The 20th Capri Spring School on Transport in Nanostructures 2026

<table>
<tr><th></th><th>Sunday
12.04.2026</th><th>Monday
13.04.2026</th><th>Tuesday
14.04.2026</th><th>Wednesday
15.04.2026</th><th>Thursday
16.04.2026</th><th>Friday
17.04.2026</th><th>Saturday
18.04.2026</th></tr>
<tr><td>Chair</td><td rowspan="11">Registration Hotel Senaria

18:50-19:30</td><td>Schönenberger</td><td>De Martino</td><td>Bercioux</td><td>Fazio</td><td>Egger</td><td rowspan="12">Departure</td></tr>
<tr><td>9:00-9:55</td><td>F. Tafuri</td><td>P. Brouwer</td><td>S. Gueron</td><td>A. Hofmann</td><td>Y. Nazarov</td></tr>
<tr><td>10:00-10:55</td><td>C. Morais Smith</td><td>G. Platero</td><td>C. Beenakker</td><td>A. Yacoby</td><td>S. Trebst</td></tr>
<tr><td>11:00-11:30</td><td colspan="5">Coffee Break & Poster Session</td></tr>
<tr><td>11:30-12:25</td><td>F. von Oppen</td><td>K. Flensberg</td><td>A. Levy Yeyati</td><td>N. Poccia</td><td>N. Andrei</td></tr>
<tr><td>13:00-16:00</td><td colspan="5">Lunch Break</td></tr>
<tr><td>Chair</td><td>Egger</td><td>Lucignano</td><td rowspan="5">Free Afternoon</td><td>Bercioux</td><td>De Martino</td></tr>
<tr><td>16:00-16:55</td><td>T. Schmidt
S.Maji</td><td>A. Nava
A. Jimeno-Pozo</td><td>A. Stern</td><td>D. Oriekhov
J. Zijderveld</td></tr>
<tr><td>17:00-17:30</td><td colspan="2">Coffee Break & Poster Session</td><td colspan="2">Coffee Break & Poster Session</td></tr>
<tr><td>17:30-18:25</td><td rowspan="2">Official Poster Session</td><td>V. Koenye
G. Lemut</td><td>T. Martin
N. Demazure</td><td>E. Andriyakhina
A.L. Rigotti Maresco</td></tr>
<tr><td>18:30-19:30</td><td>W. Samuelson
F. Vinas Bostroem</td><td>H. Lyu
C. Duse</td><td>I. Verstraeten
Y. Wang</td></tr>
<tr><td>20:00 Dinner</td><td>Le Arcate</td><td>Le Arcate</td><td>Le Arcate</td><td>Free dinner</td><td>Le Arcate</td><td>Le Arcate</td></tr>
</table>

Monday session

F. Tafuri (Università di Napoli Federico II): *Hybrid Josephson junctions opportunity for quantum hardware and science advance* (50+5 min)

Superconducting systems are a natural and versatile platform for a variety of applications including quantum technologies, and are of undoubtful inspiration also for the development of novel notions in solid state physics. Josephson junctions (JJs) are key structures, because of their unique properties, of their potential to manipulate the macroscopic wave function of a condensate and of their extreme flexibility as circuit elements. Progress in material science and nanofabrication gives opportunities to create unique hybrid JJs which can be smartly integrated in complex architectures, paving the way to novel effects and novel avenues for quantum control and detection. We will discuss some aspects of the frontiers of the Josephson effect discussing examples of unique solutions to cutting edge problems in condensed matter physics as well as to very advanced applications, including in the field of quantum computing. An integrated quantum device can be better than the sum of its ingredients. We will report on special properties of hybrid JJs on how to engineer the macroscopic phase in quantum circuits, including unconventional systems, which make possible alternative layouts for the superconducting modules inside a more general architecture also through a comparative study of fluctuations and of electro-dynamical properties. The diversity in Josephson junctions opens 'horizons'. Much remains to be done!

C. Morais Smith (Utrecht University): (50+5 min)

F. von Oppen (Freie Universität Berlin): *Exciton condensates in quantizing magnetic fields* (50+5 min)

Exciton condensates in quantizing magnetic fields were already studied in the early days of the quantum Hall effect. Recent experiments have provided evidence for exciton insulators in electron-hole bilayers in heterobilayers of transition metal dichalcogenides. In this talk, I will discuss exciton condensates in quantizing magnetic fields in view of these recent experiments.

