffusive SNS junctions under microwave irradiation.

Keywords: Josephson junction, microwaves

*Speaker

Multi-gap superconductivity in LaAlO3/SrTiO3 interfaces

Nicolas Bergeal * [1]

[1] Laboratoire de Physique et dÉtude des Matériaux – Université Pierre et Marie Curie - Paris 6, ESPCI ParisTech, Centre National de la Recherche Scientifique : UMR8213 – France

The achievement of high-quality epitaxial interfaces involving transition metal oxides gives a unique opportunity to engineer artificial materials where new electronic phases take place. The discovery of a high mobility two-dimensional electron gas (2-DEG) confined in a quantum well at the interface between two insulating oxides such as LaAlO3 and SrTiO3, is probably one of the most prominent examples in the field. Unlike more conventional semiconductor based quantum wells, conducting electrons in SrTiO3fill 3d-bands, which gives a favourable ground for the emergence of complex electronic phases. In particular, 2D superconductivity and strong spin orbit coupling have been reported in such interfaces. A key feature of these electronic systems lies in the possibility to control their carrier density by electric field effect. In this talk, I will present recent resonant microwave transport measurements on (110) oriented interfaces that allows extracting the superfluid stiffness Js, i.e. the energy scale that controls the phase rigidity of the superconducting condensate. We evidence a transition from single-condensate to two-condensate superconductivity driven by continuous and reversible electrostatic doping, which we relate to the Lifshitz transition between 3d bands in the quantum well. We find that the superconducting gap is suppressed while the second band is populated, challenging Bardeen–Cooper–Schrieffer theory. We ascribe this behaviour to the existence of superconducting order parameters with opposite signs in the two condensates due to repulsive coupling.

Keywords: supraconductivity, oxide interfaces, superconducting stiffness

*Speaker

Phonon-mediated quantum state transfer between remote superconducting qubits and phonon interferometry

Audrey Bienfait * [1,2], Kevin Satzinger [3,4], Youpeng Zhong [1], Hung-Shen Chang [1], Ming-Han Chou [4], Christopher Conner [1], Etienne Dumur [1], Joel Grebel [4], Gregory Peairs [3,1], Rhys Povey [1], Andrew Cleland [1]

[1] University of Chicago (University of Chicago) – PME 5640 S Ellis Ave Chicago IL 60615, United States

[2] Laboratoire de Physique de lÉNS Lyon (Phys-ENS) – École Normale Supérieure - Lyon, Université Claude Bernard Lyon 1, Centre National de la Recherche Scientifique : UMR5672 – 46 allée dÍtalie 69007 Lyon, France

[3] Physics Department [Santa Barbara] – University of California, Broida Hall, Santa Barbara, CA 93106-9530 USA, United States

[4] University of Chicago (University of Chicago) – IME 5646 S Ellis Ave Rm 235 Chicago IL 60615, United States

Superconducting qubits are providing very interesting opportunities for building hybrid quantum systems, by linking these high-performance microwave frequency electrical devices to other quantum systems. One compelling opportunity is provided by the ability to couple superconducting qubits to acoustically-active structures, which can potentially serve to connect these qubits to other two-level systems or to optical signals, as well as manipulate and detect phonons. Among possible acoustic structures, surface acoustic waves (SAWs) devices have gathered a strong interest. Several groups have reported the coherent coupling of standing SAWs modes to superconducting qubits [1-4], opening the door to the control and detection of localized quantum phonon states as well as measurement of their Wigner function [5]. In this talk, I will describe our progress in using individual itinerant SAW phonons to couple superconducting qubits. The experimental device comprises a 2-mm-long SAW resonator coupled to two qubits. The resonator operates at 4 GHz and has a 500 ns phonon bounce time, allowing the release and recapture of individual itinerant photons into the resonator as well as the acoustic transfer of quantum states between the two superconducting qubits. We also implement a simple phonon interferometry experiment. [1] M. V. Gustafsson, et al, Science, 346, 207-211, 2014

R. Manenti, et al, Phys. Rev. B, 93, 041411, 2016

B. A. Moores, Phys. Rev. Lett., 120, 227701, 2018

A. N. Bolgar, et al, Phys. Rev. Lett., 120, 223603, 2018

K. J. Satzinger, et al, Nature, 563, 7733, 2018

Keywords: superconducting qubits, phonons, surface acoustic waves

*Speaker

Coherent manipulation of the valley in graphene

Paul Brasseur * [1]

[1] CEA saclay/spec – Université Paris Sud - Paris XI – France

Showing coherent manipulation in solid state electronic devices is an outstanding challenge for quantum information purposes. If the mainstream approach has focused on the quantum operation of localized two levels system (spin qubit, superconducting qubit), a promising and alternative approach would be to manipulate the qubit while its propagation forming the so-called flying qubit. If manipulating photons flying qubits in the vacuum would be, at first glance, a natural choice due to their long coherence length, electronic devices , because of their small size, have the tremendous advantage of the scalability. So far, charge flying qubit, where the information is encoded into the position, has been mainly studied and coherence time is too small to envision reliable two qubit gates. Recently, the possibility to encode the qubit into the valley bit in two-dimensional layered materials has generated a lot of interest. In particular, it has been shown that valley degeneracy was lifted in graphene in a strong magnetic field (few tesla). A necessary condition to show the feasibility of valleytronics devices would be to address and coherently manipulate individual valley. In this experiment based on a pn junction in the quantum hall regime, we demonstrate that we can adress indivudally and coherently manipulate the valley pseudospin.

Keywords: graphene, valley, coherence, pn junction

*Speaker

Topological pumping: from the Quantized Hall Effect to circuit QED

David Carpentier * [1]

[1] CNRS - Laboratoire de Physique de l'ENS de Lyon (Phys-ENS) – CNRS : UMR5672, École Normale Supérieure (ENS) - Lyon – 46 allée d'Italie 69007 Lyon, France

In this presentation, I focus on transport of a quantum system of topological origin. I show how the quantized hall effect, the current through a Thouless pump and a frequency Floquet converter can be treated within the same formalism. This allows to propose new designs to detect topological transport in circuit QED. Finally, I discuss the situation of a topological pendulum realized when considering a closed topological quantum circuit.

Keywords: Topological Matter, Transport, Quantum circuit

*Speaker

Tunnelling spectroscopy of the graphene quantum Hall topological insulator

Alexis Coissard * [1], Louis Veyrat [1], Herve Courtois [2], Hermann Sellier [3], Benjamin Sacépé† [3]

[1] Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel – Institut Néel, CNRS, Univ. Grenoble Alpes – 38000 Grenoble, France, France
[2] Université Grenoble Alpes – Université Grenoble Alpes – France
[3] Institut Néel (NEEL) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

Charge neutral graphene develops a quantum Hall topological insulator phase when the Coulomb potential is screened by a high-k dielectric environment. This phase features spin-filtered helical edge channels and exhibits the quantum spin Hall effect, which are of high interest for spintronics and topological superconductivity. The topological gap that opens in the bulk of this quantum Hall topological insulator cannot, however, be quantitatively measured by transport measurements. In this work we present STM spectroscopy performed on high-mobility graphene devices with a home-made hybrid AFM-STM operating at 4K and up to 14T. Using SrTiO3 high-k dielectric as a substrate, we screen the long-range Coulomb interaction to induce the quantum Hall topological insulator phase in the zeroth Landau level of graphene. We carry out high-resolution Landau level spectroscopy in the bulk graphene. Tuning the charge carrier density with a back-gate enables us to unveil the pinning of Fermi level in the Landau levels, a key phenomenon in the quantum Hall physics that indicates the high quality of our sample. When the Fermi level fills the zeroth Landau level, we observe the opening of the ferromagnetic gap resulting from the Stoner instability. This gap is found to be in good agreement with the Coulomb energy scale that takes into account the screening dielectric environment.

Keywords: Graphene / Tunnelling spectroscopy / Quantum spin Hall / Quantum Hall topological insulator

*Speaker
†Corresponding author: benjamin.sacepe@grenoble.cnrs.fr

Photon detector resolving photon number in a microwave propagating mode

Rémy Dassonneville *† [1], Théau Peronnin [1], Réouven Assouly [1], Antoine Essig [1], Jeremy Stevens [1], Daniel Szombati [1], Benjamin Huard [1]

[1] Laboratoire de Physique de lÉNS Lyon – École Normale Supérieure - Lyon, Université Claude Bernard Lyon 1, Centre National de la Recherche Scientifique : UMR5672 – France

Photon detection is a key element in the emerging quantum technologies such as sensing, communication, and computing. However, in the microwave domain, it is challenging to detect a single photon due to its low energy. The detection of itinerant single microwave photons has been demonstrated only recently [1-3]. However, a detector that can resolve the number of photons in a propagating mode is still missing. Here we propose and realize a detector that can count the number of photons of a propagating microwave wave packet, without destroying them. This detector implements a three-step protocol. In the first step, we catch the itinerant wave packet and store it inside a high-Q resonator used as a memory. Then, with an optimal sequence of binary questions, we single-shot count the memory photon number, thanks to its dispersive interaction to a transmon qubit. Finally, we release the stored wave packet back into the transmission line.The sample used [4] consists of a Josephson Parametric Converter (JPC) with a low-Q (buffer) and a high-Q (memory) modes where the memory is dispersively coupled to a transmon qubit, which in turn is dispersively coupled to a readout resonator. By an adapted modulation of the JPC 3-wave mixing term, arbitrary incoming wave packets on the buffer can be caught and stored in the memory with a very high efficiency .To count, we non-destructively transfer the information on the photon number into the state of the qubit which is then read out with a 97% single-shot fidelity in 350 ns. One qubit readout thus contains one bit of information on the photon number. With several questions, one can thus pinpoint the photon number. The cornerstone is then the ability to count -ask several questions- in a timescale short compared to the memory lifetime of 4 . Finally, using the same JPC 3-wave mixing term, the memory photons are released into the buffer which quickly leaks into the transmission line. [1] Kono et al, Nature Physics, (2018), [2] Besse et al, Phys. Rev. X (2018), [3] Lescanne et al, arXiv: 1902.05102 [4] Peronnin et al, arXiv:1904.04635

Keywords: itinerant microwave photon, photon counter, Josephson junction, Josephson parametric converter

*Speaker

†Corresponding author: remy.dassonneville@ens-lyon.fr

Electron quantum optics in superconducting junctions using levitons

Anthony David * [1,2]

[1] Laboratoire PHotonique ELectronique et Ingénierie QuantiqueS (PHELIQS) – Commissariat à l'énergie atomique et aux énergies alternatives : DRF/IRIG/DEPHY/PHELIQS/GT – 17 Avenue des Martyrs, 38000 Grenoble, France
[2] Centre de Physique Théorique - UMR 7332 (CPT) – Aix Marseille Université : UMR7332, Centre National de la Recherche Scientifique : UMR7332 – Campus de Luminy, Case 907163 Avenue de Luminy, 13288 Marseille cedex 9, France

Quantum electronic transport in a junction between a normal metal and a BCS superconductor connected to a voltage lower than the superconducting gap is dominated by the Andreev reflexion. In this work we studied the Andreev reflection by applying a potential to the junction that is composed by a constant (dc) signal and a periodic (ac) signal in order to send to the sample the electrons "one by one" in the philosophy of electron quantum optics. Here the periodic voltage has a Lorentzian temporal shape that allows the study of the transport of minimal electronic excitations: an electron that propagates directly above the Fermi level without accompanying undesirable electron-hole pairs. This type of excitation is called Leviton, named after Levitov who predicted it in normal and semiconducting metals in the 90s. The aim of this work is then to extend this minimal-excitation concept to systems with strong correlations namely superconductors.

Keywords: Quantum transport, Andreev reflection, Levitons, Electron Quantum optics

*Speaker

High kinetic inductance microwave resonators made by He-Beam assisted deposition of tungsten nanowires

Richard Deblock * [1]

[1] Laboratoire de Physique des Solides (LPS) – CNRS : UMR8502 – Université Paris-Sud, Laboratoire de Physique des Solides 91405 Orsay, France

J. Basset, D. Watfa, G. Aiello, M. Fechant, A. Morvan, J. Estève, J. Gabelli, M. Aprili, R. Weil, A. Kasumov, H. Bouchiat, and R. Deblock
We evaluate the performance of hybrid microwave resonators made by combining sputtered Nb thin films with Tungsten nanowires grown with a He-beam induced deposition technique. Depending on growth conditions, the nanowires have a typical width between 35 and 75 nm and thickness between 5 et 40 nm. We observe a high normal state resistance which together with a critical temperature Tc=5K ensures a high kinetic inductance making the resonator strongly nonlinear. Both lumped and coplanar waveguide resonators were fabricated and measured at low temperature exhibiting internal quality factors up to 3990 at 4.5 GHz in the few photon regime. Analyzing the wire length, temperature, and microwave power dependence, we extracted a kinetic inductance for the W nanowire of LK=15 pH per square, which is 250 times higher than the geometrical inductance, and a Kerr non-linearity as high as 200 Hz per photon at 4.5 GHz. The nanowires made with the helium focused ion beam are thus versatile objects to engineer compact,high impedance, superconducting environments with a mask and resist free direct write process.
Reference : Appl. Phys. Lett. 114, 102601 (2019).

