

Résumés des présentations et posters

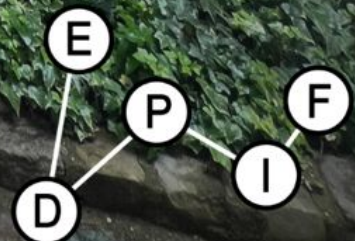
Book of Abstracts

17 Juin 2024
9h - 17h30

Amphithéâtre Farabeuf
Campus des Cordeliers, Sorbonne Université
15 Rue de l'École de Médecine, 75005 Paris

Journée scientifique de l'EDPIF
EDPIF Scientific Day

Website



Schedule

- 8:30 • Welcome desk opens
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- 9:00 • Introductory word — Frédéric Chevy
- 9:15 • Invited speaker — Joshua McGraw
-
- 9:45 • *Léonard Lehoucq* — Astrophysical Gravitational-Wave Background from Stellar-Mass Compact Binary Coalescences
- 10:00 • *Hongting Dong* — Metal nanoparticles pass through protoplast interfaces and intracellular distributions
- 10:15 • *Nolan Burban* — Emergent collective migration in cell monolayers
-
- 10:30 • Coffee break
-
- 11:00 • *Damien Toquer* — Non Linear Ionic Transport inside Nanoslits: Effect of the confinement on the correlations between electrolytes
- 11:15 • *Léo Touzo* — Exact results for active particles with long-range interactions
- 11:30 • *Stanislas Loiseau* — Effects of turbulent flows on human stem cells : survival and nanoparticle secretion
- 11:45 • *Adrià Medeiros* — Perfect spin projection in an ideal spin-photon interface via polarization filtering
- 12:00 • *Gautier Creutzer* — Interacting laser-trapped circular Rydberg atoms
-
- 12:15 • Poster session
- 12:30 • Lunch

Schedule

- 14:00 • *Xue Ma* — Surface Bubble Accelerates Evaporation
- 14:15 • *Marianne Billoir* — Investigating the Time-Dependent Response of Glioma Cells to Radiotherapy: Comparison of a Compartmental Model to Experiments
- 14:30 • *Coraline Letouzé* — X-ray Absorption spectroscopy by Dynamical Mean-field theory
- 14:45 • *Dan Wang* — Two dimensional electron system Pt/Ge (111) for Spintronics
- 15:00 • *Michael Vaz* — Near and far field interaction of rotating atoms mediated by the electromagnetic vacuum
- 15:15 • *Camille Bagès* — Influence of mechanical constraints on tropomyosin-actin interaction
-
- 15:30 • Coffee break & Poster session
-
- 16:00 • *Lars Kürten* — Making the hard sphere nucleation discrepancy disappear
- 16:15 • *Mukil Muppall* — Fe(II) spin crossover on graphene and noble metal surfaces
- 16:30 • *Lisa Kauffmann* — How Amphipathic Helices from Proteins Allow Binding to Lipid Droplets
- 16:45 • Invited speaker — Sarah Houver
-
- 17:30 • Cocktail

Student Presentations

Section 1

- Author: **Léonard Lehoucq**
Title: “Astrophysical Gravitational-Wave Background from Stellar-Mass Compact Binary Coalescences”
Affiliation: *CNRS, Institut d’Astrophysique de Paris*

The astrophysical Stochastic gravitational-wave backgrounds (SGWB) results from the superposition of numerous individually unresolved gravitational-wave (GW) signals. In this talk, I will present different ways of modelling the populations of stellar-mass compact binary coalescence (CBC) that source this background. I will discuss the use of population synthesis models to estimate the expected rate and properties of CBC. I will also show how these predictions are used to calculate the resulting SGWB amplitude and spectral shape, and what are the main astrophysical uncertainties on this background. Finally, I will discuss the prospects for detecting the SGWB with current and future gravitational-wave detectors.

- Author: **Hongting Dong**

Title: “Metal nanoparticles pass through protoplast interfaces and intracellular distributions”

Affiliation: *MSC*

Heavy metals absorbed and accumulated by plants from the soil can pose a health risk if they enter the food chain through crop uptake, which is a complex biological process that depends on multiple factors. To understand how the size and surface properties of metal nanoparticles affect the uptake and intracellular accumulation in plants, we prepared fluorescent PEG-coated gold nanoparticles of different sizes (5-50 nm) and surface functionalities: positive, negative and neutral charge. We quantitatively investigated nanoparticle uptake and accumulation in *Arabidopsis Thaliana* protoplasts using confocal fluorescence microscopy. The results show that the number of particles absorbed is inversely proportional to the size of the nanoparticles. Furthermore, positively charged nanoparticles rapidly accumulate on the surface of the protoplasts whereas negatively charged particles accumulate more slowly on the cell surface and neutral nanoparticles rapidly penetrate into the protoplasts. All charged nanoparticles are found to accumulate in the cytoplasm and cellular organelles such as lipid droplets and vacuoles. These findings indicate that the uptake and intracellular accumulation of gold nanoparticles in *Arabidopsis* protoplasts are significantly affected by their surface charge and size and give a better understanding of metal nanoparticle uptake and accumulation in plants.

- Author: **Nolan Burban**
Title: “Emergent collective migration in cell monolayers”
Affiliation: *Institut Curie*

Understanding the collective migration of cell monolayers is crucial for insights into various biological processes, such as wound healing and cancer metastasis. In this study, we present a theoretical model to describe the collective motion of Human Bronchial epithelial cells. Modeling the cells as interacting active Brownian particles, we perform coarse-graining to transition from the microscopic, single-agent scale to the macroscopic, collective tissue scale. By incorporating correlations in cell positions and orientations, our model reveals novel terms that establish connections with preexisting hydrodynamic theories. This framework enables us to explore the behavior of migrating cell monolayers under more complex conditions, such as the introduction of anisotropy, thereby providing deeper insights into the dynamics of collective cell movement.