Monday session

T. Schmidt (University of Luxembourg): *Quantum-Hall-Superconductor Interfaces* (20+5 min)

We study interfaces of quantum Hall states and type-II superconductors, which have been proposed as a platform to realize Majorana and parafermionic bound states for topological quantum computation. In particular, we investigate geometries where a superconducting nanowire is coupled to a pair of QH edge states. Firstly, we show that this geometry can be regarded as a superconducting analog of a Hong-Ou-Mandel inferferometer, which has become an important experimental tool to characterize the exchange statistics of Laughlin quasiparticles of QH states. We show that interference signatures in such a superconducting interferometer can be used to study the interplay of exchange statistics and Andreev reflection processes [1]. Moreover, due to the smallness of the superconductor, one expects fluctuations of the superconducting order parameter to be significant in such devices. Using a combination of analytical methods (bosonization and conformal field theory) and numerical methods (DMRG), we investigate the phase diagram of superconducting pairing with order parameter fluctuations on a pair of fractional QH states at filling factor $\nu = 2/3$, as a potential platform to realize $\mathbb{Z}_3$ parafermions [2].

[1] Maxime Jamotte, Tom Menei, Manohar Kumar, Alexander Zyuzin, and Thomas L. Schmidt, to be submitted.
[2] Steffen Bollmann, Andreas Haller, Jukka I. Vayrynen, Thomas L. Schmidt, and Elio J. Konig, arXiv:2510.26686 [cond-mat.str-el]

S.Maji (AGH University of Krakow): *Mixing of edge modes in a quantum Hall system proximitized by a superconductor* (20+5 min)

The semiconductor-superconductor hybrid nanostructures in the Quantum Hall regime spurred interest in the last few years as a possible platform to design different topological phases. The edge states formed at the quantum hall domain can couple with the superconductor via processes such as Andreev reflection and form hybridized electron-hole states, referred to as Chiral Andreev Edge States (CAESs) [1]. Under specific conditions, CAESs are expected to be self-conjugate, reducing to chiral Majorana edge modes, which are the building blocks of the fault-tolerant quantum computer [2]. In this work, we systematically investigate the transport properties of the CAESs in superconductor-proximitized quantum Hall systems under different spin effects, such as Zeeman interaction and spin-orbit (SO) coupling. Unlike QH systems, conductance measurements show oscillatory behaviour in QH-SC system, which can be explained by the phase-dependent electron-hole conversion probability [3]. The conductance oscillations as a function of chemical potential or magnetic field are well described by the analytical probability expression, which is a function of the QH-SC interface length and the zero-energy wave-vector difference of the CAES pair. Zeeman field applied to different directions splits the CAES pair in spin branches, and the wave-vector difference extracted from either of them continues to describe the oscillatory nature. SO coupling introduces mixing between CAES modes. Transport becomes multi-mode although the oscillatory behaviour of conductance persists. Injected electron in one mode can transmit into other CAES modes in the presence of SO coupling, which reveals non-zero transmission probability. Similar calculations are performed for ν > 2 regimes which shows complex oscillations. Moreover, non-zero transmission is observed between electron and hole channels. In summary, we show that the mode-mixing in this QH-SC system for a higher filling-factor or under the effect of SO coupling is the key factor that determines the transport of proximitized edge states, offering a new aspect on it.

[1] Y. Takagaki, Phys. Rev. B **57**, 4009 (1998)
[2] S. Maji, M. P. Nowak, Phys. Rev. B **112**, 195422 (2025)
[3] Lingfei Zhao et. al, Nat. Phys, **16**, 862 (2020)

The 20th Capri Spring School on Transport in Nanostructures 2026

Tuesday sesion

P. Brouwer (Freie Universität Berlin): *Proximity superconductivity in chiral Kagome antiferromagnets* (50+5 min)

Recent experiments on the chiral Kagome antiferromagnet Mn_3Ge have provided strong evidence of proximity-induced spin-polarized superconductivity. We introduce and explore a minimal model which exhibits a rich phase diagram as a function of chemical potential and spin canting. We find a valley-singlet superconducting phase for chemical potentials and canting consistent with the experimental system. This phase transitions into a Chern insulator at larger canting and gives way to topological superconducting phases with Chern numbers CBdG = ±1, ±3 at other chemical potentials. Our results show that proximity-induced superconductivity in Kagome antiferromagnets is a promising route towards superconductivity with spin-polarized Cooper pairs.

G. Platero (Materials Science Institute of Madrid, CSIC): *Quantum state transfer in low-dimensional lattices* (50+5 min)

The recent fabrication and control of semiconductor quantum dot arrays open the possibility to use these systems as quantum links between distant sites in a quantum processor. Their task is the transfer of quantum information between distant sites, an indispensable part of large-scale quantum information processing[1,2]. Also, the recent implementation of quantum dot arrays has shown their feasibility as quantum simulators of complex lattices[3]. Recently, it has been shown how to imprint non trivial topology in a quantum dot array by means of Floquet engineering [4]. In this talk I will briefly review the different protocols to transfer particles and quantum states in quantum dot arrays.Then, I will discuss an alternative way to transfer information with high fidelity, by using robust edge states in systems with nontrivial topology [5,6]. I will discuss the long-range particle transfer mediated by edge states in different atomic array configurations and the role of topological domain walls to speed up the transfer [7]. I will first consider the simplest topological insulator, a dimer chain, in which the domain walls are induced by changing the hopping amplitude dimerization. Then, I will discuss the Creutz-Ladder model [7,8], where the domain walls can hold two topological states. It allows to use one as a quantum memory while the other transfers information through the wall, allowing for complex transfer operations between topological states. Finally, a protocol for entanglement generation between distant qubits, mediated by a topological lattice, the stub-SSH, will show the feasibility of these systems to transfer information and generate entanglement with high fidelity.