Keywords: superconductivité, kinetic inductance, quantum engineering

*Speaker

The electron radar

Hubert Souquet-Basiège [1], Gwendal Feve [2], Benjamin Roussel* [3], Pascal Degiovanni † [4]

[1] Laboratoire de Physique (LP ENSL) – École Normale Supérieure - Lyon, Centre National de la Recherche Scientifique : UMR5672, Université Claude Bernard - Lyon I – 46 allée d'Italie, 69007 Lyon, France, France
[2] Laboratoire Pierre Aigrain (LPA) – CNRS : UMR8551, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Paris VII - Paris Diderot, Ecole Normale Supérieure de Paris - ENS Paris – Département de Physique Ecole Normale Supérieure 24, rue Lhomond F-75231 Paris Cedex 05, France
[3] Advanced Concept Team - European Space Agency (ACT) – Advanced Concepts Team TEC-SF, ESTEC Keplerlaan 1 2201 AZ Noordwijk, Netherlands
[4] Laboratoire de Physique – CNRS : UMR5672, Ecole Normale Supérieure de Lyon – France

Inspired by the classical radar theory from the 50s, I will discuss how single to few electron interferometry can be used to probe the electromagnetic field generated by a mesoscopic device on sub-nanosecond time scale. I will show how concepts from signal processing can be adapted to electron quantum optics to obtain the propert framework for discussing the electron radar theory. In particular, the electronic ambiguity function that characterizes the time/frequency resolution of such an electron radar will be introduced and specific examples discussed.

Keywords: electron quantum optics, interferometry, quantum sensing

*Corresponding author: benjamin.roussel@esa.int
†Speaker

Imaging Ballistic and Topological Transport in Graphene/Hexagon Boron Nitride Heterostructures

Ziwei Dou * [1]

[1] Laboratoire de Physique des Solides (LPS) – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – Bat. 510 91405 Orsay cedex, France

By stacking graphene on hexagonal boron nitride, the charge mobility of the graphene is greatly enhanced, with the mean free path reaching micrometer size. Also, by aligning graphene and boron nitride crystals with a small twisted angle, a moiré superlattice can be formed which breaks sublattice symmetry, opens an energy gap at the Dirac point, and introduces non-zero Berry curvature in the momentum space. As a result, the mesoscopic devices based on such heterostructures host a wide range of ballistic and topological transport phenomena. Scanning gate microscopy utilizes the metallic tip of the atomic force microscope as a moveable gate to the device, which locally changes the Hartree potential and modifies the transport signals of the devices. The spatial distribution of the transport current can thus be imaged. This work, by imaging the ballistic trajectories as well as a transition from bulk to edge conduction near the Dirac point of the graphene/boron nitride heterostructures, showcases how scanning gate microscopy can offer further insight into the mechanisms of the ballistic and topological transport in 2D materials.

Keywords: Graphene/boron nitride heterostructures, Ballistic and topological transport, Scanning gate microscopy

*Speaker

Transmitting the quantum state of electrons across a metallic island with Coulomb interaction

Hadrien Duprez *† [1], Emile Sivre [1], Anne Anthore [1], Abdelhanin Aassime [1], Antonella Cavanna [1], Ulf Gennser [1], Frederic Pierre‡ [1]

[1] Centre de Nanosciences et de Nanotechnologies (C2N) – CNRS, Université Paris Sud, Université Paris Saclay – 10 boulevard Thomas Gobert, 91120 Palaiseau, France

Interactions are generally detrimental to quantum coherence. As an illustration, inelastic collisions of electrons in a metal destroy their coherence. For this reason, a metallic island with floating voltage is usually seen as a practical implementation of a dephasing probe [1,2]. In contradiction with this picture, it is predicted that when a metallic island with a *large* charging energy relative to other energy scales inserted along a *single* electronic channel, the quantum coherence of electrons transmitted across it should be entirely preserved [3,4] (see also [5]). I will present the experimental observation of this phenomenon, using an electronic Mach-Zehnder interferometer in the quantum Hall regime to characterize the coherence [6]. Inserting a metallic island along one of the interferometer's paths results in quantum interferences of the same 90% visibility as in the island's absence, whereas the periodicities upon sweeping a gate voltage and the magnetic field are modified. In contrast, connecting a second channel to the island suppresses the interferences. In our system, due to quantum Hall chirality, the injection and emission points of the channel are spatially separated at the island's interface. The preserved coherence therefore corresponds to a non-local transmission of the electrons' quantum state. This was coined 'electron teleportation' in the similar Majorana/Coulomb based phenomenon proposed in [7]. [1] Büttiker, *IBM J. Res. Develop.* **32**, 63 (1988) [2] Roulleau, Portier, Roche, Cavanna, Faini, Gennser, Mailly, *PRL* **102**, 236802 (2009) [3] Clerk, Brouwer & Ambegaokar, *PRL* **87**, 186801 (2001) [4] Idrisov, Levkivskyi & Sukhorukov, *PRL* **121**, 026802 (2018) [5] Lee, Lee & Sim, *PRB* **86**, 235444 (2012) [6] Duprez, Sivre, Anthore, Aassime, Cavanna, Gennser & Pierre, arXiv:1902.07569, to be published in *Science* (2019) [7] Fu, *PRL* **104**, 056402 (2010)

Keywords: Coulomb interaction, quantum coherence, Mach Zehnder

*Speaker
†Corresponding author: hadrien.duprez@c2n.upsaclay.fr
‡Corresponding author: frederic.pierre@c2n.upsaclay.fr

A hydrogen atom reveals the Berry phase of graphene

C. Dutreix * [1], H. González-Herrero [2], I. Brihuega [2], M. I. Katsnelson [3], C. Chapelier [4], V. T. Renard [4]

[1] Université Bordeaux, CNRS, LOMA, UMR 5798, F-33405 Talence, France – Université de Bordeaux, CNRS : UMR5798 – France
[2] Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain – Spain
[3] Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands – Netherlands
[4] Université Grenoble Alpes, CEA, IRIG, PHELIQS, Grenoble, France – CEA INAC - PHELIQS – France

Various experimental techniques can measure the spectral properties of the electrons in materials, but only a few evidence the topological properties of the electronic wave functions. In graphene, the massless relativistic behavior of the electrons relies on a topological phase singularity of the wave functions at the Dirac points. Probing this electronic behavior traditionally requires an external magnetic field to measure the Berry phase picked up by the wave functions orbiting around a Dirac point [1]. I will present a complementary approach to evidence the Berry phase of graphene in the absence of a magnetic field, with a scanning tunneling microscope. I will show that the phase singularity of the wave functions can be imaged directly in real space, in the way the charge density reorganizes around a hydrogen adatom, through a phenomenon ubiquitous for classical waves but commonly believed unobservable in quantum mechanics so far [2].

K. S. Novoselov, et al., Nature 438, 197 (2005); Y. Zhang, et al., Nature 438, 201 (2005); D. Xiao, et al., RMP 82, 1959 (2010)

C. Dutreix, H. González-Herrero, I. Brihuega, M. I. Katsnelson, C. Chapelier & V. T. Renard, Nature 574, 219 (2019)

Keywords: graphene, Berry phase, wavefront dislocation, scanning tunnelling microscopy

*Speaker

Normal and superconducting transport through helical edge channels in the quantun Hall topological insulator phase of graphene.

Corentin Déprez *† [1], Louis Veyrat [1], Hadrien Vignaud [1], Alexis Coissard [1], Hermann Sellier [1], Benjamin Sacépé‡ [1]

[1] Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel – Institut Néel, CNRS, Univ. Grenoble Alpes – 38000 Grenoble, France, France

The ground state of charge neutral graphene in the quantum Hall regime was predicted to be a topological insulator with a ferromagnetic order and spin-filtered, helical edge channels. [1,2] Experimentally, this phase is rarely observed because lattice-scale anisotropies favor other insulating ground states with gapped edge excitations. [3,4] Using a SrTiO3 high-k dielectric substrate that screens Coulomb interactions in the graphene, we managed to promote the ferromagnetic phase at charge neutrality for magnetic fields as low as 1 T. We studied the transport properties of this phase and observed evidence for helical edge transport which features an inelastic backscatering length of 1.2 μm at 110K. [5] With the use of superconducting electrodes that withstand high magnetic field, we also induced superconducting proximity effect and observed a supercurrent flowing through the helical edge channels. This new and versatile graphene platform opens new avenues for topological superconductivity. [1] D. A. Abanin, P. A. Lee, and L. S. Levitov, "Spin-Filtered Edge States and Quantum Hall Effect in Graphene," Phys.Rev. Lett. 96, 176803 (2006). [2] M. Kharitonov, S. Juergens, and B. Trauzettel, "Interplay of topology and interactions in quantum Hall topological insulators: U(1) symmetry, tunable Luttinger liquid, and interaction-induced phase transitions," Phys. Rev. B 94,035146 (2016) [3] A. F Young, C. R Dean, L. Wang, H. Ren, P. Cadden-Zimansky, K. Watanabe, T. Taniguchi, J. Hone, K. L. Shepard, and P. Kim, "Spin and valley quantum Hall ferromagnetism in graphene," Nature Physics 8, 550–556(2012). [4] M. Kharitonov, "Phase diagram for the nu= 0 quantum Hall state in monolayer graphene," Phys. Rev. B 85,155439 (2012). [5] L. Veyrat, C. Déprez, A.Coissard, X. Li, F. Gay, K. Watanabe, T. Taniguchi, Z. V. Han, B. A. Piot, H. Sellier, B. Sacépé, "Helical qantum Hall phase in graphene on SrTiO3" arXiv:1907.02299 (2019)

Keywords: graphene, Quantum Hall effect, helical edge state

*Speaker

†Corresponding author: corentin.deprez@neel.cnrs.fr

‡Corresponding author: benjamin.sacepe@neel.cnrs.fr

Multiplexed photon number measurement of a cavity using the fluorescence of a coupled qubit.

Antoine Essig *† [1], Quentin Ficheux [1], Théau Peronnin [1], Nathanael Cottet [1], Raphaël Lescanne [2], Alain Sarlette [3,4], Pierre Rouchon [3,4], Zaki Leghtas [2,3,4], Benjamin Huard‡ [1]

[1] Laboratoire de Physique – Université de Lyon, ENS de Lyon, Université Claude Bernard - Lyon I, CNRS : UMR5672 – F-69342 Lyon, France

[2] Laboratoire Pierre Aigrain (LPA) – École normale supérieure - Paris, Université Pierre et Marie Curie - Paris 6, Université Paris Diderot - Paris 7, Centre National de la Recherche Scientifique : UMR8551 – Département de Physique Ecole Normale Supérieure 24, rue Lhomond F-75231 Paris Cedex 05, France

[3] Centre Automatique et Systèmes – MINES ParisTech - École nationale supérieure des mines de Paris – Centre Automatique et Systèmes, Mines-ParisTech, PSL Research University, 60, bd Saint-Michel, 75006 Paris, France

[4] Inria de Paris – QUANTIC team – 2 rue Simone Iff -CS 42112 -75589 Paris Cedex 12, France

Measuring the photon number of an electromagnetic mode in a quantum nondemolition manner is instrumental to control the quantum state of a cavity, detect photon emission or measure work. In the microwave domain it can be done using the dispersive coupling between the cavity of interest and a coupled Rydberg atom or superconducting circuit. This method has been used successfully to count up to about a dozen photons, to realize Quantum Zeno dynamics experiments, or count photon number parity. Yet this technique has constraints on the measurement time. In particular it increases with the maximal number of photons. In this contribution, we present a technique that avoids this constraint by using the resonant fluorescence of a qubit coupled to the resonator of interest and a multiplexing measurement of the fluorescence field. We show an experiment where an independent quantum state tomography can be performed on the resonator to compare the result of the conventional method to this new technique.