Section 2

- Author: **Damien Toquer**

Title: “Non Linear Ionic Transport inside Nanoslits: Effect of the confinement on the correlations between electrolytes”

Affiliation: *LPENS/ENS/PSL*

Thanks to recent experimental advances, it is now possible to study the transport of water and ions confined up to one molecular layer. An example of such a system is the 2D nanoslit, made of sheets of 2D materials, like graphene or hexagonal boron nitride. Experimental measures of the ionic conduction under an external electric potential proves that the ionic transport is non linear, even at small fields.

Because of this extreme confinement, the interaction between the ions are strongly enhanced, allowing them to associate to form pairs called Bjerrum pairs. Simulations showed that there is in fact a critical temperature, below which all the ions associate in pairs. The transition to this fully paired state is known as the Kosterlitz Thouless transition.

Adding an electric field along the slit allows the pairs to dissociate. This will create additional free ions that will be able to conduct the current. This effect is called the second Wien effect. In bulk water it leads to an additional quadratic contribution to the current, only at large field. In our system, as a consequence of the strong correlations between the ions, their transport becomes anisotropic, yielding to a non universal - interaction dependant - exponent, even at small field.

- Author: **Léo Touzo**

Title: “Exact results for active particles with long-range interactions”

Affiliation: *LPENS*

Active particles are systems which follow an out-of-equilibrium stochastic dynamics due to their ability to convert energy into directed motion, similar to living organisms. At variance with a passive Brownian particle subjected to a simple white noise, active particles experience a random noise that is correlated in time, leading to a persistent motion. This gives rise to many interesting features such as non-Boltzmann steady states, as well as emergent collective behaviors, such as motility-induced phase transitions or flocking phenomena. Famous models of active particles include the run-and-tumble particle (RTP), inspired from the motion of the bacteria *E. Coli*. Despite the surge of interest for those systems during the last two decades, very few analytical results exist concerning systems of interacting active particles, beyond contact interactions. In this talk I will introduce two models of RTP's with long-range interactions: the active Dyson Brownian motion (or active log gas) [1,2], and the active rank diffusion (or active 1D Coulomb gas) [3]. For both systems, exact results can be obtained in the stationary state concerning the mean particle density, as well as the fluctuations of particle positions, showing the emergence of non-equilibrium transitions.

[1] L. Touzo, P. Le Doussal, G. Schehr, 2023 EPL 142 61004

[2] L. Touzo, P. Le Doussal, G. Schehr, 2024 Phys. Rev. E 109 014136

[3] L. Touzo, P. Le Doussal, 2024 EPL 145 41001

- Author: **Stanislas Loiseau**

Title: “Effects of turbulent flows on human stem cells : survival and nanoparticle secretion ”

Affiliation: *MSCmed*

Bioreactors are common systems used to cultivate human stem cells for pharmaceutical applications. Those systems are stirred through the rotation of impellers of diverse geometries, provoking turbulent flows. Several effects of turbulent flows on stem cell biology have been reported in literature in the past years. This study focuses, through a multidisciplinary approach combining flow modelling and cell biology, on cell survival and capacity to secrete pharmaceutically active nanoparticles that are gaining more and more interest in regenerative medicine : extracellular vesicles.

- Author: **Adrià Medeiros**

Title: “Perfect spin projection in an ideal spin-photon interface via polarization filtering”

Affiliation: *C2N - Université Paris Saclay*

The search for an ideal light-matter interface is of great interest for the development and scalability of quantum photonic-based technologies, allowing for the implementation of deterministic quantum gates that uses the solid-state qubit to modify the state of the flying qubit. For that, an efficient read-out of the matter qubit state with single photons is required. In our work, a semiconductor Quantum Dot (QD) embedded in a micropillar cavity is charged with a single electron and is put under weak resonant excitation. In our protocol, we exploit the interference between the reflected light from the cavity and the single photons emitted by the QD. The information of the electronic spin is encoded on the polarization degree of freedom of the reflected light [1]. Therefore, by performing a projective measurement on a first photon reflected from the device, we project the spin qubit into one of its eigenstates. We track its evolution back to the stationary regime through the conditional polarization state of the subsequent photons. This work paves the way for entanglement between a single spin and a single incoming photon in QD systems.

[1] Nature Communications vol. 15, 598 (2024)

- Author: **Gautier Creutzer**

Title: “Interacting laser-trapped circular Rydberg atoms”

Affiliation: *Laboratoire Kastler-Brossel, Collège de France, Sorbonne Université, ENS-PSL, CNRS*

Quantum simulators based on arrays of laser-trapped Rydberg atoms have produced impressive results in the recent years, in particular for their ability to emulate large systems of interacting spins in two dimensions. Circular Rydberg atoms, namely Rydberg atoms with maximal orbital momentum, have long natural lifetimes, typically 100 times longer than their low-momentum counterparts. This makes them well suited to the quantum simulation of the dynamics of interacting quantum systems.

To benefit from these long lifetimes, we trap individual circular Rydberg atoms in optical bottle beams based on the ponderomotive force. In addition, we implement an optical detection method capable of distinguishing the different energy levels and spatially resolving the array.

I will report on our recent experimental activities, in which we measure the dipole-dipole interaction between two circular Rydberg atoms. We characterize it through microwave spectroscopy, and we can both control the geometry of the pair and dynamically tune the interaction strength via the surrounding electric field. Finally, we record oscillations which demonstrate the expected coupling between spin and motional degrees of freedom in a Rydberg-atom system.