[1] D. Fernández-Fernández *et al.*, Quantum **8**,1533 (2024)
[2] M. De Smet *et al.*, Nature Nanotech. **20**,866 (2025)
[3] M. Kiczynski *et al.*, Nature **606**, 694 (2022); C.J. van Diepen et al., PRX **11**, 041025 (2021)
[4] B. Pérez-González *et al.*, Phys. Rev. Lett. **123**, 126401 (2019)
[5] N. Lang *et al.*, npj QI., **3**, 47 (2017); F. Mei et al., Phys Rev A **98**, 012331 (2018)
[6] J. Zurita, C. E. Creffield, G. Platero, Quantum **5**, 591 (2021)
[7] J. Zurita *et al.*, Quantum **7**, 1043 (2023); J. Zurita *et al.*, Quantum **9**, 1625 (2025)
[8] Y. He et al., Phys. Rev. Lett. **126**, 103601 (2021)

K. Flensberg (Niels Bohr Institute): *Signatures of non-Hermitian effect in multiterminal hybrids* (50+5 min)

The talk discusses signatures of non-Hermitian physics in superconducting multiterminal hybrids. In the first part, we discuss how exceptional points are visible in tunneling spectroscopy and how to classify them as fragile or robust in terms of their topology. The second part deals with signatures of non-Hermitian skin effect in nonlocal transport and how to distinguish this from other sources of non-reciprocal conductance.

Tuesday session

A. Nava (HHU - Universität Düsseldorf): *Markovian Mpemba and Pontus-Mpemba effects in open nonequilibrium quantum systems* (20+5 min)

We generalize the classical thermal Mpemba effect (where an initially hot system relaxes faster to the final equilibrium state than a cold one) to open quantum systems coupled to several reservoirs. We show that, in general, two different types of quantum Mpemba effects are possible. They may be distinguished by quantum state tomography. However, the existence of a quantum Mpemba effect (without determining the type) can already be established by measuring simpler observables such as currents or energies. We illustrate our general results for experimentally feasible cases. Furthermore, following a strategy of fishermen in Pontus described by Aristotle, we introduce the Pontus-Mpemba effect as a two-step protocol, which includes the time needed for preparing the system in the "far" initial state. For Markovian (classical or quantum) systems coupled to multiple reservoirs, all possible Pontus-Mpemba effects fall into three classes. The theory is applied to open two-state systems where all three classes can be realized.

A. Jimeno-Pozo (Donostia International Physics Center): *Polarized phases and chiral superconductivity in multilayer graphene* (20+5 min)

Rhombohedral multilayer graphene hosts a rich interplay of interaction-driven phases due to its narrow bands and enhanced electronic correlations. Electron-electron interactions can stabilize a variety of spin- and valley-polarized phases across multilayer graphene, revealing a broad landscape of flavour symmetry breaking. Superconducting instabilities arising from repulsive interactions within a Kohn–Luttinger–RPA framework support unconventional pairing in these materials. Focusing on rhombohedral tetralayer graphene, an improved treatment of interactions and screening provides a more realistic description of the normal state and favours a chiral superconducting phase near polarized metallic states. These results highlight the intimate connection between band renormalization, flavour polarization, and unconventional superconductivity in graphene multilayers.

V. Koenye (University of Amsterdam): *Alterelectrics: The Electric Counterpart of Altermagnets* (20+5 min)

Altermagnets are a new class of materials that mix features of both ferromagnets and antiferromagnets. They have spin-split bands like ferromagnets but still show no net magnetization. Their underlying symmetries also lead to unusual effects, such as a strong piezomagnetic effect and hyperbolic wave dispersion. This raises an important question: which of these behaviors actually come from magnetism, and which are simply a result of symmetry? In this work, we separate these two aspects by proposing a non-magnetic analogue of an altermagnet, built from polarized chains. These “alterelectrics” show anisotropic piezoelectricity and surface states with hyperbolic wave dispersion, demonstrated through a simple model. Instead of spin-split bands, the electronic states localize on opposite surfaces, producing strongly anisotropic, surface-dependent transport.

G. Lemut (Freie Universität Berlin): *Step-Edge Anomaly in Topological Metals* (20+5 min)

Bulk–boundary correspondence guarantees the presence of robust, anomalous states on the boundary of topological matter. The edges of a two-dimensional Chern insulator harbor one-dimensional chiral states, which have a conductance $n\, e2/h$, where n is an integer that is solely determined by the bulk. In this work we show that step edges on the surface of three-dimensional topological metals realize anomalous chiral states with a robust fractional conductance Ke2/h, where K is also fixed by the bulk and assumes non-integer values. We explain this prediction rigorously on the basis of the topology of gapless systems, exemplify it on a lattice model, and connect to recent experimental observations of enhanced density of states at step-edge in topological metals.