Keywords: superconducting circuits, quantum information, microwave resonator

*Speaker

†Corresponding author: antoine.essig@ens-lyon.fr

‡Corresponding author: benjamin.huard@ens-lyon.fr

Tunneling time probed by quantum shot noise

Julien Gabelli * [1]

[1] Laboratoire de Physique des Solides (LPS) – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – Bat. 510 91405 Orsay cedex, France

The time that a particle takes to traverse an electronic junction by tunneling has been discussed in theory [1] but not detected directly. Here, we take advantage of both optical information and electronic fluctuations from a tunneling event to estimate this traversal time at around 1.1 femtosecond. Measuring this traversal time requires current measurements at optical frequencies and remains challenging. However, it has been known for more than 40 years that as soon as the bias voltage exceeds one volt, the junction emits infrared radiation as an electrically driven optical antenna [2]. We demonstrate here that the photon emission results from the fluctuations of the current inside the tunneling barrier. Photon detection is then equivalent to a measurement of the current fluctuations at optical frequencies, allowing to probe the tunneling time. Based on this idea, we perform optical spectroscopy and electronic current fluctuation measurements in the far from equilibrium regime. Our experimental data are in very good agreement with theoretical predictions based on the Landauer Büttiker scattering formalism. By combining the optics and the electronics, we directly estimate the so-called traversal time [3].

R. Landauer & T. Martin. Barrier interaction time in tunneling. *Review of Modern Physics.* **66**, 217 (1994).

J. Lambe & S. L. McCarthy. Light emission from inelastic electron tunneling. *Physical Review Letter.* ***37***, 923 (1976).

P. Février & J. Gabelli. *Nature Communications,* **9**, 4940 (2018)

Keywords: quantum tunneling, shot noise, photon emission

*Speaker

Realizing arbitrary quantum operations on a mechanical oscillator

Daniel Garcia-Sanchez * [1]

[1] Institut des Nanosciences de Paris (INSP) – Sorbonne Universite, Centre National de la Recherche Scientifique : UMR7588 – Sorbonne-Université, Case 840 4 place Jussieu 75252 Paris Cedex 05, France

Quantum optomechanics and electromechanics is a fast growing field with promising applications in quantum information. Recently non-classical mechanical states have been realized. However, full control of a quantum mechanical mode, which is necessary for successful quantum information processing based on electromechanical systems, has yet to be demonstrated. We aim to develop a novel quantum electromechanical device capable of obtaining full quantum control of a macroscopic mechanical resonator by integrating a phononic microcavity with a superconducting transmon qubit. We expect to achieve a very strong qubit-phonon coupling coefficient that will allow the realization of any quantum unitary operation on the phononic mode. This will have important applications in quantum information and quantum sensing. In addition this project opens the route to test the relevance of the quantum mechanics to the macroscopic world.

Keywords: Superconducting qubits, electromechanics

*Speaker

Engineering topological superconductivity with magnetic skyrmions

Maxime Garnier * [1]

[1] Laboratoire de Physique des Solides (LPS) – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – Bat. 510 91405 Orsay cedex, France

The search for topological superconductivity and Majorana fermions has mostly relied on the combination of conventional superconductivity, spin-orbit coupling and magnetism. However, recent experiments probing Majorana features have proved challenging. Therefore, it is worth considering alternative platforms which remove the material constraints due to spin-orbit coupling, and possibly increase the robustness and electric controllability. Magnetic textures are an interesting alternative as they provide an effective spin-orbit coupling due to the exchange interaction. Highly controllable nanoscale magnetic textures known as magnetic skyrmions have been highlighted as prime candidates.

In this talk, I will present our recent results on the nature and the properties of the induced superconductivity at the interface between a conventional superconductor and a magnetic skyrmion [1, 2]. Taking into account orbital effects, I will discuss the conditions for vortex nucleation in the superconductor. Adding the exchange interaction, I will show that the system sustains a topological superconducting phase characterized by a possible Majorana zero mode in the core of the skyrmion and a chiral Majorana mode around its edge. I will further discuss the stability of this phase to relatively strong disorder. Most importantly, the Majorana states are robust to typical deformations of the texture's edges. I will conclude by highlighting a few systems that might be suitable for the experimental realization of our setup.

M. Garnier, A. Mesaros and P. Simon, *Topological superconductivity with deformable magnetic skyrmions*, Communications Physics, 2 (1) 126 (2019).

M. Garnier, A. Mesaros and P. Simon, Topological superconductivity with orbital effects in magnetic skyrmion based heterostructures, arXiv:1909.12671 (2019).

Keywords: Supraconductivité, topologie, Majorana, magnétisme, skyrmion

*Speaker

Magnetoconductance, Quantum Hall Effect, and Coulomb Blockade in Topological Insulator Nanocones

Raphael Kozlovsky* [1], Ansgar Graf † [2,1], Denis Kochan [1], Klaus Richter [1], Cosimo Gorini [1]

[1] Institut für Theoretische Physik, Universität Regensburg – Germany
[2] Laboratoire de Physique des Solides, Université Paris-Saclay – Universite Paris Sud, 91405 Orsay Cedex, France – France

Magnetotransport through cylindrical topological insulator (TI) nanowires is governed by the interplay between quantum confinement and geometric (Aharonov-Bohm and Berry) phases. However the much broader class of TI nanowires with varying radius is accessible by studying its simplest member, a TI nanocone. Such nanocones allow to observe intriguing mesoscopic transport phenomena: While the conductance in a perpendicular magnetic field is quantized due to higher-order topological hinge states, it shows resonant transmission through Dirac Landau levels in a coaxial magnetic field. Furthermore, it may confine surface Dirac electrons and lead to Coulomb blockade. The above-mentioned effects should occur for experimentally accessible values of system size and magnetic field, suggesting that TI nanocone junctions may serve as building blocks for Dirac electron optics setups. (arXiv:1909.13124, 2019)

Keywords: Topological Insulators, Nanowires, Confinement, Quantum Hall Effect, Magnetoconductance

*Corresponding author: raphael.kozlovsky@ur.de
†Speaker

Imaging quantum Hall backscattering in graphene

Marco Guerra *† [1], Sacépé Benjamin [1], Hermann Sellier‡ [1]

[1] Institut Néel (NEEL) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

We report on a scanning gate microscopy (SGM) experiment that provides spatial information on the position and uniformity of the backscattering between chiral quantum Hall edge states in a high-mobility graphene Hall bar. The electrically polarized tip of the microscope enables local manipulation of edge states, promoting tunnelling of charge carriers between the counter-propagating modes, either directly or trough localized quantum Hall islands. This disorder-induced tip-mediated backscattering is revealed by deviations from the zero longitudinal resistance, as observed in narrow mesoscopic Hall bars.
A local graphite backgate allows us to characterize the electrostatic lateral confinement, showing a net reduction of backscattering for wider devices. We also identify a series of concentric rings which are typical of Coulomb blockade transport through a localized state gated by the tip. The diamond-shaped stability diagram recorded at finite source-drain bias demonstrates the key-role of Coulomb blockade in the percolation of quantum Hall channels through a disordered potential landscape.

Keywords: SGM, graphene, quantum Hall, backscattering

*Speaker
†Corresponding author: marco.guerra@neel.cnrs.fr
‡Corresponding author: hermann.sellier@neel.cnrs.fr

Photon-assisted charge-parity jumps in a superconducting qubit

Manuel Houzet * [1]

[1] Univ. Grenoble Alpes, IRIG-PHELIQS, F-38000 Grenoble, France and CEA, INAC-PHELIQS, F-38000 Grenoble, France – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble, Université Grenoble Alpes – France

We evaluate the rates of energy and phase relaxation of a superconducting qubit caused by stray photons with energy exceeding the threshold for breaking a Cooper pair. All channels of relaxation within this mechanism are associated with the change in the charge parity of the qubit, enabling the separation of the photon-assisted processes from other contributions to the relaxation rates. Among the signatures of the new mechanism is the same order of rates of the transitions in which a qubit loses or gains energy, in agreement with recent experiments.

Keywords: transmon, photon

*Speaker

Modulation of superconducting nanowires critical current driven by tunneling quasiparticle injection

Thomas Jalabert * [1], Florence Levy-Bertrand [2], Claude Chapelier [1]

[1] CEA-IRIG-PHELIQS – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble – 17 rue des Martyrs 38054 Grenoble Cedex 9, France

[2] Institut Néel – Université Grenoble Alpes, CNRS : UPR2940 – 25 rue des Martyrs 38042 Grenoble cedex 9, France

Quasiparticles dynamics often governs the ultimate performances of superconducting devices and out-of-equilibrium superconductivity has therefore attracted a long-standing interest [1]. In order to probe the microscopic mechanisms at play, injection of quasiparticles with the help of a tunnel junction has often been employed at the mesoscopic scale, thanks to the outstanding progress in modern nanotechnology. However, lithographed tunnelling barriers lack spatial resolution and do not allow to vary the bias voltage and the tunnelling current independently. In order to overcome these two limitations we used a homemade Scanning Tunnelling Microscope (STM) working at very low temperature (50 mK) and monitored the critical current of superconducting nanowires as a function of the tip position and the tunnelling set-point.
In Nbnanowires, we observed a drastic reduction of the critical current by injecting a tunnelling current of quasiparticles 6 orders of magnitude lower, that we interpret as a local increase of the electronic temperature. The critical current is strongly dependent on the injection position along the nanowire, the injection rate and the energy of the quasiparticles. At large energies compared to the superconducting gap, the reduction of the critical current is controlled by the injected power, and our measurements show that the diffusion of heat by phonons explains the injection power and position dependencies. By contrast, when reducing the energy at constant injection rate, the critical current sharply decreases close to the gap energy, signalling the breakdown of the quasi-equilibrium model. We also probed the spectral properties of current carrying nanowires, and induced vortices to create spatial disorder in the density of states. Thus, this experiment opens a new perspective to investigate the competition between diffusion, relaxation and recombination of quasiparticles in strongly disordered superconductors with various applications such as in photon detection.
A. I. Larkin and Y. N. Ovchinnikov, *Nonequilibrium Superconductivity*, edited by D. N. Langenberg and A. I. Larkin (NorthHolland, Amsterdam, 1986).

Keywords: Out of equilibrium superconductivity, quasiparticle dynamics, STM

*Speaker

Quantised Fermi-arc-mediated transport in Weyl semimetal nanowires

Vardan Kaladzhyan * [1], Jens Bardarson [1]

[1] Royal Institute of Technology [Stockholm] (KTH) – SE-100 44, Stockholm, Sweden, Sweden

We study longitudinal magnetotransport in Weyl semimetal nanowires. We show that depending on radii of nanowires there are two qualitatively different regimes of transport with respect to the chemical potential in the sample. First, for low doping most of the contribution to conductance comes from the Fermi arc surface states, and thus conductance grows linearly with the chemical potential; the flux dependence changes in steps of one quantum of conductance with characteristic interference oscillations. Second, for highly-doped samples the dominant contribution to conductance is quadratic in the chemical potential, and mostly conditioned by the bulk states; the flux dependence shows clearly that both the surface and the bulk states contribute to conductance. The two aforementioned regimes prove that the contribution of Fermi arc surface states is salient and, therefore, crucial for understanding transport properties of finite-size Weyl semimetal systems.

Keywords: Weyl semimetal, magnetotransport, finite, size effects, Fermi arc surface states

*Speaker

Josephson radiation in a superconductor-quantum dot-superconductor junction

Baptiste Lamic *† [1], Julia Meyer‡ [2], Manuel Houzet§ [3]

[1] CEA, IRIG-PHELIQS, F-38000 Grenoble, France (PHELIQS) – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble – CEA-Grenoble, 17 rue des Martyrs, F-38054 Grenoble cedex 9, France

[2] Univ. Grenoble Alpes, IRIG-PHELIQS, F-38000 Grenoble, France and CEA, IRIG-PHELIQS, F-38000 Grenoble, France – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble – France

[3] Univ. Grenoble Alpes, IRIG-PHELIQS, F-38000 Grenoble, France and CEA, INAC-PHELIQS, F-38000 Grenoble, France – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble, Université Grenoble Alpes – France

When a junction formed by two superconductors is voltage biased, one can detect a Josephson radiation whose frequency ω is usually equal to the Josephson frequency [1]. A fractional Josephson effect with radiation at half the Josephson frequency was predicted when the superconductors are topological [2-5]. This revived the interest in Josephson radiation in the condensed matter community. In this work, we derive the power density spectrum of the radiation emitted by a voltage-biased Josephson junction formed by a quantum dot connected to conventional superconductors. We investigate the role of non-adiabatic processes using a Markov model of the Andreev bound state dynamics. We find that such a junction may display a conventional or a fractional Josephson effect. Furthermore, we determine the contribution of the non-adiabatic transitions to the linewidth of the Josephson radiation. Thus, we assess the limitations of using the current noise spectrum to probe the topological nature of a junction.