Section 3

- Author: **Xue Ma**

Title: “Surface Bubble Accelerates Evaporation ”

Affiliation: *Laboratoire Matière et Systèmes Complexes, Université Paris Cité*

Liquid evaporation inside a simple circular tube is a pure diffusion process known as Stefan diffusion tube problem. However, introducing a bubble at the liquid surface remarkably changes the evaporation dynamics. Different bubble/vessel aspect ratio leads to different evaporation rates. A vapor jet erupting from the apex of the bubble generates a forced vapor convection, transporting mass away from the vicinity of the bubble into the atmosphere. We characterize the fountain-like jet by measuring its height and foot diameter with Schlieren imaging technics. We simultaneously measure the evaporation rate, which enables us to relate the presence of the vapor jet to the evaporation efficiency.

- Author: **Marianne Billoir**

Title: “Investigating the Time-Dependent Response of Glioma Cells to Radiotherapy: Comparison of a Compartmental Model to Experiments”

Affiliation: *IJCLab*

Gliomas constitute the majority of malignant brain tumors in adults. Their ability to diffusely infiltrate neighboring brain tissue makes them very hard to treat and they are typically associated with a poor prognosis. Radiation therapy stands as a crucial cornerstone of their therapeutic strategy, entailing the delivery of fractionated doses according to a precise schedule. This approach allows surrounding non-cancerous tissues to recover between treatment fractions. Nevertheless, despite remarkable advancements in the field, there has been no definitive improvement in the long-term survival of glioma patients. A potential explanation lies in the lack of temporal description of the conventional radiobiological models of the tumor’s response to radiation on which are planned the therapy sessions.

To address this gap, we propose a simple, biologically motivated, compartment-based model characterizing the temporal response of glioma cells to single dose radiation therapy. To validate our model, we conducted in vitro experiments using time-resolved fluorescence microscopy to track the density of F98 glioma cells following exposure to varying radiation doses and initial cell concentrations. We show that it is possible to get an excellent agreement between the model and the data with only four free parameters. We also highlight an interesting adverse effect of the initial cell density at high doses.

- Author: **Coraline Letouzé**

Title: “X-ray Absorption spectroscopy by Dynamical Mean-field theory”

Affiliation: *Sorbonne Université*

X-ray Absorption spectroscopy (XAS) provides rich and valuable information about the chemical state and local environment of selected elements in solids. However, the resulting spectra must be analyzed through comparison with numerical XAS spectra. Accurate and reliable theoretical description of the electronic state of the absorbing site and its surroundings is therefore crucial for the analysis of experimental data. In strongly correlated materials, the strong Coulomb interaction between electrons renders such large many-body quantum systems very challenging and they must be solved with approximate models and numerical methods. In my PhD project, I try to include in the modelling of XAS not only the absorbing atom but also a continuum of surrounding electronic states. I will present my work on Nickel Oxide (NiO), a paradigmatic example of strongly correlated materials, using dynamical mean-field theory and a Matrix-Product-State impurity solver.

- Author: **Dan Wang**

Title: “Two dimensional electron system Pt/Ge (111) for Spintronics”

Affiliation: *LPEM*

Spintronics, which aims to exploit the electrons spin for the development of novel information storage or logic devices, is nowadays a major and competitive research field in physics. Exploiting spin degree of freedom increases the functionality of electronic devices and enables such devices to overcome physical limitations related to speed and power. Currently, one of the most promising way to achieve the desired control of the electrons spin is by the application of external electric field in presence of the so called Rashba spin-orbit coupling (SOC). The essential feature of Rashba SOC is that a spin-polarized electron moving in an electric field experiences an effective magnetic field which drives the precession of the spin orientation even without an external magnetic field. In this study, we investigated the electronic properties of Pt single atomic layer on Ge(111) by molecular beam epitaxy (MBE) in an ultra-high vacuum (UHV) environment. Our preliminary results, obtained through angle-resolved photoemission spectroscopy (ARPES), suggest the presence of a possible Rashba SOC in the system. These findings provide valuable insights for the potential utilization of Rashba SOC in Pt/Ge electron system for future applications.

- Author: **Michael Vaz**
Title: “Near and far field interaction of rotating atoms mediated by the electromagnetic vacuum”
Affiliation: *SPEC (CEA Paris-Saclay)*

The quantum vacuum field is known to be responsible for non trivial interaction forces such as the famous Casimir effect between two conducting plates. It is actually also responsible for the microscopic van der Waals attraction forces between atoms or non-polar molecules by creating a fluctuating electric dipole moment leading to the London and Casimir-Polder results as well as a thermal expression for large enough temperatures. Moreover, the thermal vacuum field can have a dissipating behaviour by dragging the polarizable objects moving in its black-body radiation frame. We have investigating the possibility that the vacuum field leads to a new dissipation phenomenon between interacting atoms.

Hence, we elaborated a semi-classical model allowing us to describe two rotating atoms through classical equations of motion but coupled by the quantum fluctuations of the electromagnetic vacuum. This model allows us to recover the literature results and to obtain new analytical and numerical results about friction on a rotating pair of identical atoms.

- Author: **Camille Bagès**

Title: “Influence of mechanical constraints on tropomyosin-actin interaction”

Affiliation: *Institut Jacques Monod - CNRS - Université Paris Cité*

Actin is part of the cytoskeleton, a system of protein filaments presents in the cytoplasm of all eukaryotic cells. Actin assembles into semi-flexible filaments that play an important role in the regulation of cell mechanics. For instance, actin filaments control cell shape, support cell motility, and mediate cell’s biochemical responses to external mechanical signals.

In cells, actin filaments assemble in multiple networks, composed of various actin binding proteins (ABP) and which undergo different mechanical constraints. The dozens of tropomyosin isoforms are key components of these networks as they cover most actin filaments and regulate the activity of the other ABP in an isoform specific manner. One fundamental question is to understand how tropomyosin isoforms selectively localise into actin networks. The hypothesis of this project is that the mechanical context of each actin network regulates tropomyosin recruitment.