The 20th Capri Spring School on Transport in Nanostructures 2026

Tuesday session

W. Samuelson (Lund University): *Quantifying robustness and locality of Majorana bound states in interacting systems* (20+5 min)

Protecting qubits from perturbations is a central challenge in quantum computing. Topological superconductors with separated Majorana bound states (MBSs) provide a strong form of protection that only depends on the locality of perturbations. While the link between MBS separation, robust degeneracy, and protected braiding is well understood in non-interacting systems, recent experimental progress in short quantum-dot-based Kitaev chains highlights the need to establish these connections rigorously for interacting systems. In this talk, I will discuss how this can be done by defining MBSs from many-body ground states and show how their locality constrains their coupling to an environment. This, in turn, quantifies the protection of the energy degeneracy and the feasibility of non-abelian braiding.

F. Vinas Bostroem (Niels Bohr Institute): *Spin-orbit coupling in germanium-based super-semi structures* (20+5 min)

Germanium has recently gained attention for use in quantum technology for several reasons: it can be grown in controllable SiGe/Ge stacks, controlled electrically, and can be isotopically purified minimize hyperfine interaction. Germanium holes have exceptionally large mobility, exhibit strong spin-orbit coupling, as well as tunable g-factors. Proximitized germanium has proven to host a hard superconducting gap, making this an excellent candidate for super-semi devices. Using kp Hamiltonians (Luttinger-Kohn) for germanium hole bands, as well as tight-binding methods, I investigate properties for SN and SNS junctions. The heavy hole and the light hole bands have different magnitude of effective pairing in proximitized germanium, which we suggest could be seen from conductance measurements. To model SNS junctions and Andreev spin qubits properly we investigate how so-called “direct Rashba” is affected by confinement and applied electrical fields. In contrast to using an effective (often unknown) Rashba term, this gives possible control knobs for Andreev spin qubits, and other germanium-based super-semi quantum devices.

Wednesday session

S. Gueron (Laboratoire de Physique des Solides): *Probing Topology with Mesoscopic Physics* (50+5 min)

Second Order Topological Insulators (SOTIs) are a new family of materials, predicted to be insulating in the bulk and surfaces, and perfectly conducting along dimensional crystal hinges. Similarly to Quantum Spin Hall edges states in 2D Topological Insulators, the hinge states are expected to carry current with no dissipation and no backscattering, due to their unique spin-momentum-locked configuration, also called helicity. I will present mesoscopic physics experiments that have uncovered the special properties of SOTIs. In particular, I will explain why induced superconductivity was instrumental to the discovery that Bismuth was a Second Order Topological Insulator [1-5]. I will also present recent extension to new SOTI materials [6,7] and to non- superconducting contacts, as well as to the investigation of the current-induced spin polarization due to spin-momentum locking in the hinge states [8]. Finally, I will present a new detection scheme of orbital currents in 2D materials [9], that has the potential to reveal persistent currents circulating at the hinges of a mesoscopic SOTI crystal.

[1] Schindler *et al.*, Nat. Phys. **14**, 918 (2018).
[2] Murani *et al.*, Nat. Comm. **8**,15941 (2017).
[3] Beenakker, https://www.condmatjclub.org/uploads/2018/03/JCCM_March_2018_01.pdf
[4] Murani *et al.*, Phys.Rev. B **96**, 165415 (2017) ; Phys. Rev. Lett. **122**, 076802 (2019).
[5] Bernard *et al.*, Nat. Phys. **19**, 358 (2023).
[6] Lefeuvre *et al.*, Phys. Rev X **16**, 011031 (2026).
[7] Ballu *et al.*, to be published in Phys. Rev. Research (2026).
[8] Bard et al, in preparation.
[9] Vallejo Bustamante *et al.*, Science **374**, 1399 (2021); Phys. Rev. Lett. **131**, 116201 (2023). This work is a collaborative work conducted in the Mesoscopic Physics group in Orsay.

C. Beenakker (Leiden University): *Tangent fermion Luttinger liquid* (50+5 min)

We present a"tangent fermion" method to discretize the Hamiltonian of a helical Luttinger liquid on a one-dimensional lattice, including two-particle backscattering processes that may open a gap in the spectrum. The fermion-doubling obstruction of the sine dispersion is avoided by working with a tangent dispersion, preserving the time-reversal symmetry of the Hamiltonian. The numerical results from a tensor network calculation on a finite lattice confirm the expectation from infinite-system analytics, that a gapped phase with spontaneously broken time-reversal symmetry emerges when the Fermi level is tuned to the Dirac point and the Luttinger parameter crosses a critical value.