C.W.J. Beenakker e-print arXiv:1112.1950 (2011). [2] A. Y. Kitaev, Physics-Uspekhi44, 131 (2001). [3] H.J. Kwon, K. Sengupta, and V.M. Yakovenko, Eur. Phys. J. B **37**, 349 (2004) [4] R.S. Deacon, J. Wiedenmann, E. Bocquillon, F. Dominguez, T.M. Klapwijk, P. Leubner, C. Brune, E.M. Hankiewicz, S. Tarucha, K. Ishibashi, H. Buhmann, and L.W. Molenkamp Phys. Rev. X **7**, 021011 (2017) [5] D. Laroche, D. Bouman, D.J. van Woerkom, A. Proutski, C. Murthy, D.I. Pikulin, C. Nayak, R.J. van Gulik, J. Nygard, P. Krogstrup, and L.P. Kouwenhoven, *Nat Commun* **10,** 245 (2019)

Keywords: junction Josephson, majorana, noise, power spectrum, quantum dot

*Speaker

†Corresponding author: baptiste.lamic@cea.fr

‡Corresponding author: julia.meyer@univ-grenoble-alpes.fr

§Corresponding author: manuel.houzet@cea.fr

Exponential suppression of bit-flips in a qubit encoded in an oscillator

Zaki Leghtas * [1]

[1] LPENS (LPENS) – Ecole Normale Supérieure de Paris - ENS Paris – France

A quantum system interacts with its environment, if ever so slightly, no matter how much care is put into isolating it. As a consequence, quantum bits (qubits) undergo errors, putting dauntingly difficult constraints on the hardware suitable for quantum computation. New strategies are emerging to circumvent this problem by encoding a qubit non-locally across the phase space of a physical system. Since most sources of decoherence are due to local fluctuations, the foundational promise is to exponentially suppress errors by increasing a measure of this non-locality. Prominent examples are topological qubits which delocalize quantum information over real space and where spatial extent measures non-locality. In this work (arXiv:1907.11729 < https://arxiv.org/abs/1907.11729>), we encode a qubit in the field quadrature space of a superconducting resonator endowed with a special mechanism that dissipates photons in pairs. This process pins down two computational states to separate locations in phase space. As we increase this separation, we measure an exponential decrease of the bit-flip rate while only linearly increasing the phase-flip rate. Since bit-flips are continuously and autonomously corrected at the single qubit level, only phase-flips are left to be corrected via a one-dimensional quantum error correction code. This exponential scaling demonstrates that resonators with non-linear dissipation are promising building blocks for universal fault-tolerant quantum computation with drastically reduced hardware overhead.

Keywords: superconducting qubits

*Speaker

Magneto-optical signatures of gapped noda lines in NbAs2 and the hyperbolic transformation

Xin Lu * [1]

[1] Laboratoire de Physique des Solides (LPS) – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – Bat. 510 91405 Orsay cedex, France

Recent density functional theory calculations have shown that the spin-orbit coupling triggers energy gaps along the nodal lines in materials in the transition metal di-pnictides family, such as NbAs2. Using polarized optical and magneto-optical spectroscopy, the spectroscopic signature of these gaps are found. After proposing a low-energy model, we first calculate the optical conductivity in the absence of the magnetic field by which the observed experiment results are corroborated. Then, we study the optical conductivity in the presence of the magnetic field taking into account magnetic anisotropy invoking the hyperbolic transformation. As a result of the hyperbolic transformation, the Fermi velocity and the gap measured on the spectra are renormalized by the Lorentz boost similar in the relativity. Furthermore, the common selection rules associated with the dipolar transition are not well defined any more whereas some new rough selection rules are established depending on the direction of the magnetic field. Finally, we predict the existence of a critical angle away from the nodal line direction of the magnetic field beyond which the Landau quantization cannot exist.

Keywords: Magneto, optics, Gapped nodal line semimetal

*Speaker

Machine learning for many-body physics

Marjan Macek *† [1,2], Corentin Bertrand [3], Bill Trigs [4], Philipp Dumitrescu [3], Olivier Parcollet [3], Xavier Waintal [5]

[1] CEA, IRIG-PHELIQS – CEA IRIG-PHELIQS – France
[2] Université Grenoble Alpes – Université Grenoble Alpes, Université Grenoble Alpes – France
[3] CCQ Flat Iron Institute – United States
[4] CNRS, LEAR – INRIA Greoble-Rhône Alpes, Univ. Grenoble-Alpes, Laboratoire Jean Kuntzman – France
[5] Univ. Grenoble Alpes, CEA, INAC-PHELIQS, F-38000 Grenoble, FRANCE – Univ. Grenoble Alpes, CEA, INAC-PHELIQS, F-38000 Grenoble, FRANCE – France

Anderson impurity model is one of the simplest correlated quantum many-body systems but can still contain interesting physical phenomena such as Kondo effect or nanonelectronic systems such as interacting quantum dot coupled to leads. Despite the simplicity, computational methods which are fast, precise and have a controlled error are lacking. Diagrammatic determinantal Monte Carlo is one of these methods and has seen significant advances in recent years [1,3]. In this method, one expands the observables of interacting many-body Hamiltonian in a perturbation series of interaction strength. Each term is a sum of all n-th order Feynman diagrams, which themselves are n-dimensional integrals [1].

Traditionally, high dimensional integrals are calculated with the Metropolis algorithm, where one of the challenges is the design of efficient updates [1]. Recent works used machine learning to optimize updates [2]. Furthermore, summing the perturbation series requires terms with high precision, which is time-consuming with the Metropolis algorithm [3].

In this work, we discard the Metropolis algorithm and sample the integrand directly. We use machine learning to obtain a model from the model class. The model class was built on our understanding of integrand properties. We applied and benchmarked the new algorithm to our previous work studying the Anderson impurity model [1,3]. In sign-problem-free cases, we can show a speed-up of several orders of magnitude.

Phys. Rev. B 91 245154 (2015)

Phys. Rev. B 95 041101 (2017)

Phys. Rev. X 9, 041008 (2019)

Keywords: Quantum Monte Carlo, Anderson impurity model

*Speaker

†Corresponding author: marjan.macek@cea.fr

Photonic heat flow modulation using charge quantization

Olivier Maillet * [1], Diego Subero [1], Dmitry Golubev [1], Jukka Pekola [1]

[1] PICO group, Low Temperature Laboratory, Aalto University – Finland

We experimentally demonstrate a photonic heat modulation mechanism that is based on the antagonism between Josephson tunneling and charging effects in a single Cooper pair transistor [1]. Using a single gate voltage, we tune electrostatically the photonic heat conductance between two mesoscopic resistors kept under an electronic temperature difference. The measured photonic thermal conductance goes from a maximum when Josephson effect is favoured to a minimum when the Coulomb gap is fully developed. A good agreement is found with a model based on the Landauer formula for heat transport. Incidentally, this provides a new type of photonic heat valve, using only gate voltages without requiring a magnetic flux as is usually done. [1] O. Maillet et al., in preparation

Keywords: Quantum heat transport, thermal microwave radiation, charge phase duality, Josephson junctions, Coulomb blockade

*Speaker

Imaging work and dissipation in the quantum Hall state of graphene

Arthur Marguerite * [1], John Birkbeck [2], Amit Aharon-Steinberg [1], Dorri Halbertal [1], Kousik Bagani [1], Ido Marcus [1], Yuri Myasoedov [1], Andrei Geim [2], David Perello [2], Eli Zeldov [1]

[1] Weizmann Institute of Science (WIS) – Israel
[2] National Graphene Institute and School of Physics and Astronomy – United Kingdom

Topology is a powerful recent concept asserting that quantum states could be globally protected against local perturbations. Dissipationless topologically protected states are thus of major fundamental interest as well as of practical importance in metrology and quantum information technology. Although topological protection can be robust theoretically, in realistic devices it is often fragile against various dissipative mechanisms, which are difficult to probe directly because of their microscopic origins. By utilizing scanning nanothermometry [1], we visualize and investigate microscopic mechanisms undermining the apparent topological protection in the quantum Hall state in graphene. Our simultaneous nanoscale thermal and scanning gate microscopy shows that the dissipation is governed by crosstalk between counterpropagating pairs of downstream and upstream channels that appear at graphene boundaries because of edge reconstruction. Instead of local Joule heating, however, the dissipation mechanism comprises two distinct and spatially separated processes. The work generating process that we image directly and which involves elastic tunneling of charge carriers between the quantum channels, determines the transport properties but does not generate local heat. The independently visualized heat and entropy generation process, in contrast, occurs nonlocally upon inelastic resonant scattering off single atomic defects at graphene edges, while not affecting the transport. Our findings offer a crucial insight into the mechanisms concealing the true topological protection and suggest venues for engineering more robust quantum states for device applications.

D. Halbertal, J. Cuppens, M. Ben Shalom, L. Embon, N. Shadmi, Y. Anahory, H. R. Naren, J. Sarkar, A. Uri, Y. Ronen, Y. Myasoedov, L. S. Levitov, E. Joselevich, A. K. Geim, and E. Zeldov, "Nanoscale thermal imaging of dissipation in quantum systems", *Nature* **539**, 407 (2016).

A. Marguerite, J. Birkbeck, A. Aharon-Steinberg, D. Halbertal, K. Bagani, I. Marcus, Y. Myasoedov, A. K. Geim, D. J. Perello, and E. Zeldov, "Imaging work and dissipation in the quantum Hall state in graphene", (Nature in press) arXiv:1907.08973

Keywords: graphene, edge reconstruction, quantum Hall effect, scanning, dissipation, SQUID

*Speaker

The physics of Twisted Bilayers of Graphene under Heterostrain

Florie Mesple * [1], Guy Trambly De Laissardière [2], Claude Chapelier [1], Vincent Renard [1]

[1] cea/pheliqs/irig/lateqs – UGA-CNRS-CEA – France
[2] université paris saclay/lptm – Université Paris-Saclay,Sorbonne Universités – France

Recently, a superconducting phase has been detected in twisted bilayers of graphene (TBLG)[1], a Van der Waals heterostructure in which the interference of two rotated atomic lattices results in a moiré pattern. Previous research [2] has shown that the moiré and its electronic structure are not only controlled by the rotation between the layers but also by the relative strain between them (heterostrain). Besides, Scanning Tunneling Microscopy (STM) can be used to image the Moiré and deduce both the angle and the deformation between the layers of graphene using commensurability analysis [3]. What's more, it is the ideal tool to probe the electronic properties on a nanometer scale. In this context, in order to understand strain effect on TBLGs, it is of huge interest to look in a heterostrain perspective at the prolific STM data on TBLGs available in the recent literature, and question the physics at play in these systems : in what extent the electronic properties can be explained by strain effects ?