To carry out this study, I perform in vitro experiments with purified proteins. To apply controlled mechanical constraints, I use microfluidics: the drag force of the fluid flow generates a tension over tens of single actin filaments simultaneously. I also designed experiments combining microfluidics with either optical or magnetic tweezers to apply precise tension or torsion. These experiments allow me to assess whether forces tune the affinity of specific tropomyosin isoforms. Overall, this study will shed light on the mechano-regulation of actin binding proteins activity.

Section 4

- Author: **Lars Kürten**

Title: “Making the hard sphere nucleation discrepancy disappear”

Affiliation: *Gulliver UMR 7083, CNRS, ESPCI Paris, Université PSL*

Crystal nucleation and self-assembly are the underlying mechanisms of a variety of natural phenomena and technical applications. Consequently, tremendous scientific effort has been devoted to understanding these fundamental processes over the last few decades. Despite continuous progress in this field, a massive disagreement persists between nucleation rates measured experimentally and those predicted by computer simulations. Predicting nucleation is an immense problem, with discrepancies in a number of systems, including Argon [1] and metallic and molecular systems [2].

In the most studied system, colloidal hard spheres, the discrepancy is many orders of magnitude. In contrast to the experiments conducted in the last millennium, we, for the first time, investigated density matched systems in the regime of the discrepancy at the single-particle level, with confocal imaging to calculate nucleation barriers from the particle-resolved data. Advances in structural analysis methods enabled us to precisely map our results to hard sphere simulations and compare nucleation barriers for identical state points. With our method, the nucleation barriers show reasonable agreement, leading to the disappearance of the discrepancy.

[1] Sinha, et al., J. Chem. Phys. 132 (2010), 064304

[2] G.C. Sosso, et al., Chem. Rev. 116 (2016), 7078-7116

- Author: **Mukil Muppall**
Title: “Fe(II) spincrossover on graphene and noble metal surfaces”
Affiliation: *Universite Paris Cite*

Spin-crossover (SCO) molecules exhibit switchable spin states (high spin – HS – and low spin – LS – states) that can be controlled by external stimuli like light, temperature or electric field. This makes them promising molecules for incorporation in devices. Recently, it has been demonstrated that the spin state of thin molecular films (down to 100 nm) influences the conduction of electrons in graphene. To go to thinner thicknesses, it is of great interest to study this switching property with regards to the substrate on which the molecules are grown on and with respect to film thickness.

- Author: **Lisa Kauffmann**

Title: “How Amphipathic Helices from Proteins Allow Binding to Lipid Droplets”

Affiliation: *Laboratoire de Physique de l'ENS*

Lipid droplets serve as critical energy storage compartments within cells. These droplets are composed of a core of neutral lipids surrounded by a phospholipid monolayer[2]. Proteins are also present on the surface of these droplets. The composition of neutral lipids and phospholipids is known to influence the specific recruitment of proteins to lipid droplets [3]. Two pathways for protein binding to lipid droplets have been described[1]. In this project, we will focus on unfolded proteins in the cytoplasm that fold upon contact with lipid droplets. These proteins typically form a secondary structure known as the amphipathic helix [1]. However, how these helices sense the physicochemical properties of lipid droplets and bind specifically to them is not well understood.

To achieve the project's aim, a screening of different amphipathic helices will be conducted to elucidate how these helices sense the physicochemical properties of the lipid droplets and bind specifically to them.

[1] Song, J. et al., (2022). Identification of two pathways mediating protein targeting from ER to lipid droplets, *Nature cell biology*

[2] Thiam, A. R., & Beller, M. (2017). The why, when and how of lipid droplet diversity. *Journal of Cell Science*, 130(2), 315-324

[3] Chorlay, A., & Thiam, A. R. (2020). Neutral lipids regulate amphipathic helix affinity for model lipid droplets. *Journal of Cell Biology*

Posters

- Author: **Gregorio Beltramo**

Title: “Injection locking of a self-pulsing integrated nano-cavity to an external self-pulsing driving force”

Affiliation: *Universite Paris-Cite, CNRS*

We study the locking phenomena of a Self-Pulsing oscillator entrained by an external signal coming from a similar Self-Pulsing oscillator. As a function of both laser wavelength and input power we study the evolution of the locking phenomena. Various locking $n : m$ locking ratios are found by sweeping the wavelengths and optical power while we are exciting both of the cavity resonances.

Posters

- Author: **Nathan Bigan**
Title: “Non-Newtonian fluid confined at the nanoscale: deposition and characterization”
Affiliation: *Micromegas - Hummink*

- Author: **Natalie Blot**
Title: “Limits to Design”
Affiliation: *ESPCI*

Recent work has provided many paradigms to design and control the self-assembly of colloidal building blocks to obtain desired geometries. In the case of DNA coated colloids, McMullen et al demonstrate in that temperature protocols can be used to hierarchically fold a chain of colloids of particular types, eg a “colloidomer” into a desired rigid conformation. Since this process happens out of equilibrium, a well chosen assembly protocol can select a series of metastable states, and can therefore reliably construct clusters with high free energies. Extending this work in two and three dimensions, we discover that not all geometries are equally easy to design- in fact, given a limited alphabet of building blocks, the majority are impossible to design! Among the designable few, there are again strongly preferred structures, in that many more protocols assemble some than others. Using exhaustive enumeration of potential assembly protocols, we can investigate what makes these clusters so special. Conversely, we can also ask what makes their undesignable counterparts “hard.” Our results show that assembly is indeed biased towards symmetry, similar to claims about biological evolution of proteins, as well as showing that larger designable clusters typically contain smaller designable clusters within them.