A. Yeyati (Universidad Autónoma de Madrid): *Andreev physics: from transport to qubits* (50+5 min)

Andreev processes provide the foundation for our understanding of transport in hybrid superconducting devices. This framework is now being challenged by novel experimental regimes that probe Andreev physics at high magnetic fields or in quantum circuits where large phase fluctuations play a central role. In this presentation, I will discuss recent work by our group along these two directions. First, I will examine transport mediated by chiral Andreev states in a proximitized two-dimensional electron gas (2DEG) in the quantum Hall regime, and the possible emergence of topological superconducting phases in these systems [1]. In the second part, I will discuss multiterminal, high-transparency Josephson junctions that form quantum circuits and analyze their potential as protected Andreev qubits [2,3].

[1] Y. Baba, A. Levy Yeyati and P. Burset, arXiv:2507.14074
[2] F.J. Matute-Cañadas, L. Tosi and A. Levy Yeyati, PRX Quantum **5**, 020340 (2024)
[3] J. Caceres, F.J. Matute-Cañadas, D. Sanz Marco, J. Ortuzar, E. Flurin, C. Urbina, H. Pothier, A. Levy Yeyati and M.F. Goffman (in preparation)

The 20th Capri Spring School on Transport in Nanostructures 2026

Thursday session

A. Hofmann (University of Basel): *Hybrid Superconductor-Semiconductor Quantum Devices* (50+5 min)

I will give a quick introduction to transport properties of semiconductors and superconductors, before going into detail about the physics that can be observed when combining the two material systems. I will introduce the better-known workhorse for super-semi devices, InAs, and then present Ge, a material system that has gained increased attention in recent years.

A. Yacoby (Harvard University): *Local Probes of Spin Excitations in Quantum Matter* (50+5 min)

Over 50 years ago Halperin and Hohenberg [1] predicted that certain magnetic systems behave analogously to liquid Helium. In this talk I will describe some of our recent work that uses NV center magnetometry to explore spin excitations in layered magnets. By employing different measurement modalities we are able to directly observe signatures of magnon hydrodynamics and magnon second sound which is analogous to second sound in superfluid liquid Helium. Finally by directly detecting coherent spin waves we are able to devise a new scattering platform for exploring mesoscopic magnetism.

[1] Halperin and Hohenberg, Physical Review 188, 898 (1969)

N. Poccia (University of Naples "Federico II" & IFW-Dresden): *Searching for control and scaling-up the energies in cuprate superconducting twistronics* (50+5 min)

High temperature superconducting complex oxides ($La_{2-x}Sr_xCuO_4$, $YBa_2Cu_3O_{7-x}$, $Bi_2Sr_2CaCu_2O_{8+x}$) are complex quantum materials where dominant states are not spatially homogeneous [1]. The quantum melted electronic crystal [2] lives in a heterogeneous landscape of “puddles” [3], correlated to a complex phase diagram [4]. Some of the interest in these materials now centers less on nitrogen-range T_C: and is progressively less motivated by achieving higher superconducting critical temperatures than before, but more on controlling this unparalleled and still-mysterious electronic state. Four decades of materials progress have clarified both limitations and enormous potential of these superconducting quantum materials, including their dominant *d*-wave order nature from grain-boundary junctions [5] and interference experiments [6], flourishing in an early attempt to demonstrate macroscopic quantum tunneling and energy level quantization in bicrystal grain-boundary $YBa_2Cu_3O_{7-x}$ junctions [7]. However, the characteristic voltage parameter of cuprate Josephson junctions, $I_C R_n$, remained for long-time in the low values of 0.5–2 meV, hindering their potential in the second quantum revolution. Based on recent material science breakthrough with cryogenic stacking technologies [8], it was measured a forward jump to 20–25 meV in a comparable twist-angle junction, using $Bi_2Sr_2CaCu_2O_{8+x}$ crystals and a wide *d*-wave angular dependence was observed. I will therefore discuss our understanding of the intrinsic fragility of these systems, the new phenomenology discovered and the electrical engineering challenges that we are addressing [9] for potential superconducting quantum technologies [10].

[1] Elbio Dagotto, Science **309**, 257 (2005).
[2] Eduardo Fradkin *et al.,*Annu. Rev. Condens. Matter Phys. **1**,.153 (2010).
[3] Michela Fratini *et al.*, Nature **466**, 841 (2010).
[4] Bernhard Keimer *et al.*, Nature **518**, 179 (2015).
[5] Hans Hilgenkamp & Jochen Mannhart, Rev. Mod. Phys. **74**, 485(2002).
[6] Dale Van Harlingen, Rev. Mod. Phys. **67**, 515 (1995).
[7] Thilo Bauch *et al.*, Science **311**, 57 (2006).
[8] SY Zhao *et al.*, Science **382**, 1422 (2023).
[9] Tommaso Confalone *et al.*, Small **21**, e06520 (2025)
[10] Valentina Brosco *et al.*, Phys. Rev. Lett.**132**, 017003 (2024).