Unconventional superconductivity in magic-angle graphene superlattices ; Yuan Cao, Valla Fatemi, Shiang Fang, Kenji Watanabe, Takashi Taniguchi, Efthimios Kaxiras and Pablo Jarillo-Herrero Nature volume 556, pages 43–50 (05 April 2018)

Electronic Spectrum of Twisted Graphene Layers under Heterostrain ; L. Huder, A. Artaud, T. Le Quang, G. T. de Laissardière, A. G.M. Jansen, G. Lapertot, C. Chapelier, and V. T. Renard, Phys. Rev. Lett. 120, 156405

Universal classification of twisted, strained and sheared graphene moiré superlattices ; A. Artaud, L. Magaud, T. Le Quang, V. Guisset, P. David, C. Chapelier and J. Coraux Scientific Reports volume 6, Article number: 25670 (2016)

Keywords: Twisted bilayers of graphene, Strain, STM

*Speaker

Topology and perfect metal in trilayer moire graphene

Christophe Mora * [1]

[1] Laboratoire Matériaux et Phénomènes Quantiques (MPQ) – CNRS : UMR7162, Université Paris VII - Paris Diderot – France

The past decade has witnessed remarkable experimental achievements in the study of two-dimensional materials such as graphene, graphene-like compounds[1] or transition metal dichalcogenide (TMD) with the long-term goal of tailoring arbitrary heterostructures with desired properties. An inherent advantage of two-dimensional structures is the possibility of electrical doping to tune the Fermi level in different regimes of transport. Stacking monolayers with a small twist angle forming moiré patterns has been demonstrated to dramatically change the band structure, generating gaps and band flattening in a controllable manner, forming in certain cases topological phases of matter. The discovery in 2018 of Mott physics and unconventional superconductivity[2,3] in twisted bilayer graphene has given a very strong boost to the field. It clearly offers a versatile platform to explore strongly correlated matter in a relatively simple system. We discuss the electronic structure of twisted graphene with three layers. We first show how the band structure can be obtained in a continuum approximation valid for large moiré superlattices. We identify "magic angles" as well as flat band regions relevant for many-body physics. Our main result[4], obtained through a symmetry analysis of the band model, is to prove that the trilayer geometry is a perfect metal in the sense that it is gapless at all energies. This remarkable property is a consequence of the number of topologically protected Dirac cones in the system. It is protected by an emergent particle-hole symmetry. [1] *Elemental Analogues of Graphene: Silicene, Germanene, Stanene, and Phosphorene,* S. Balendhran et al. small 2015, 11, 640 [2] *Correlated insulator behaviour at half-filling in magic-angle graphne superlattices*, Cao et al., Nature 556, 43 (2018) [3] *Unconventional superconductivity in magic-angle graphene superlattices*, Cao et al., Nature 556, 80 (2018) [4] *Flat bands and perfect metal in trilayer moiré graphene*, C. Mora, N. Regnault, B. A. Bernevig, Phys. Rev. Lett. 123, 026402 (2019)

Keywords: graphene moiré

*Speaker

Dynamical conductivity of the Fermi arc and the Volkov-Pankratov states on the surface of Weyl semimetals

Dibya Mukherjee * [1]

[1] Systèmes élastiques : du désordre à la plasticité (SEDP) – Centre National de la Recherche Scientifique : GDR2284 – Laboratoire de Phys. des solides Bâtiment 510 91405 ORSAY CEDEX, France

Weyl semimetals are known to host massless surface states called Fermi arcs. These Fermi arcs are the manifestation of the bulk-boundary correspondence in topological matter and thus are analogous to the topological chiral surface states of topological insulators. It has been shown that the latter, depending on the smoothness of the surface, host massive Volkov-Pankratov states that coexist with the chiral ones. In this talk, I will present these VP states in the framework of Weyl semimetals, namely their density of states and magneto-optical response. I will demonstrate the selection rules corresponding to optical transitions which lead to anisotropic responses to external fields. In the presence of a magnetic field parallel to the interface, the selection rules and hence the poles of the response functions are mixed.

Keywords: Weyl semimetal, magneto, optical conductivity, surface states

*Speaker

Two-terminal conductance measurements in Selective Area Grown nanowires

Gerbold Ménard * [1,2], Gian-Luca Anselmetti [1], Esteban Martinez [1], Denise Puglia [1], Filip Malinowski [1], Andrew Higginbotham [1], Lucas Casparis [1], Karsten Flensberg [1], Charles Marcus [1]

[1] Center for Quantum Devices and Station Q Copenhagen (Qdev) – Denmark
[2] Service de physique de l'état condensé (SPEC) – CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif sur Yvette France – France

Majorana quasiparticles have generated years of intense research following the first observation of zero-bias anomalies in semiconductor-superconductor heterostructures [1] due to the promises they hold in the field of quantum computing. However, despite these efforts, definitve proofs of the topological nature of these excitations are still being sought after. In particular, one of the most significative prediction for Majorana fermions is that the zero-bias anomalies are to be found at both sides of a wire. Performing a simultaneous conductance measurements at both sides of a wire would be a significative step forward allowing us to verify this theoretical prediction. Unfortunately, usual InAs nanowires are grown on a substrate before being transferred onto another chip before being processed, which prevents from defining a well-defined electrical ground without defects in the center of the wire. An alternative to these standing wires are the so-called SAG [2] (selective area growth) wires that grow directly on a chip that can be directly processed and can be connected electronically through the epitaxial Al thin film deposited in MBE. Using this technique, we realized three-terminals nanowire structures allowing us to probe both sides of the same wire simultaneously [3,4]. In this presentation, I will discuss the advantage of this SAG wires and present results we obtained in these systems in relation to topological signatures as well as future possible developments using this technique.

V. Mourik et al., Science 336, 1003 (2012)

S. Vaitiekenas et al., Phys. Rev. Lett. 121, 147701 (2018)

G. Anselmetti et al., arXiv:1908.05549 (2019)

G. Ménard et al., arXiv:1905.05505 (2019)

Keywords: Transport, nanowire, correlation, Majorana, Andreev bound states

*Speaker

Understanding the electrical manipulation of hole spins in silicon

Yann-Michel Niquet * [1], Benjamin Venitucci [1], Jing Li [1], Léo Bourdet [1], Alessandro Crippa [2], Simon Zihlmann [2], Romain Maurand [2], Anthony Amisse [2], Agostino Aprà [2], Rami Ezzouch [2], Xavier Jehl [2], Marc Sanquer [2], Louis Hutin [3], Benoit Bertrand [3], Maud Vinet [3], Silvano De Franceschi [2]

[1] Interdisciplinary Research Institute of Grenoble, Modeling and Exploration of Materials Laboratory (CEA IRIG-MEM) – Université Grenoble Alpes, CEA IRIG-MEM – 17, rue des Martyrs 38054 Grenoble cedex 9, France

[2] Interdisciplinary Research Institute of Grenoble, Quantum Photonics, Electronics and Engineering Laboratory (CEA IRIG-PHELIQS) – Université Grenoble Alpes, CEA IRIG-PHELIQS – 17, rue des Martyrs 38054 Grenoble cedex 9, France

[3] Laboratoire d'Electronique et des Technologies de l'Information (CEA LETI) – Université Grenoble Alpes, CEA LETI-MINATEC – 17, rue des Martyrs 38054 Grenoble Cedex 9, France

Hole spin qubits in silicon have been successfully demonstrated in the last few years [1, 2]. At variance with electrons, hole spins are strongly coupled to the real-space motion of the carrier by spin-orbit coupling. This enables fast electrical manipulation through electric dipole spin resonance (EDSR). Coherent control with Rabi frequencies as large as 80 MHz and inhomogeneous dephasing times close to 300 ns have for example been achieved on silicon-on-insulator devices [1, 2]. Hole spin qubits actually show rich physics due to the interplay between the heavy- and light-hole components. The response of the hole spins to electric and magnetic fields is, in particular, very anisotropic and dependent on the shape and symmetry of the wave function.

We review the physics of hole spins in silicon. We show that spin-orbit coupling in the valence band is dominated by a "direct" interaction resulting from the mixing between heavy-hole, light-hole and split-off bands. We then discuss our latest results on the modeling of hole spin qubits in silicon and germanium, obtained in the g-matrix formalism [2, 3]. The latter captures the linear response of spins to electric and magnetic fields and can be used to model electron and hole spin qubits at very low computational cost. We outline, in particular, the general role of symmetries in hole spin qubits, and show how the wave functions, Rabi frequency and coherence times can be tuned by structural and electrical confinements. We demonstrate that silicon provides excellent opportunities for fast hole spin manipulation (despite weak spin-orbit coupling), owing to its very anisotropic valence band that enhances the heavy- and light-hole mixing [4]. Finally, we discuss the effects of strains on hole spins. We show that hole spin qubits are indeed very sensitive to strains due to the small energy scales involved in these devices. They do, in particular, drive a transition between "heavy-hole" and "light-hole" qubits with very different fingerprints. These results improve our understanding of hole spin qubits and open the way for a better control of these devices.

R. Maurand et al., Nature Communications 7, 13575 (2016). [2] A. Crippa et al., Physical Review Letters 120, 137702 (2018). [3] B. Venitucci, L. Bourdet, D. Pouzada and Y.-M. Niquet, Physical Review B 98, 155319 (2018). [4] B. Venitucci and Y.-M. Niquet, Physical Review B 99, 115317 (2019).

*Speaker

Keywords: Spin, orbit coupling, holes, silicon, spin qubits, modeling

Real-Space Visualization of Majorana Edge Modes on the Nano-Scale Magnet-Superconductor Hybrid System

Alexandra Palacio Morales * [1], Roland Wiesendanger [2], Howon Kim [2], Dirk. K. Morr [3], Eric Mascot [3], Sagen Cocklin [3], Stephan Rachel [4], Thore Posske [2]

[1] Université Paris Sud (LPS) – je n'ai pas de tutelle – France
[2] Hamburg University – Germany
[3] University of Illinois at Chicago – United States
[4] University of Melbourne – Australia

Superconductivity and magnetism have been seen for a long time as antagonist until recent progress shows that their coupling leads to new phenomena. Specially, Majorana Fermions (MF) have attracted widespread interest for their promising potential for future applications in topological quantum computation. Advances in nano-fabrication techniques combined with local probe microscopies have paved the way to build up such hybrid systems and to analyze them at the nanoscale. Recently, results on ferromagnetic chains [1] and ferromagnetic nanoislands [2] on a conventional superconductor revealing Yu-Shiba-Rusinov (YSR) bands were reported. These YSR bands are the precursors to observe MF modes at the edge of these hybrid systems at low dimensionality. However, the observation of these MF modes is still a subject of debate and has raised questions about experimental considerations that must be accounted. Lack of well-defined structures, MF spatial distribution and evolution inside the hybrid structures are among the reasons of these concerns. Hence, other combinations of superconductors and magnetic systems possibly holding MF such as non-collinear magnetic spin textures with well-defined structures should be investigated in order to deeply understand their physics.
Here, we present emergent phenomena appearing on the Fe magnetic nanowire with non-collinear spin textures on Re(0001) surface build up by atom manipulation [3]. Moreover, we report on the first unambiguous experimental detection and visualization of chiral Majorana edge states in a monolayer topological superconductor, a prototypical magnet-superconductor hybrid system comprised of nano-scale Fe islands of monoatomic height on a Re(0001)-O(2×1) surface [4, 5].
S. Nadj-Perge et al., Science **346**, 602 (2014) [2] G. C. Ménard et al., Nat. Comm. **8**, 2040 (2017) [3] H. Kim et al., Science Adv. **4**, eaar5251 (2018) [4] A. Palacio-Morales et al., Nano Lett. **16**, 6252-6256 (2016) [5] A. Palacio-Morales et al., Science Adv. **5**, eaav6600 (2019)

Keywords: Shiba&Majorana states, STM, nanomagnetism, superconductivity, topology

*Speaker

Conductance quantization in topological Josephson junction circuits

Léo Peyruchat * [1]

[1] Collège de France – CNRS : USR3573 – France

At its essence, topology is about quantized properties, like the well-known example of the number of holes an object has. In the context of superconductivity, the quantization applies to the electric charge, the magnetic flux, and the combination of both which is the quantum of resistance.
Using the building block of quantum circuits, the Josephson junction, the first two quantization effects have been demonstrated with respectively the cooper pair pump and the Shapiro steps. But the hallmark of the quantum hall effect, the quantization of the conductance, has not been shown with superconducting circuits.
We propose a quantum circuit made of tunnel junctions, which effectively realizes a QHE without magnetic field. This circuit allows to close the metrological triangle using only Josephson junctions.

Keywords: josephson junction, topology, metrology

*Speaker

Two-level-system as topological actuator for nano-mechanical modes

Clement Dutreix [1], Remi Avriller [1], Brahim Lounis [2], Fabio Pistolesi * [1]

[1] Laboratoire Ondes et Matière dÁquitaine (LOMA) – Centre National de la Recherche Scientifique : UMR5798, Université de Bordeaux : UMR5798 – Université de Bordeaux, PAC Talence, bât. A4N, 351 Cours de la Libération, 33405 TALENCE CEDEX, France
[2] Laboratoire Photonique, Numérique et Nanosciences (LP2N) – Université de Bordeaux, Institut dÓptique Graduate School, Centre National de la Recherche Scientifique, Institut d'Optique Graduate School – Institut d'Optique d'AquitaineRue François Mitterrand33400 TalenceFrance, France

We investigate theoretically the dynamics of two quasi-degenerate mechanical modes coupled to a two-level system. We show that by driving the latter with a coherent field one can engineer the effective mechanical spectrum leading to an exceptional degeneracy point where the two mechanical modes coalesce. It allows the topological actuation of the modes by adiabatically varying the drive frequency and intensity. This is supported by quantum jump Monte-Carlo simulations to account for strong quantum fluctuations induced by spontaneous emission. We also propose an experimental realisation in nano-electromechanics, where the flexural modes of a charged suspended carbon nanotube couple the electric dipole of a single driven molecule by Stark effect.