- Author: **Ambroise Boyer**

Title: "A hybrid approach to improve linear photonic Bell-state measurement"

Affiliation: *Laboratoire Kastler-Brossel Sorbonne Université*

Quantum non gaussian states engineering[1][2][3] and measurements are essential to leverage the full potential of quantum technologies. In this context, optical quantum information processing critically relies on Bell-state measurement, a ubiquitous operation for quantum communication and computing. Its practical realization involves the interference of optical modes and the detection of a single photon in an indistinguishable manner. Yet, in the absence of efficient photon-number resolution capabilities, errors arise from multi-photon components, decreasing the overall process fidelity. Here, we introduce a novel hybrid detection scheme for Bell-state measurement[4], leveraging both on-off single-photon detection[5] and quadrature conditioning via homodyne detection. We derive explicit fidelities for quantum teleportation[6] and entanglement swapping[7] processes employing this strategy, demonstrating its efficacy. We also compare with photon-number resolving detectors and find a strong advantage of the hybrid scheme in a wide range of parameters.

In order to perform such protocols on our experiment, we routinely produce optical states thanks to spontaneous down conversion in optical cavities. We produce states in both the Fock basis, such as one and two photon state, and cat basis (odd and even) as well as superpositions ("qubits") of these states. Thus, we want to benchmark their non gaussianity and introduce a criterion that quantifies the non gaussianity of the coherences[8] of these states.

[1] O. Morin et al., "Remote creation of hybrid entanglement between particle-like and wave-like optical qubits", *Nature Photonics* 8, 570 (2014)

[2] K. Huang et al., "Optical synthesis of large amplitude squeezed coherent-state superpositions with minimal resources", *Physical Review Letters* 115, 023602 (2015)

[3] H. Le Jeannic et al., "Remote preparation of continuous-variable qubits using loss-tolerant hybrid entanglement of light," *Optica* 5, 1012-1015 (2018)

[4] B. Asenbeck et al., "A hybrid approach to improving the linear photonic Bell-state measurement", (in preparation)

[5] H. Le Jeannic et al., "High-efficiency WSi superconducting nanowire single-photon detectors for quantum state engineering in the near infrared", *Optics Letters* 41, 5341 (2016)

- [6] T. Darras et al., "A quantum-bit encoding converter", *Nature Photonics* 7, 165-170 (2023)
- [7] G. Guccione et al., "Connecting heterogeneous quantum networks by hybrid entanglement swapping", *Science Advances* 6, 22, eaba4508 (2020)
- [8] B. Asenbeck et al., "Experimentally verifiable criteria of non-gaussian coherences", (in preparation)

- Author: **Luisa Bruno**
Title: “Lymph node mechanics and its impact on immune cells”
Affiliation: *Institut Cochin*

B cells are key components of the adaptive immune response. They are mostly known for producing antibodies; in order to do that, naïve B cells have to recognize and internalize the antigen through their B cell receptor (BCR). This process takes place in the lymph node and is known to be a mechanosensitive process. This suggests that the microenvironment mechanics plays an important role in B cells immune function. To establish the role of lymph node mechanics in B cell function we use a system of lymph node slices kept alive to characterize the stiffness of the tissue and its rheological properties. We characterized the stiffness of the tissue by atomic force microscopy (AFM). We assessed micro rheology information by analyzing lipid droplets movements and deformation to determine the flow inside the tissue and to define the stress experienced by cells. We will extend our measurements to inflamed tissues subjected to external perturbations.

- Author: **Sylvain Cam**

Title: “Development of an AF4 analytical approach to understand the complexity and evolution of cell secretomes”

Affiliation: *MSCmed*

More refined and complete characterization of cell secretomes are needed to accelerate the development of extracellular vesicles (EV) derived medicine towards clinical applications. The AF4 separation technique (Asymmetric Flow Field-Flow Fractionation) is well suited to fractionate complex media into subpopulations, in order to characterize each of their individual components. It can be used for quality control, or to identify potent fractions. Currently, most EV studies focus on exosome isolation with little interest in the other elements produced by the cells. AF4 can be developed in a dedicated fashion to address EV issues. The goal of this work is to establish a polyvalent separative method to use AF4 at its full potential for extended secretome characterization.

Conditioned supernatants recovered from 2D HeLa-cultures placed in complete medium or serum-deprived medium for 48h were used to model 2 types of secretomes. They served to fine-tune the AF4 separative and detection parameters. Isolated subpopulations were identified using inline AF4 detectors (MALS/DLS/UV-Vis/dRI), dot blotting and cryoEM. The purification of HeLa conditioned media were performed by ultracentrifugation (UC), tangential flow filtration (TFF) and ultrafiltration (UF) and analysed by AF4.

The AF4 separation method developed allows to track the evolution of a cell secretome composition over time. The coupling with dot blotting and electronic microscopy is a powerful tool to get access to the identity of each subpopulation. The comparison of three EV purification techniques by AF4 shows that UF and TFF can conserve the full sample with little changes regarding subpopulation proportions while increasing concentration. UC selects a range of sizes depending on the centrifugation parameters and can isolate subpopulations.

AF4 coupled to MALS/DLS/UV-Vis/dRI analyses is effective to investigate fine variations in biological samples, spot effects related to production and isolation protocols and identify the composition of a mix. This new approach paves the way for further multimodal analyses, and the use of AF4 as a quality control in the field of nanotherapeutics and bioproduction.