The 20th Capri Spring School on Transport in Nanostructures 2026

Thursday session

A. Stern (Weizmann Institute of Science): *tba* (50+5 min)

tba

T. Martin (Centre de Physique Théorique, Aix Marseille Univ): *Anyon Braiding on the Single Edge of a Fractional Quantum Hall State* (20+5 min)

Anyons are quasiparticles with fractional statistics, bridging between fermions and bosons. We propose an experimental setup to measure the statistical angle of topological anyons emitted from a quantum point contact (QPC) source. The setup involves an Ω-shaped junction along a fractional quantum Hall liquid edge, formed by defining a droplet with two negatively biased gates. In the weak tunneling regime, we calculate the charge current, showing its time evolution depends solely on the anyons' statistical properties, with temperature and scaling dimension affecting only the constant prefactor. We compute the crosscorrelation between the anyon current transmitted from the source and the current after the Ω junction, providing a direct method to detect anyon braiding statistics (Phys. Rev. Lett. **135**, 146601 (2025)).

N. Demazure (Centre de Physique Théorique, Aix Marseille Univ): *Charging energy effects on a single-edge anyon braiding detector* (20+5 min)

We propose a setup to directly measure the anyonic statistical angle on a single edge of a fractional quantum Hall system, without requiring independent knowledge of non-universal parameters. We consider a Laughlin edge state bent into a closed loop geometry, where tunneling processes are controllably induced between the endpoints of the loop. To illustrate the underlying physical mechanism, we compute the time-dependent current generated by the injection of multiple anyons, and show that its behavior exhibits distinctive features governed by the anyonic statistical angle. The measured current reflects quantum interference effects due to the time-resolved braiding of anyons at the junction. To establish experimental relevance, we introduce a protocol where anyons are probabilistically injected upstream of the loop via a quantum point contact (QPC) source. Phase jumps imprint measurable signatures in the cross-correlation noise, enabling a controlled statistical analysis of the braiding phase. In a second time we include capacitive effects which are known to play a crucial role in mesoscopic capacitors. Both the current and the current cross-correlations are modified but the extraction of the statistical angle is still possible.

Thursday session

H. Lyu (Laboratoire de Physique de l'ENS): *Anyon braiding in the time domain* (20+5 min)

We use the geometry of the anyon collider and two-particle interferometry to extensively study the properties of anyons for more complex phases of the FQH effect such as the filling factor 1/3, 2/5 and in particular the non-abelian case (filling factor 5/2). Several types of anyon sources are used: random and stationary sources of topological anyons generated by a DC biased quantum point contact and trigerred anyon excitations generated by voltage pulses applied to an ohmic contact. We have implemented a HOM experiment at filling factor $v=1/3$ to probe the effects of anyon braiding on the dynamics of anyon tunneling. When braiding is trivial ($\theta x N=2\pi$), the characteristic tunneling timescale is set by the temporal width of the emitted pulses as one would naively expect. In contrast, we observe that when braiding is present ($\theta x N<2\pi$), the characteristic timescale for anyon tunneling is increased and reflects the temporal correlations at the edge given by $\tau\delta$. From our measurements, we extract $\delta=2/3$, showing the non-universal character of the scaling dimension (where $\delta=1/3$ is measured). We observe that braiding effects on the dynamics of anyon tunneling are suppressed for pulses carrying $N=3$ anyons, corresponding to a braiding phase $\theta=2\pi/N=2\pi/3$, in accordance with previous measurements of θ at $v=1/3$.

C. Duse (Stanford University): *Hybrid superconducting circuit architecture to probe van der Waal heterostructures* (20+5 min)

Coupling to microwave photons in high-quality superconducting resonators in a circuit QED architecture enables sensitive readout of artificial atoms. Similar architectures in van der Waals (vdW) systems enable measurements of impedance at relevant frequency scales, which can elucidate the nature of correlated electronic states beyond what's accessible with conventional DC transport. Here, I will share our work on developing a hybrid vdW-superconductor architecture that enables simultaneous quasi-DC electrical transport and microwave impedance measurements of dual-gated vdW heterostructures. We couple a high-impedance microwave resonator to a vdW hall bar device and demonstrate that the resonator frequency shift and quality factor are sensitive probes of the vdW channel resistance as independently measured at quasi-DC frequencies across the phase diagram. Our proposed hybrid architecture provides a general framework for probing the impedance of dual-gated vdW heterostructures at microwave frequencies, including kinetic inductance from vdW superconductivity.

The 20th Capri Spring School on Transport in Nanostructures 2026

Friday session

Y. Nazarov (Delft University of Technology): *Quantized transconductance emerges from non-symmetric quantum fluctuations* (50+5 min)

We show theoretically that weak quantum fluctuations induced by a non-symmetric electromagnetic environment may lead to a quantized transconductance of a multi-terminal quantum contact rather than to a blockade of transport in the contact. The result suggests the possibility to realize Quantum Hall phenomenology without its common ingredients and/or a topological quantum state.