Keywords: electronic two, level systems, opto, mechanics, topology

*Speaker

Correlated transport in driven coupled Bose-Einstein condensates

Denis Feinberg [1], Enrico Compagno , Guillaume Quesnel * [2], Luigi Amico [3,4], Anna Minguzzi [5]

[1] Institut Néel (NEEL) – CNRS : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France
[2] Institut Néel (NEEL) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France
[3] Università degli studi di Catania [Catania] – Piazza Università, 2 95131 Catania, Italy
[4] LANEF – LANEF – France
[5] Laboratoire de Physique et Modélisation des Milieux Condensés (LPMMC) – Université Grenoble Alpes, CNRS : UMR5493 – France

Coupled Bose-Einstein condensates (BEC) trapped in optical lattices allow to explore new quantum regimes and also to simulate other condensed matter systems where interactions and phase coherence play together. We study three BEC's coupled by bosonic Josephson junctions, and introduce a strong symmetric potentiel offset to induce atomic pair correlations into the system. First, with static repulsive interactions only, a nearly perfect resonance betwen two states differing by one transferred boson pair can be obtained. Second, driving the interaction – controlled by Feshbach resonance – at a frequency resonant with a boson pair transition allows to create generalized entangled NOON states – or W-states - of the form —0N0> + —N00> + —00N> with a high fidelity.

Keywords: Bose, Einstein Condensates, Entanglement, Josephson Junction, Driven Systems

*Speaker

Correlated transport in driven coupled Bose-Einstein condensates

Guillaume Quesnel * [1]

[1] Institut Néel (NEEL) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

Coupled Bose-Einstein condensates (BEC) trapped in optical lattices allow to explore new quantum regimes and also to simulate other condensed matter systems where interactions and phase coherence play together. We study three BEC's coupled by bosonic Josephson junctions, and introduce a strong symmetric potentiel offset to induce atomic pair correlations into the system. First, with static repulsive interactions only, a nearly perfect resonance betwen two states differing by one transferred boson pair can be obtained. Second, driving the interaction – controlled by Feshbach resonance – at a frequency resonant with a boson pair transition allows to create generalized entangled NOON states – or W-states - of the form —0N0> + —N00> + —00N> with a high fidelity.

Keywords: Bose, Einstein Condensates, Entanglement, Josephson Junction, Driven Systems

*Speaker

A Mesoscopic Spectrometer Based on the Josephson Effect

Joël Griesmar [1], Fabien Lafont [1], Ramiro Rodriguez * [1], Vincent Benzoni [1], Léo Peyruchat [1], Jean-Loup Smirr [1], Çağlar Girit† [1]

[1] Flux Quantum Lab, CNRS USR 3573, Collège de France, Paris, France (CDF) – Collège de France, CNRS : USR3573 – 11 place Marcelin Berthelot - 75231 Paris Cedex 05, France

A key element of mesoscopic topological systems, such as hybrid semiconductor-superconductor circuits, are Andreev Bound States, single quasiparticles localized at superconducting weak links. The characteristic transition energy of these states is twice the superconducting gap (90 GHz in aluminum). Conventional microwave techniques allow probing these states but only in a limited bandwidth. We implement a new broadband spectrometer operating at frequencies up to 180 GHz, with a 2 MHz linewidth and a minimal theoretical sensitivity of 5 kHz, based on the Josephson effect which converts a DC voltage to microwave oscillations at a frequency proportional to this voltage. Conveniently, the absorption of the emitted photons is directly measured in the DC current-voltage characteristic of the spectrometer. Using a symmetrical SQUID biased at half a flux quantum allows decoupling the spectrometer from parasitic environmental modes. In addition, careful design of the biasing circuit reduces the number of remaining modes and damps them. Furthermore the spectrometer can be inductively coupled to a system that resides on a different chip. We demonstrate this spectroscopy technique by detecting the plasma frequency, at around 100 GHz, of an RF-SQUID fabricated both on- and off-chip.

Keywords: Josephson Junction, Mesoscopic Spectrometer, Mesoscopic Superconductivity

*Speaker

†Corresponding author: caglar.girit@college-de-france.fr

Helical quantum Hall phase in graphene on SrTiO3

Benjamin Sacépé * [1]

[1] Institut Néel (NEEL) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

Helical edge states in topological insulators and semiconducting nanowires are attracting a tremendous amount of attention due to the prospect of inducing and manipulating Majorana states in superconducting hybrid devices. However, most of the topological systems studied so far for Majorana physics remain obscured by material issues such as bulk parasitic bulk conduction or inhomogeneous chemical potential. In this talk I will present a new type of topological insulator constructed on the basis of the quantum Hall effect of graphene. I will show that the ground state of charge neutral graphene under perpendicular magnetic field is a quantum Hall topological insulator with a ferromagnetic order that exhibits spin-filtered, helical edge channels. The topological phase emerges in the graphene zeroth Landau level via a suitable screening of the Coulomb interaction by a SrTiO3 high-k dielectric substrate. We observed robust helical edge transport emerging at a magnetic field as low as 1 T and withstanding temperatures up to 110 K over micron-long distances. This new and versatile graphene platform opens up a promising avenue for topological superconductivity.

Keywords: quantum hall, graphene, SrTiO3

*Speaker

Coulomb drag effect induced by the third cumulant of current

Ines Safi * [1], Eugene Sukhorukov , Artem Borin

[1] Laboratoire de Physique des Solides (LPS) – LPS Orsay – Bât 510, Université Paris-Sud/Paris-Saclay 91405 Orsay Cedex, France

The Coulomb drag effect arises due to electron-electron interactions when two metallic conductors are placed in close vicinity to each other. It manifests itself as a charge current or voltage drop induced in one of the conductors, if the current flows through the second one. Often it can be interpreted as an effect of rectification of the nonequilibrium *quantum* noise of current. Here, we investigate the Coulomb drag effect in mesoscopic electrical circuits and show that it can be mediated by *classical* fluctuations of the circuit collective mode. Moreover, by considering this phenomenon in the context of the full counting statistics of charge transport, we demonstrate that not only the noise power but also the third cumulant of current may contribute to the drag current. We discuss the situations where this contribution becomes dominant.
Refs:
I. Safi, Phys. Rev. B 99, 045101 (2019). A. Borin, I. Safi, and E. Sukhorukov, Phys. Rev. B 99, 165404 (2019).

Keywords: Drag current. Third cumulant.

*Speaker

Unified out-of-equilibrium fluctuation relations for the high-frequency noise

Ines Safi * [1]

[1] Laboratoire de Physique des Solides (LPS) – LPS Orsay – Bât 510, Université Paris-Sud/Paris-Saclay 91405 Orsay Cedex, France

Classical laws of transport and Fluctuation-Dissipation Theorem (FDT) fail in out-of-equilibrium interacting nano-structures. Thus we pursue the derivation of alternative quantum laws for time-dependent transport within a perturbative theory, independently on details of interactions, and providing a unifying framework for a large family of strongly correlated systems at arbitrary dimensions [1,2,3]. Those laws are obeyed by current noise across a normal tunnel junction, or voltage noise across a dual Josephson junction coupled to a gaussian or non-gaussian electromagnetic environment.
Here, the high-frequency noise is shown to obey out-of-equilibrium fluctuation relations (FRs), without requiring initial thermalization, provided one starts from a stationary out-equilibrium regime [4]. In case one ensures initial thermalization, noise obeys an out-of-equilibrium Fluctuation-Dissipation Relation [3] different from that derived by Rogovin and Scalapino [5], particulaily because the theory doesn't require any particle-hole symmetry, nor, more generally, inversion symmetry. An interesting application arises in the Fractional Quantum Hall Effect (FQHE), where the FRs are shown to offer methods for the determination of the fractional charge, even with edge reconstruction, and without knowledge of the underlying microscopic description. Those methods have been implemented for the Jain series of filling factors; though such a description is not clearly established, FRs are robust and have been checked for the high-frequency noise, measured for the first time in the FQHE [6], and leading to determine without ambiguity the predicted fractional charges. A similar achievement has been reached using an out-of-equilibrium FR we have derived for the photo-assisted noise [1], measured also for the first time (in the zero-frequency limit) in the FQHE [7].
I. Safi, arXiv:1401.5950. O. Parlavecchio, C. Altimiras, J.-R. Souquet , P. Simon, I. Safi, P. Joyez, D. Vion, P. Roche, D. Estève and F. Portier, Phys. Rev. B 93, 045102 (2016). [2] B. Roussel, P. Degiovanni, I. Safi, Phys. Rev. B 93, 045102 (2016).[3] I. Safi, Phys. Rev. B 99, 045101 (2019); A. Borin, I. Safi, and E. Sukhorukov, Phys. Rev. B 99, 165404 (2019). [4] I. Safi, submitted to Phys. Rev. B (2019). [5] D. Rogovin & D. J. Scalapino, ANN. Phys. 96, p. 1 (1974) [6] R. Bisognin, H. Bartolomei, M. Kumar, I. Safi, J.-M. Berroir, E. Bocquillon, B. Plaçais, A. Cavanna, U. Gennser, Y. Jin, and G. Fève, Nature Comm. {10}, number 1708 (2019) [7] M. Kapfer, P. Roulleau, I. Farrer, D. A. Ritchie, and D. C. Glattli, Science 363, 846-849 (2019)

Keywords: Bruit haute fréquence. Effet Hall Quantique Fractionnaire. Relation de Fluctuation hors, équilibre.

*Speaker

Effects of quasi-particle injection on the critical current of a superconducting nanowire

Sarath Sankar * , Manuel Houzet [1], Julia Meyer [2], Thomas Jalabert [3], Claude Chapelier [4]

[1] Univ. Grenoble Alpes, IRIG-PHELIQS, F-38000 Grenoble, France and CEA, INAC-PHELIQS, F-38000 Grenoble, France – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble, Université Grenoble Alpes – France

[2] Univ. Grenoble Alpes, INAC-SPSMS, F-38000 Grenoble, France and CEA, INAC-SPSMS, F-38000 Grenoble, France – Université Joseph Fourier - Grenoble I – France

[3] CEA-IRIG-PHELIQS – Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) - Grenoble – 17 rue des Martyrs 38054 Grenoble Cedex 9, France

[4] Institut Nanosciences et Cryogénie (INAC) – Université Grenoble Alpes, Commissariat à l'énergie atomique et aux énergies alternatives : DRF/INAC – CEA-Grenoble, 17 rue des Martyrs, F-38054 Grenoble cedex 9, France

Understanding the effects of quasi-particle injection in mesoscopic superconducting systems is an important and active topic of research in condensed matter physics. We theoretically investigate the effects of quasi-particle injection from a weakly coupled normal lead on the critical current of a superconducting nanowire. We are motivated by an intriguing experimental observation: upon quasi-particle injection from an STM tip at a constant tunneling current, the critical current shows a non-monotonous dependence on the bias voltage. Assuming fast relaxation of the quasi-particles and coupling of the system to a hot electromagnetic environment, we formulate a theoretical explanation of the observation using the quasi-classical approach.

Keywords: superconducting nanowires, nonequilibrium quasiparticles, critical current spectroscopy

*Speaker

Single-photon emission mediated by single-electron tunneling in plasmonic nanojunction

Quentin Schaeverbeke * [1,2]

[1] Laboratoire Ondes et Matière d'Aquitaine (LOMA) – Université de Bordeaux : UMR5798, Centre National de la Recherche Scientifique : UMR5798 – Bât. A4 Recherche Physique 351, Cours de la Libération 33405 TALENCE CEDEX, France
[2] Donostia International Physics Center - DIPC (SPAIN) (DIPC) – Spain

Scanning tunneling microscopy (STM) is a powerful spectroscopic tool to probe electronic density of state an vbrationnal modes of surfaces and molecules with atomic resolution [1]. In the nanoplasmonic cavity formed by the STM tip and the substrate, the tunneling current can also induce single molecule fluorescence [2]. However the physical mechanism responsible for light-emission is still discussed today.
In the present talk we discuss one mchanism for light-emission in an STM junction for which the cavity lectric field couples to the current-inuced charge fluctuations of a single molecule allowing the excitation of the cavity mode. In the experimentaly relevant limit of large damping rate of the cavity an arbitrary coupling strength to a single-electronic level, we show that at the first inelastic threshil of photon emission, the emitted light is anti-bunched with a vanishing second order correlation function. The current and light intensity display Franck-Condon steps at multiples of the cavity frequency with a width contolled by the cavity damping rate. Thus we predict current-driven non-classical light emission from a single electronic level [3].