Posters

- Author: **Emmanuel Castiel**
Title: “Phase diagram of iron within DFT+DMFT”
Affiliation: *CEA DIF*

- Author: **Sergei Celaj**

Title: “Demonstration of whispering gallery mode lasing in microcavities”

Affiliation: *Sorbonne University - INSP*

Our work involves creating a biosensor capable of detecting bio-particles through fluorescence detection. This biosensor is based on dielectric microdisks whispering gallery modes (WGM) excitation. Those modes travelling along a circular trajectory, are inducing at the surface an evanescent wave. For a biomolecule-luminescent molecule cluster within the evanescent wave region, the WGM excitation gives rise to a luminescent molecule emission attesting the presence of the biomolecule. We first fabricate microdisks over thin cylindrical pedestals. To do so we use IP-L 780 photoresist and a commercial Nanoscribe Professional GT2 machine, which operates on two-photon lithography. Characterization of the structure is done using Scanning Electron Microscopy. We then spin a highly concentrated solution of CdS/CdSe/CdS quantum dots on the microdisks. After UV laser illumination, the fluorescence of the quantum dots excites the whispering gallery modes of the microdisks. They are detected and characterized by optical spectroscopy. We demonstrate experimentally that the quality factor of the resonator exceeds 103, proving the light confinement within the cavity and the quality of the microdisk fabrication. Finite Difference Time Domain (FDTD) simulations show good agreement with the experimental modes and polarization. At the end, by using a pulsed laser with sufficient energy, we could demonstrate lasing of the quantum dots/microdisk, a preliminary to the bio-detection step. In this talk we will discuss the fabrication of the microdisk, and the spectroscopy of whispering gallery modes and laser modes.

- Author: **Quentin Chaboche**
Title: “Shaping Biological Tissues using Topological Defects”
Affiliation: *Institut Curie*

The formalism of nematic tissues describes many biological systems: from surfaces of stress fibers, fibroblast tissues or bacterial colonies. In those tissues, topological defects appear to play a key role, namely in shaping these 2D tissues in the 3D space. We study the deformation induced by a single integer topological defect from a theoretical point of view, showing that the features we describe are already present in the passive system. We also aim to develop an in vitro cell tissue displaying such deformations.

- Author: **Anaïs Chochon**

Title: “Engineering light-matter interaction : Waveguide QED with cold neutral atoms and slow-mode nanophotonic crystals”

Affiliation: *Laboratoire Kastler Brossel - Sorbonne Université*

Our understanding of light-matter interactions has led to numerous practical applications in modern-day society and is also at the heart of the second quantum revolution. The quantum theory behind those interactions known as “quantum electrodynamics” (QED) allowed us to push the atom-photon coupling by developing new methods, first with cavities and more recently with nanoscopic waveguides. The field of Waveguide QED has emerged in that sense and has already broadened to many different types of quantum emitters (e.g cold atoms, quantum dots, superconducting qubits) and waveguides (nanofibers, nanophotonic crystals). In our group, we are developing a new platform to interface cold Rubidium atoms with slow-mode nanophotonic crystals (PCWs). The high confinement and low group velocities of the PCWs-guided modes will allow us to increase the atom-photon coupling by a few orders of magnitude, paving the way for future applications in quantum information and simulation. Combining cold atoms with nanophotonic devices raises many technical challenges from the design and nanofabrication of the waveguide to its integration in the cold atom set-up. The toolbox needed to circumvent those challenges includes high-order modes optical tweezers for tight transport of single atoms close to the waveguide surface.

- Author: **Guilhem Curé**
Title: “Managment of magnetic iron nanoparticles in human stem cells in 2D and 3D”
Affiliation: *Institut Curie - UMR 168*

- Author: **Demba Demba**

Title: “Combining nitrogen doping and vacancies for tunable resonant states in graphite”

Affiliation: *MPQ*

Graphitic materials such as graphene, graphite have remarkable properties due to their honeycomb structure of sp^2 hybridized carbon atoms. Beyond the pristine material, a current challenge is to tune the properties of these materials, for example via defect engineering. Nitrogen doping has attracted most attention in recent years because it allows to enhance and tune graphene properties potentially extending its application possibilities compared to the pristine form. Nitrogen in graphene leads to a n-doping together with the formation of a resonant unoccupied state. Another way of structural manipulation of graphene and graphite is a controlled defect creation known as ion irradiation. This technique has been demonstrated to tune graphene properties and create single and double artificial vacancies in it. Here we have combined Ar ion sputtering with remote post process nitrogen doping in a graphite sample in order to first investigate the Ar^+ irradiation effects by probing the created vacancies and characterizing their electronic signatures. We also investigate how the nitrogen doping influences the electronic properties at the vacancy sites, and the overall consequences in the graphite properties. First of all, we find that the nitrogen doping in graphite is acting very similarly to what has been reported in graphene. Secondly, we observed using scanning tunneling microscopy/ spectroscopy STM/STS the formation of different types of vacancies. Our spectroscopic study reveals the formation of peaks in the density of states in the unoccupied state region for vacancies in pristine graphite, while after nitrogen doping the peaks turn to the occupied states region. This allows to envision new strategies to tune the activity of graphitic materials by controlling different types of active sites with potentially a donor or acceptor character.

- Author: **Antoine Favier**

Title: “Herbertsmithite : understanding defects effect on ground state”

Affiliation: *Laboratoire de Physique des Solides - Université Paris-Saclay*

Posters

- Author: **Leah Friedman**

Title: “Precise and scalable self-organization in mammalian pseudo-embryos”

Affiliation: *Institut Pasteur*

- Author: **Félix Garreau de Loubresse**

Title: “Combining a quantum cryptographic protocol with a high-efficiency quantum memory”

Affiliation: *Laboratoire Kastler Brossel*

Highly-efficient quantum memories as key devices for the creation of large-scale quantum networks, as they enable the reversible storage of qubits and acts as synchronizing nodes for swapping operations. One promising platform is cold-atom, a record high efficiency entanglement transfer between light and cold-atom-based quantum memories has been reported by our group [1]. A necessary functionality of future quantum networks will be secure quantum communication. It is thus of interest to combine cryptographic primitives and quantum memories. To this end, we implemented the quantum money protocol [2] with a high efficiency quantum memory layer based on cold-atom. The purpose of this protocol is to secure transactions between a bank, a client and a vendor. While other protocols such as quantum key distribution are well advanced, quantum money has not yet seen the same experimental progress, owing to the difficulty in implementing efficient enough quantum storage devices to beat the security threshold which is highly sensitive to errors and losses [3]. In this context, the high efficiency and low noise performance of our memory platform is critical to implement such protocol. We benchmarked the main sources of noise contributing to the resulting error rate and demonstrated that the security threshold can be beaten.