S. Trebst (University of Cologne): *Monitored topology* (50+5 min)

We discuss the effects of measurements on topological quantum memories and discuss the resulting learning phase diagrams. Two elementary scenarios are considered, the toric code fixed point and a deformed version of the toric code brought to its Ising critical transition point. We will illustrate that for both cases there is a finite learning threshold and discuss the emerging non-unitary field theory and its relation to Nishimori physics, in terms of numerical simulations and some exact results.

N. Andrei (Rutgers University): *Thermodynamics in a split Hilbert space: Quantum impurity in interacting environments* (50+5 min)

A rich phase diagram arises when a quantum spin impurity is placed in an interacting environment. Different phases arise depending on the relative strengths of the various interactions, in marked difference from the traditional Kondo effect, the canonical example of a spin impurity placed in a metal, where only one phase prevails. We show further that in each phase the Hilbert space splits into several towers of excitations and as a result the thermodynamics requires tower summation in each phase. We compute explicitly the resulting impurity entropy in each phase and show that it exhibits interesting behavior which is experimentally verifiable and reflecting the underlying tower structure. We explore how the tower structure is reflected in the transport properties of the system.

Friday session

D. Oriekhov (Kavli Institute of Nanoscience, TU Delft): *Interpretable tensor-neural networks as topological invariants* (20+5 min)

Much attention has been devoted to the use of machine learning to approximate physical concepts. Yet, due to challenges in interpretability of machine learning techniques, the question of what physics machine learning models are able to learn remains open. Here we bridge the concept a physical quantity and its machine learning approximation in the context of the original application of neural networks in physics: topological phase classification. We construct a hybrid tensor-neural network object that exactly expresses real space topological invariant and rigorously assess its trainability and generalization. Specifically, we benchmark the accuracy and trainability of a tensor-neural network to multiple types of neural networks, thus exemplifying the differences in trainability and representational power. Our work highlights the challenges in learning topological invariants and constitutes a stepping stone towards more accurate and better generalizable machine learning representations in condensed matter physics

J. Zijderveld (Delft University of Technology): *Symmetric approximant formalism for statistical topological matter* (20+5 min)

We show theoretically that weak quantum fluctuations induced by a non-symmetric electromagnetic environment may lead to a quantized transconductance of a multi-terminal quantum contact rather than to a blockade of transport in the contact. The result suggests the possibility to realize Quantum Hall phenomenology without its common ingredients and/or a topological quantum state.

E. Andriyakhina (Freie Universität Berlin): *Ignition of Spin-Triplet Supercurrent in an S/F/S Josephson Junction* (20+5 min)

We develop a theory of ballistic junctions with a uniformly precessing ferromagnetic or half-metallic interlayer and show that magnetic dynamics generate spin-polarized triplet superconducting correlations in both N/F/S and S/F/S geometries. For the N/F/S structure, we show that precession induces equal-spin Andreev reflection and a long-ranged spin-polarized proximity amplitude; in the half-metal limit, where subgap transport is absent without precession, the zero-bias conductance becomes finite only due to the drive and exhibits a resonant enhancement under ferromagnetic resonance. For the S/F/S junction, we demonstrate that the same mechanism produces a dc Josephson current of spin-polarized triplet origin: in the half-metal limit the junction is effectively off for static magnetization but switches on once the magnetization precesses, while for a ferromagnetic interlayer the precession-induced contribution remains long-ranged and survives averaging over junction length. In the experimentally relevant small-angle limit, the induced Josephson current is approximately sinusoidal in phase and its critical value scales quadratically with the precession angle, identifying microwave-driven magnetization dynamics as a practical route to controllable, nanosecond switching of triplet superconducting transport.

A.L. Rigotti Manesco (Niels Bohr Institute): *Loopless multiterminal quantum circuits at odd parity* (20+5 min)

We theoretically investigate loopless multiterminal hybrid superconducting devices at odd fermion parity with time-reversal symmetry. We find that the energy-phase relationship has a double minimum corresponding to opposite windings of the superconducting phases. Spin-orbit coupling introduces multi-axial spin splittings, in contrast to two-terminal devices, where spin dependence is uniaxial. Capacitive shunting localizes quantum circuit states in the wells and exponentially suppresses their splitting. For weak spin-orbit coupling, the system has a four-dimensional spin-chirality low-energy subspace that can be universally controlled only by electric fields.
Link: https://doi.org/10.48550/arXiv.2601.13369

Friday session

I. Verstraeten (University of Antwerp): *Proximitized Bilayer Graphene Quantum Dots: Continuum and Atomistic Approaches* (20+5 min)