Qiu, X. H., Nazin, G. V. & Ho, W., Phys. Rev. Lett., 92, 206102 (2004)

Bernt, R., Gaisch, R., Gimzewski, J. K., Reihl, B., Schlittler, R. R., Schneider, W. D., & Tschudy, M., Science, 262(5138), 1425-1427 (1993)

Q. Schaeverbeke, R. Avriller; T. Frederiksen et F. Pistolesi, Single-photon emission mediated by single-electron tunneling in plasmonic nanojunctions, arXiv:1907.11269 (2019)

Keywords: Quantum transport, Nanophotonics, Quantum cavities

*Speaker

Quantum rifling: protecting a qubit from measurement back-action

Daniel Szombati * [1,2], Alejandro Frieiro Gomez [2], Clemens Muller [3], Tyler Jones [2], Markus Jerger [2], Arkady Fedorov [2]

[1] ENS Lyon – École normale supérieure - Lyon (ENS Lyon) – 15 parvis René Descartes, 69342 Lyon, France
[2] University of Queensland – St Lucia, Queensland 4072, Australia
[3] IBM Ruschlikon – Switzerland

Quantum mechanics postulates that measuring the qubit's wave function results in its collapse, with the recorded discrete outcome designating the particular eigenstate the qubit collapsed into.
We show this picture breaks down when the qubit is strongly driven during measurement.
More specifically, for a fast evolving qubit the measurement returns the time-averaged expectation value of the measurement operator, erasing information about the initial state of the qubit, while completely suppressing the measurement back-action.
We call this regime "quantum rifling", as the fast spinning of the Bloch vector protects it from deflection into either of its two eigenstates. We study this phenomenon with two superconducting qubits coupled to the same probe field and demonstrate that quantum rifling allows us to measure either one of the two qubits on demand while protecting the state of the other from measurement back-action.
Our results allow for the implementation of selective read out multiplexing of several qubits, contributing to efficient scaling up of quantum processors for future quantum technologies.

Keywords: measurement back_action, qubit multiplexing, strong coupling, cqed

*Speaker

Superconductivity from Coulomb repulsion in 3D Luttinger semimetals

Sergueï Tchoumakov * [1]

[1] Institut Neel – CNRS : UPR2940 – France

The role of the Coulomb repulsion between electrons in superconductivity is a long-standing issue and it is usually considered as a perturbation that competes against electron pairing (e.g. the pseudo-potential in electron-phonon coupling). Though, screening of the Coulomb potential can lead to attraction for some electron modes as illustrated by the Kohn-Luttinger and plasmon mechanisms of superconductivity.

In the present work we study the superconductivity driven by the screened Coulomb repulsion in three-dimensional Luttinger semimetals, motivated by results on YPtBi. We show how the quadratic band touching and strong spin-orbit coupling in these semimetals affect screening, quasi-particles properties and superconductivity. Since the critical temperature is a complex function of the dielectric permittivity, we show a methodology to evidence the scattering mechanisms that are the most responsible for superconductivity.

Keywords: superconductivity, luttinger, semimetals, screening, plasmons, Friedel oscillations, correlations, quasiparticles, variational, dielectric, permittivity, Coulomb, repulsion

*Speaker

Towards gate-tunable transport in GOI technology

Tom Vethaak * [1]

[1] CEA-INAC-PHELIQS-LATEQS – , Universitey of Grenoble Alpes (UGA) – France

Germanium on insulator (GOI) is a promising platform for gate-tunable superconducting transport, due to its clean interface between the oxide and the germanium, and the low Schottky barrier to most metals. Doping can be used to reduce the spatial extension of the Schottky barrier and increase the carrier concentration, while the increased scattering due to these impurities also reduces the mobility and shortens the superconducting coherence length. By studying the behaviour of Al/Ge/Al junctions of different doping levels, we have found a regime where coherent transport occurs between leads separated by 200 nm (T $<$ 300 mK).

This work discusses the variation of the temperature at which resistance-free transport occurs with the length and the doping level of the channel, as well as the variation of the critical current with temperature and magnetic field (Fraunhofer patterns).

Keywords: germanium, germanium on insulator, GOI, gate tunable, superconductivity, transport, Fraunhofer

*Speaker

Topological phases of polaritons in a cavity waveguide

Guillaume Weick * [1]

[1] Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS) – université de Strasbourg, CNRS : UMR7504 – 23 rue du Loess - BP 43 - 67034 Strasbourg Cedex 2 - France, France

We study the unconventional topological phases of polaritons inside a cavity waveguide, demonstrating how strong light-matter coupling leads to a breakdown of the bulk-edge correspondence. We observe an ostensibly topologically nontrivial phase, which unexpectedly does not exhibit edge states. Our findings are in direct contrast to topological tight-binding models with electrons, such as the celebrated Su-Schrieffer-Heeger (SSH) model. We present a theory of collective polaritonic excitations in a dimerized chain of oscillating dipoles embedded inside a photonic cavity. The added degree of freedom from the cavity photons upgrades the system from a typical SSH SU(2) model into a largely unexplored SU(3) model. Tuning the light-matter coupling strength by changing the cavity size reveals three critical points in parameter space: when the polariton band gap closes, when the Zak phase changes from being trivial to nontrivial, and when the edge state is lost. These three critical points do not coincide, and thus the Zak phase is no longer an indicator of the presence of edge states. Our discoveries demonstrate some remarkable properties of topological matter when strongly coupled to light, and could be important for the growing field of topological nanophotonics. Ref: C.A. Downing, T.J. Sturges, G. Weick, M. Stobinska, L. Martin Moreno, arXiv:1907.02013

Keywords: topological phases of matter, topological photonics, polaritons, hybrid systems, strong light, matter coupling, bulk, edge correspondence

*Speaker

Heat Transport and Thermopower in a Single-Quantum-Dot Device

Bivas Dutta , Danial Majidi , Alvaro Garcia-Corral , Serge Florens [1], Theo Costi , Herve Courtois [2], Clemens Winkelmann * [3]

[1] Institut Néel (NEEL) – CNRS : UPR2940 – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France
[2] Université Grenoble Alpes – Université Grenoble Alpes, Université Grenoble Alpes – France
[3] Institut Néel (NEEL) – CNRS : UPR2940, Université Grenoble Alpes – 25 rue des Martyrs - BP 166 38042 GRENOBLE CEDEX 9, France

We report on measurements of the thermopower and heat transport in a gate-tunable individual single-quantum dot junction, fabricated using the electromigration technique. A pair of superconducting junctions inserted in the vicinity of the junction enables us to raise and/or monitor the electronic temperature of one of the two leads, the other one being well thermalized to the bath. Using this setup, we study the heat dissipation in the quantum-dot junction as a function of both the gate potential and the bias. The data highlights the gate-sensitivity of the thermal conductance through the quantum dot.
In the Kondo regime, we report the first measurement of the Seebeck coefficient. This fundamental thermoelectric parameter is obtained by directly monitoring the magnitude of the voltage induced in response to a temperature difference across the junction, while keeping a zero net tunneling current through the device. Striking sign changes of the Seebeck coefficient are induced by varying the temperature, depending on the spin configuration in the quantum dot [1]. The comparison with numerical renormalization group (NRG) calculations demonstrates that the tunneling density of states is generically asymmetric around the Fermi level in the leads, both in the cotunneling and Kondo regimes.
Dutta et al., Nano Lett. 19, 506 (2019)

Keywords: thermoelectricitity, thermal effects at nanoscale, Kondo effect, quantum dot

*Speaker

High-impedance microwave resonator as a quantum bus for hole spin qubits in silicon

Cécile Yu * [1], Gonzalo Troncoso Fernández-Bada [1], Simon Zihlmann [1], Romain Maurand [1]

[1] CEA-IRIG-PHELIQS – Université Grenoble Alpes – 17 rue des Martyrs, 38000 Grenoble, France

Quantum computing is a major new frontier in technology promising computing power unattainable by conventional computers. Many different materials and approaches have been explored so far, with an increasing effort on scalable implementations based on solid-state platforms. Among these, silicon is emerging as a promising route to quantum computing with true potential in terms of scalability and manufacturability. With the recent development of spin-orbit qubit based on hole in silicon [1], it is nowadays conceivable to use a microwave photon as a " quantum bus " for long distance spin-orbit qubit interaction. The strong spin/photon coupling has been recently achieved using an engineered spin-orbit interaction with electron spin in silicon [2,3] or in carbon nanotube [4], our goal here is to use the intrinsic spin-orbit term in the valence band of silicon to achieve this
coherent spin/photon coupling. Here we will present our co-integration project : a CMOS silicon spin qubits embedded in a NbN

superconducting microwave resonator. We will describe the experimental efforts to engineer the high impedance resonator in the coplanar waveguide geometry. It is the first step towards long-range coupling of hole spin qubits in silicon.

Maurand, R. et al. A CMOS silicon spin qubit. Nature Comm. 7,13575 (2016)

Samkharadze, N. et al. Strong spin-photon coupling in silicon. Science 359, 6380 (2018)

Mi, X. et al. A coherent spin–photon interface in silicon. Nature 555, 599 (2018)

Viennot, J. et al. Coherent coupling of a single spin to microwave cavity photons. Science 349, 6246 (2016)

Keywords: superconducting cavity, cqed, spin qubit

*Speaker

Strain tuning and mobility enhancement by reduction of random strain fluctuations

Lujun Wang [1], Simon Zihlmann * [1], Andreas Baumgartner [1], Jan Overbeck [1], David, I Indolese [1], Kenji Watanabe [2], Takashi Taniguchi [2], Peter Makk [1], Christian Schönenberger [1]

[1] Department of Physics and Astronomy [Basel] – Klingelbergstrasse 82, CH-4056 Basel, Switzerland
[2] National Institute for Materials Science (NIMS) – National Institute for Materials Science, Tsukuba, Ibaraki 305-0044, JAPAN, Japan

We demonstrated recently deterministic and reproducible in situ strain tuning of graphene electronic devices [1]. Central to this method is the full hBN encapsulation of graphene, which preserves the exceptional quality of pristine graphene for transport experiments. In addition, the on-substrate approach allows one to exploit strain effects in the full range of possible sample geometries and at the same time guarantees that changes in the gate capacitance remain negligible during the deformation process. We use Raman spectroscopy to spatially map the strain magnitude in devices with two different geometries and demonstrate the possibility to engineer a strain gradient, which is relevant for accessing the valley degree of freedom with pseudomagnetic fields. Furthermore, we have found that random strain fluctuations, which are present in graphene encapsulated in hBN, can be reduced by increasing the average uniaxial strain. It is well known that strain fluctuations can limit the charge carrier mobility of high quality hBN-supported graphene devices. We have found a strong correlation between an increase in mobility and a decrease in residual doping of fully hBN encapsulated graphene subjected to a global uniaxial strain [2].

Wang et al., Nano Letters, 19, 4097 (2019)

Wang et al., submitted

Keywords: graphene, strain, mobility, raman, encapsulation, hBN

*Speaker

Measure of the absorption and emission noises of a non-linear out-of-equilibrium quantum conductor

Iftikhar Zubair * [1]

[1] CEA SPEC – CEA-DRF-IRAMIS – France

The power spectral density of current fluctuations flowing through a quantum conductor is different at positive (absorption noise) and negative (emission noise) frequencies, this difference is linked by Kubo's formula to the real part of the conductor's admittance. Most attempts aiming at measuring separately the absorption and emission noise of a non-linear out of equilibrium quantum conductor where based on exploiting photon-assisted transport effects, thus imprinting the current fluctuations spectra to be measured on the I(V) curve of a test superconducting-insulator-superconducting SIS tunnel junction. Here we propose a different experimental approach: we simply measure the power exchanged between a quantum conductor and a finite frequency linear resonator whose occupation number can be externally tuned. The idea being that an empty resonator can only absorb power, and thus couples to emission noise, while a finite population of it couples unequally to the emission and absorption noise of the junction. A careful calibration of the population of the resonator thus allows extracting both quantities from power exchange measurements at different populations. This work did not only allowed us to measure absorption noise with a generic method but also stresses the physical meaning of Kubo formula, which coupled to a quantum description of the measurement setup (Lesovik & Loosen) provides a quantum version of Joule's theorem.