[1] M. Cao, F. Hoffet, S. Qiu, A. S. Sheremet and J. Laurat, “Efficient reversible entanglement transfer between light and quantum memories” *Optica* 7, 1440-1444 (2020)

[2] S. Weisner, “Conjugate Coding” *ACM Sigact News* 15, 78 (1983)

[3] M. Bozzio, E. Diamanti and F. Grosshans “Semi-device-independent quantum money with coherent states” *Phys. Rev. A* 99, 022336 (2019)

- Author: **Laurène Gatuingt**

Title: “Non-equilibrium dynamics in the antiferromagnetic cuprate Bi2212 probed by time-resolved Raman spectroscopy”

Affiliation: *Matériaux et Phénomènes Quantiques*

- Author: **Korentin Géraud**

Title: “Cold plasma endoscopy applied to Cholangiocarcinoma: from artificial bile duct model to alive porcine model”

Affiliation: *LPP - Sorbonne Université*

Posters

- Author: **Elisabeth Gliott**

Title: “Dynamics of interacting and disordered Bose gases under external drive”

Affiliation: *Laboratoire Kastler Brossel*

- Author: **Hadi Hassan**

Title: “Spin pumping in LSMO/YBCO heterostructures”

Affiliation: *Laboratoire Albert Fert, CNRS-Thales*

Spin-pumping across d-wave superconductors such as YBa₂Cu₃O_{7-d} (YBCO) at high-quality ferromagnet/superconductor interfaces provides a new playground to study spin-polarized supercurrents. Here we use wideband ferromagnetic resonance to study spin-pumping in bilayers that combine the half metallic ferromagnet La_{0.7}Sr_{0.3}MnO₃ (LSMO) and YBCO. These bilayers were epitaxially grown on NdGaO₃ (NGO) substrates with the crystallographic orientations (110)_o. We evaluated the spin conductance at the LSMO/YBCO interface by analyzing the magnetization dynamics in LSMO. We found that the Gilbert damping shows an upturn followed by a drop as the heterostructures are cooled across the normal-superconducting transition where the ab-plane of the YBCO is parallel to the interface. The upturn observed in the damping reflects an increment in the spin injection efficiency, which could be ascribed to long-range spin pumping mediated by spin triplets. This hypothesis is supported by recent evidence of the generation of spin triplets in c-axis oriented LSMO/YBCO interfaces [1]. These findings put in evidence the promising potential of high-T_c superconductors as conduits for non-dissipative spin transport over long range distances.

[1] D. Sanchez-Manzano, S. Mesoraca, F.A. Cuellar et al., Nat. Mater. 21 (2022) 188–194.

- Author: **Elodie Iglesias**

Title: “Optical-pump induced carrier dynamics in InSb: Probing the dependence of plasma frequency shift on pump fluence by THz-TDS”

Affiliation: *UPCité*

Posters

- Author: **Simon Jouveshomme**
Title: “Typical timescales of memory effects in a nanofluidic system”
Affiliation: *LPENS-CNRS*

- Author: **Thomas Krieguer**
Title: “Fermionic Theory of Ultra-Strong Light Matter Coupling”
Affiliation: *LPENS*

In the ultra-strong light-matter coupling regime (USC), the light-matter coupling constant Ω becomes a significant fraction of the matter transition frequency ω . This regime has been attracting growing attention, namely through the possibility to observe fascinating quantum phenomena, such the dynamical Casimir effect, as wells as the influence of the vacuum field fluctuation on the electronic transport. Intersubband devices, such as emitters and detectors have been natural platform to explore USC, as they can accommodate both electronic transport and highly doped quantum wells required to reach the USC regime. Up to now, the theoretical description of the USC had put the accent on the bosonization approach, where the collective electronic excitations coupled to the microcavity resonance are treated as quantum harmonic oscillators. Recently, we developed a quantum model for USC devices which treats the problem on a fermionic basis, by considering both the electronic coherences and populations as dynamical variables. Here we will discuss this model, and its possible extensions that allow treating the electronic transport as well as non-linear phenomena in the presence of microcavity and strong collective electronic effects.

Posters

- Author: **Nicolas Kuszla**
Title: “Super-Resolution Microscopy for Extracellular Vesicles Imaging”
Affiliation: *MSC-med*

Posters

- Author: **Corentin Lanore**
Title: “Towards Device-Independent Quantum Key Distribution with photonic device”
Affiliation: *IPhT*

- Author: **Lorenzo Lazzari**

Title: “Hybrid III-V/Silicon photonic circuits embedding generation and routing of entangled photon pairs”

Affiliation: *MPQ - C2N - STMicroelectronics*

Hybrid photonic devices, harnessing the advantages of multiple materials while mitigating their respective weaknesses, represent a promising solution to the effective on-chip integration of generation and manipulation of non-classical states of light encoding quantum information. We demonstrate a hybrid III-V/Silicon quantum photonic device combining the strong second-order nonlinearity and compliance with electrical pumping of the III-V semiconductor platform with the high maturity and CMOS compatibility of the silicon photonic platform. Our device embeds the spontaneous parametric down-conversion (SPDC) of photon pairs into an AlGaAs source and their subsequent routing to a silicon-on-insulator circuitry. This enables the on-chip generation of broadband telecom photon pairs by type 0 and type 2 SPDC from the hybrid device, at room temperature and with strong rejection of the pump beam. Two-photon interference with 92% visibility proves the high energy-time entanglement quality characterizing the produced quantum state, thereby enabling a wide range of quantum information applications.