*G*ate-defined bilayer graphene quantum dots (BLG QDs) have recently emerged as a novel platform for fundamental condensed matter and quantum science research, yet a seamless real-space description of their electronic structure has remained elusive. Here, we demonstrate excellent agreement between a minimal continuum model and a real-space tight-binding model describing a gate-defined BLG QD proximitized by an atomically thin semiconductor used to induce non-trivial layer-dependent spin-orbit couplings. Using an infinite mass boundary condition, we solve the full system of coupled differential equations analytically, obtaining closed-form expressions for the energy spectrum. Our continuum and tight-binding models agree across a wide range of QD sizes, external electromagnetic fields, and proximity-induced spin-orbit couplings. Armed with this capability, we demonstrate valley g-factors in the range 10–20, consistent with recent experiments, and show that the interplay between spin-orbit coupling, interlayer potential, and magnetic field enables effective engineering of Kramers energy levels in BLG QDs, which is directly relevant for qubit design. Our results complement previous theoretical studies and unlock the potential of QDs formed in BLG-based van der Waals heterostructures for quantum science applications. The tight-binding framework developed here can be utilized for realistic studies of a wide range of BLG-based QDs and, thus, may be useful for guiding future developments in the field.

Y. Wang (University of Twente): *Recoverable symmetry-broken quantum Hall states through reconstructive TBG/h-BN supermoiré* (20+5 min)

The electronic properties of two-dimensional materials, such as twisted bilayer graphene (TBG), are strongly influenced by tunable moiré structures. Here, we introduce supermoiré lattice, which is constructed through the interference of the TBG and bottom graphene/h-BN moiré patterns when the *h*-BN layer is rotated at specific angles relative to the bottom graphene. The impact of such supermoiré patterns on multilayer systems remains largely unexplored. In this study, we present half-open TBG/h-BN devices with C_{2z} spatial symmetry breaking due to a relative large-angle alignment of a *h*-BN layer. Using conductive atomic force microscopy (*c*-AFM) for current mapping, we directly observe supermoiré pattern. In this complex structure, we detect supermoiré-scale Landau levels with lifted layer and valley degeneracies and electron-hole asymmetry stemming from the one-sided *h*-BN coupling. We further investigate how dual- and tri-moiré lattices modify the asymmetry in TBG's band structure and demonstrate how spatial inversion symmetry can be restored by encapsulating TBG with an additional h-BN layer. Our results emphasize the tunability of TBG's electronic properties through engineered moiré superstructures, opening new pathways for exploring symmetry-driven quantum phases.

Poster sessions

L. Arici (Weizmann Institute of Science): *tba*
R. Ciciotti (University of Rome "Tor Vergata", Department of Physics): *Development of* Te/Bi_2Se_3 *heterostructures for photodetectors sensitive to VIS and NIR wavelengths*
S. Deb (Max Planck Institute for chemical physics of Solid): *Atomic-scale visualization of the superconducting order parameter in the misfit compound*
L.Eek (Utrecht University): *Enhanced spin-current generation in Dirac altermagnets through Klein tunneling*
J. Feigl (Walther-Meißner-Institute, Technical Univ. Munich): *High-Coherence Superconducting Qubits on Wafer Scale*
V. Jain (Julius Maximilians University of Würzburg): *Phase sensitive tests for superconducting pairing symmetry in YPtB*
J.N. Kaemmerer (Karlsruhe Institute of Technology): *Resonant escape in Josephson tunnel junctions under millimeter-wave irradiation*
A. Labordet (EMPA): *Surface-dependent phonon dynamics in 9-atom-wide graphene nanoribbons arrays*
Y. Li (The Madrid Institute of Materials Sciences — ICMM): *Towards a microscopic description of singlet-triplet hole qubits in double dots*
L. Lizba (University of Duisburg-Essen): *Coupling-energy driven pumping through quantum dots: the role of coherences*
B. Mahendru (Freie Universität Berlin): *Atomic-scale Josephson-diode effect induced by chiral Fe clusters in a Pb-Pb junction*
B. Moglia (Politecnico di Torino): *tba*
D. Nieri Orfatti (Universitat Basel - SNI): *Vertical Quantum Dots in Coupled Ge Quantum Wells*
V. Sierka (Donostia Internationa Physics Center): *Moiré Polaritonic Fourier Engineering*
M. Steiner (University of Regensburg): *Dark state formation in a zero-field split molecular triplet*
M. Subhadarshini (Institute of Physics, Bhubaneswar): *Current switching via hinge modes in higher-order topological phase with altermagnet*
B. Vasas (Budapest University of Technology and Economics): *Fabrication of superconductor-quantum dot hybrids in InAs 2DEGs*
L. van Dijk (Eindhoven University of Technology): *Transport in Selective Area Grown PbTe nanostructures*
Y.-C. Yao (University of St Andrews): *Identification of intrinsic and extrinsic in-plane twofold symmetry in* CsV_3Sb_5 *via magnetotransport*