Keywords: finite frequency measure, Kubo relation, SIS

*Speaker

Spin-Orbit induced phase-shift in Bi2Se3 Josephson junctions

Herve Aubin * [1], Alexandre Assouline [2], Cheryl Feuillet-Palma [2], Nicolas Bergeal [2], Tianzhen Zhang [2], Alireza Mottaghizadeh , Alexandre Zimmers [2], Emmanuel Lhuillier [3], Mahmoud Eddrief [3], Paola Atkinson [3], Marco Aprili [4]

[1] Centre de Nanosciences et Nanotechnologies (C2N) – CNRS : UMR9001 – 10 Boulevard Thomas Gobert, 91120 Palaiseau, France
[2] Laboratoire de Physique et dÉtude des Matériaux (LPEM) – ESPCI ParisTech, Sorbonne Universite, Centre National de la Recherche Scientifique : UMR8213 – 10 rue Vauquelin, 75231 Paris cedex 05, France
[3] Institut des Nanosciences de Paris (INSP) – Sorbonne Universite, Centre National de la Recherche Scientifique : UMR7588 – Sorbonne-Université, Case 840 4 place Jussieu 75252 Paris Cedex 05, France
[4] Laboratoire de Physique des Solides (LPS) – umr 8502 – Orsay, France

In normal materials with strong spin-orbit coupling and broken inversion symmetry, a charge current leads to a spin-polarized Fermi surface, the so-called Edelstein effect. Reciprocally, a dynamic spin polarization leads to a charge current, i.e. the inverse Edelstein effect. For superconducting Josephson junctions made from materials with strong spin-orbit coupling, even a static spin polarization leads to a superfluid current as a consequence of the inverse Edelstein effect. In Josephson interferometers, this superfluid current is manifested as an anomalous phase shift.
In this talk, I will present our study of hybrid SNS Josephson junctions and Josephson interferometers fabricated with Bi2Se3, a topological material with strong spin-orbit coupling. Simultaneous measurements of two interferometers oriented differently with an in-plane magnetic field enabled the observation of an anomalous phase shift. From the amplitude of the anomalous phase shift, one can conclude that the major contribution to the anomalous superfluid current in the Josephson junction arises from the bulk electrons in the conduction band, spin-splitted by the Rashba effect. We extract a value a=0.38 eVA for the Rashba coefficient[1], in agreement with photoemission results.

References

Assouline, A. *et al.* Spin-Orbit induced phase-shift in Bi2Se3 Josephson junctions. *Nat. Commun.* **10**, 126 (2019).

Keywords: superconductivity, Josephson, SQUID, Edelstein

*Speaker

Dynamically induced 0-Pi transition in a carbon nanotube-based Josephson junction

Diana Watfa * [1], Raphaëlle Delagrange , Alik Kasumov , Raphael Weil , Meydi Ferrier , Hélène Bouchiat , Richard Deblock

[1] Laboratoire de Physique des Solides – Université Paris-Sud - Paris 11, Centre National de la Recherche Scientifique : UMR8502 – France

Even though carbon nanotube (CNT) itself is not superconducting, contacting the tube between two superconducting contacts make it possible to induce superconductivity through it. This makes it an ideal model system for studying electronic transport and investigating the competition between two important effects in condensed matter: the Kondo effect and superconducting proximity effect. The Kondo effect is a many-body interaction between a localized impurity spin and free conduction electrons leading to the screening of the impurity spin and the appearance of a Kondo resonant state at the Fermi energy of the contacts. In this work, we have measured the DC Josephson current and AC Josephson emission of a CNT Josephson junction. The AC emission is probed by coupling the CNT to an on-chip detector (a Superconductor-Insulator-Superconductor (SIS) junction), via a coplanar waveguide resonator. The measurement of the photo-assisted current of the SIS junction gives direct access to the signal emitted by the CNT. We focus on the gate regions that exhibit Kondo features in the normal state. We demonstrate that, strikingly, when the DC supercurrent is enhanced by the Kondo effect, the AC Josephson effect is strongly reduced. This could be explained by a dynamically induced quantum transition between a singlet and a doublet state leading to a 0-Pi transition

Keywords: carbon nanotube, Kondo effect, Josephson effect

*Speaker

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Aussois

2 au 4 décembre 2019

Anthore Anne	C2N - CNRS, Palaiseau	anne.anthore@univ-paris-diderot.fr
Aprà Agostino	CEA, Grenoble	apraagostino@gmail.com
Atteia Jonathan	LPS, Orsay	jonathan.atteia@gmail.com
Aubin Hervé	C2N - CNRS, Palaiseau	herve.aubin@c2n.upsaclay.fr
Avriller Rémi	LOMA, Bordeaux	remi.avriller@u-bordeaux.fr
Basko Denis	LPMMC, Grenoble	denis.basko@lpmmc.cnrs.fr
Basset Julien	LPS, Orsay	julien.basset@u-psud.fr
Bauerle Christopher	Institut Néel, Grenoble	christopher.bauerle@neel.cnrs.fr
Berdou Camille	ENS Lyon	camille.berdou@phys.ens.fr
Bergeal Nicolas	ESPCI-LPEM, Paris	nicolas.bergeal@espci.fr
Bienfait Audrey	ENS Lyon	abienfait@uchicago.edu
Brasseur Paul		
Bretheau Landry	LSI, Palaiseau	landry.bretheau@polytechnique.edu
Carpentier David	ENS Lyon	David.Carpentier@ens-lyon.fr
Chatzikyriakou Eleni	CEA-PHELIQS/LaTEQS, Grenoble	eleni.chatzikyriakou@univ-grenoble-alpes.fr
Coissard Alexis	Institut Néel, Grenoble	alexis.coissard@neel.cnrs.fr
Courtois Hervé	Institut Néel, Grenoble	herve.courtois@grenoble.cnrs.fr
Dassonneville Rémy	Lab. de Physique, ENS Lyon	remy.dassonneville@ens-lyon.fr
David Anthony	CEA-PHELIQS/LaTEQS, Grenoble	anthony.david.phy@gmail.com
Deblock Richard	LPS, Orsay	deblock@lps.u-psud.fr
Degiovanni Pascal	ENS , Lyon	pascal.degiovanni@ens-lyon.fr
Déprez Corentin	Institut Néel, Grenoble	corentin.deprez@neel.cnrs.fr
Dou Ziwei	LPS, Orsay	willziweidou@gmail.com
Duprez Hadrien	C2N - CNRS, Palaiseau	hadrien.duprez@u-psud.fr
Dutreix Clément	LOMA, Bordeaux	clement.dutreix@u-bordeaux.fr
Essig Antoine	ENS Lyon	antoine.essig@ens-lyon.fr
Gabelli Julien	LPS, Orsay	gabelli@lps.u-psud.fr
Garcia-Sanchez Daniel	INSP, Paris	daniel.garcia-sanchez@insp.upmc.fr
Garnier Maxime	LPS, Orsay	maxime.garnier1@u-psud.fr
Gennser Ulf	C2N - CNRS, Palaiseau	ulf.gennser@c2n.upsaclay.fr
Goerbig Mark Oliver	LPS, Orsay	goerbig@lps.u-psud.fr
Goffman Marcelo	CEA-SPEC, Quantronique, Saclay	marcelo.goffman@cea.fr
Graf Ansgar	LPS, Orsay	ansgra95@gmail.com
Grenèche Jean-Marc	(GDR) Suivi des Groupements de Recherche	jean-marc.greneche@cnrs.fr
Groth Christoph	CEA/IRIG/PHELIQS, Grenoble	christoph.groth@cea.fr
Gueron Sophie	LPS, Orsay	sophie.gueron@u-psud.fr
Guerra Marco	Institut Néel, Grenoble	marco.guerra@neel.cnrs.fr
Houzet Manuel	CEA/IRIG/PHELIQS, Grenoble	manuel.houzet@cea.fr

Jalabert Thomas	CEA/IRIG/PHELIQS, Grenoble	thomas.jalabert@cea.fr
Jansen Louis	CEA/IRIG/PHELIQS, Grenoble	louis.jansen@cea.fr
Kaladzhyan Vardan	KTH Royal Institute of Technology, Stockholm	vardan.kaladzhyan@phystech.edu
Lacerda Santos Neto	CEA/IRIG/PHELIQS, Grenoble	antoniosnl@hotmail.com
Lamic Baptiste	CEA/IRIG/DEPHY/PHELIQS/GT, Grenoble	baptiste.lamic@gmail.com
Lefloch François	CEA-PHELIQS/LaTEQS, Grenoble	francois.lefloch@cea.fr
Leghtas Zaki	Mines ParisTech / ENS Paris	zaki.leghtas@mines-paristech.fr
Lu Xin	LPS, Orsay	xin.lu@u-psud.fr
Macek Marjan	CEA-PHELIQS/Quantum theory group	marjan.macek@cea.fr
Maillet Olivier	Low Temperature Laboratory, Aalto University	ol.maillet@gmail.com
Mailly Dominique	C2N - CNRS, Palaiseau	dominique.mailly@c2n.upsaclay.fr
Marguerite Arthur	Weizmann Institute of Science, Rehovot	arthur.marguerite@weizmann.ac.il
Maurand Romain	CEA/IRIG/PHELIQS, Grenoble	romain.maurand@cea.fr
Mauro Lorenzo	LOMA, Bordeaux	lorenzo.mauro@u-bordeaux.fr
Meetzger Cyril	CEA-SPEC, Saclay	cyril.metzger@cea.fr
Ménard Gerbold	CEA-SPEC, Saclay	menard@insp.upmc.fr
Mesple Florie	CEA/IRIG/PHELIQS, Lateqs, Grenoble	florie.mesple@cea.fr
Meyer Julia	CEA/IRIG/PHELIQS, Grenoble	julia.meyer@univ-grenoble-alpes.fr
Montambaux Gilles	LPS, Orsay	gilles.montambaux@u-psud.fr
Mora Christophe	MPQ, Paris	christophe.mora@phys.ens.fr
Mukherjee Dibya	LPS, Orsay	dibyakantimukherjee@gmail.com
Niquet Yann-Michel	CEA/IRIG/MEM/L_Sim, Grenoble	yniquet@cea.fr
Orignac Edmond	Laboratoire de Physique, ENS Lyon	edmond.orignac@ens-lyon.fr
Palacio Morales Alexandra	LPS, Orsay	alexandra.palacio-morales@u-psud.fr
Parmentier François	CEA-SPEC, Saclay	francois.parmentier@cea.fr
Peyruchat Léo	Flux quantum lab, Paris	lpeyruchat@gmail.com
Pillet Jean-Damien	LSI, Palaiseau	jean-damien.pillet@polytechnique.edu
Pinon Sarah	CEA Saclay/IPhT, Gif-sur-Yvette	sarah.pinon@ipht.fr
Piot Nicolas	CEA-PHELIQS, Grenoble	nicolas.piot@cea.fr
Pistolesi Fabio	LOMA, Bordeaux	fabio.pistolesi@u-bordeaux.fr
Plaçais Bernard	LPA, Paris	bernard.placais@phys.ens.fr
Pothier Hugues	CEA-SPEC, Quantronique, Saclay	hugues.pothier@cea.fr
Quesnel Guillaume	Institut Néel, Grenoble	guillaume.quesnel19@gmail.com
Renard Vincent	CEA-PHELIQS, Grenoble	vincent.renard@cea.fr
Roch Nicolas	Institut Néel, Grenoble	nicolas.roch@neel.cnrs.fr
Roche Patrice	CEA-SPEC, Quantronique, Saclay	patrice.roche@cea.fr
Rodriguez Ramiro	Flux Quantum Lab, Paris	19.rodriguez.89@gmail.com
Sacépé Benjamin	Institut Néel, Grenoble	benjamin.sacepe@neel.cnrs.fr

Safi Ines	LPS, Orsay	ines.safi@gmail.com
Sankar Sarath	CEA, Grenoble	sarath1990sankar@gmail.com
Schaeverbeke Quentin	LOMA, Bordeaux	qschaeverbeke@me.com
Szombati Daniel	Laboratoire de Physique, ENS Lyon	daniel.szombati@ens-lyon.fr
Tarento René-Jean	LPS, Orsay	tarento@lps.u-psud.fr
Tchoumakov Sergueï	Institut Néel, Grenoble	sergueits@gmail.com
Troncoso Gonzalo	CEA/IRIG/PHELIQS, Grenoble	gonzalo.troncosofernandez-bada@cea.fr
Vethaak Tom	CEA-INAC-PHELIQS-LATEQS, Grenoble	Tom.Vethaak@cea.fr
Waintal Xavier	CEA-PHELIQS, Grenoble	xavier.waintal@cea.fr
Watfa Diana	LPS, Orsay	watfa.diana94@gmail.com
Weick Guillaume	IPCMS, Strasbourg	Guillaume.Weick@ipcms.unistra.fr
Winkelmann Clemens	Institut Néel, Grenoble	clemens.winkelmann@grenoble.cnrs.fr
Yu Cécile	CEA/IRIG/PHELIQS, Grenoble	cecile.yu@cea.fr
Zihlmann Simon	CEA/IRIG/PHELIQS, Lateqs, Grenoble	zihlmann.simon@gmail.com
Zubair Iftikhar	CEA/SPEC, Gif-sur-Yvette	zubair.iftikhar@cea.fr