Posters

- Author: **Brieuc Le Dé**
Title: “Theory of Photoinduced Excited State Proton Transfer with Matrix Product States”
Affiliation: *INSP Sorbonne*

- Author: **Maxime Leuliet**

Title: “Mid-IR frequency measurements with a Si-referenced comb for H₂⁺ spectroscopy”

Affiliation: *Laboratoire Kastler Brossel (Jussieu)*

H₂⁺ molecular ions are very interesting candidates to improve the determination of fundamental constants, such as the proton-to-electron mass ratio m_p/m_e and search for new physics beyond the standard model. At LKB, H₂⁺ is sympathetically cooled by Be⁺ in a linear Paul trap and a mid-IR two-photon vibrational spectroscopy is in progress. We have tested a new laser control system, based on a frequency comb referenced on an ultra-stable signal at 1542 nm, generated by the LNE-SYRTE and delivered by the REFIMEVE fiber network. A narrow-saturated absorption line in formic acid has been extensively studied in third harmonic detection by using a CO₂ laser locked on the frequency comb. A fit model including frequency and intensity modulation distortion effects in Fabry-Pérot cavity has been developed. It allowed us to evaluate pressure, power, modulation depth and modulation frequency shifts and broadenings, leading to a central frequency measurement at a sub ppt (10⁻¹²) resolution. This test on formic acid shows that the resolution of our spectrometer is high enough for H₂⁺ spectroscopy and fundamental constant determination.

- Author: **Vitor Lima**

Title: “Interfacial effects in cuprate physics”

Affiliation: *Laboratoire de Physique des Solides - Université Paris-Saclay*

Superlattices and heterostructures of correlated oxides have been used to explore interfacial effects and to achieve additional control on the physical properties of individual constituents [1], [2], [3]. In our work [4] we present a theoretical investigation of the interfacial and thickness effects in YBa₂Cu₃O₇/La_{2/3}Sr_{1/3}MnO₃ (YBCO/LSMO) superlattices. Our findings indicate a transfer of electrons from LSMO to YBCO and, more interestingly, we find an in-plane ferromagnetic ground state within the CuO₂ planes near the interface, which appears due to the induced small local moments centered at the copper atoms, that are decoupled from the charge transfer and appear mainly due to the Mn(3d)-O(2p)-Cu(3d) hybridization in the interfacial region. These effects also leads to a suppression of Cu-3d density of states near the Fermi energy.

We argue that the net magnetic ordering and suppression of Cu-3d density of states may have implications for a better understanding and control of the electronic properties in the LSMO/YBCO superlattice, that we believe be possible to extend to multilayered cuprates, since the layered structure allows the CuO₂ planes which are not equivalent structurally to have different electronic/magnetic phases [5].

[1] A. Ohtomo et al. A high-mobility electron gas at the LaAlO₃/SrTiO₃ heterointerface. *Nature* 427, 423–426 (2004).

[2] B. Gray et al. Superconductor to Mott insulator transition in YBa₂Cu₃O₇ / LaCaMnO₃ heterostructures. *Sci Rep* 6, 33184 (2016).

[3] J. Chakhalian et al. Magnetism at the interface between ferromagnetic and super-conducting oxides. *Nature Phys* 2, 244–248 (2006).

[4] V. Lima et al. Interface and thickness effects in La_{2/3}Sr_{1/3}MnO₃/YBa₂Cu₃O₇ superlattices. *Phys. Rev. B* 109, 045128 (2024).

[5] V. Oliviero et al. Magnetotransport signatures of antiferromagnetism coexisting with charge order in the trilayer cuprate HgBa₂Ca₂Cu₃O_{8+δ}. *Nat Commun* 13, 1568 (2022).

Posters

- Author: **Quentin Louis**
Title: “Wave Source Amplification and Quenching in Time-Varying Media ”
Affiliation: *Institut Langevin, ESPCI | PSL*

- Author: **Paul Martin**

Title: “Frequency Metrology of the 1S-3S transition of the (electronic) hydrogen and deuterium atoms”

Affiliation: *LKB*

Precision laser spectroscopy experiments of hydrogen is a efficient tool to test accurate theoretical predictions of quantum electrodynamics (QED) on a simple atomic system (i.e. whose theory can be calculated to extreme accuracies), while determining the value of fundamental constants. It also leads to a better understanding of the quantum structure of atoms, one of the fundamental tests of physics and is at the heart of the problematic around the radius of the proton charge distribution (r_p). In our team, we have studied the two-photons transition 1S-3S of atomic hydrogen and recently in deuterium at 205 nm with a relative uncertainty of about $1e-12$. The continuous 205 nm laser beam is obtained by a frequency sum in a non-linear crystal. To further improve the relative uncertainty of the 1S-3S transition measurement, we plan to lock the lasers upstream of the frequency sum to a frequency comb itself directly locked to the Refimeve network, a long-distance transfer of an ultra-stable optical frequency from the SYRTE laboratory over an internet network. In order to reduce certain systematic effects, a new hydrogen source is being implemented and the vacuum chamber has been rebuilt with the addition of dry pumps.

- Author: **Nehal Mittal**

Title: “Probing topological phase transition and critical physics in a synthetic quantum Hall system”

Affiliation: *LKB, College de France*

Topological phase transitions (TPTs) differ from the conventional Landau-Ginzburg theory of phase transitions due to their lack of explicit symmetry breaking. These transitions are characterized by a change of topological invariants, exhibiting discontinuous behaviour across the transition, in contrast to the continuous change of local order parameters in conventional second-order phase transitions. Nonetheless, scale invariance emerges at the quantum critical point (QCP) due to the divergence of penetration length of edge modes, facilitating the identification of critical exponents and universality classes.

We investigate a quantum Hall ribbon in one real and one synthetic dimension encoded in the spin of Dysprosium atoms through a 2-photon Raman process. By introducing an additional optical lattice, we induce a TPT between the topological and Mott insulator phases. The critical physics of this transition is dominated by a parity-symmetric Dirac point, resulting in a half-quantized Hall effect with $C = \frac{1}{2}$. This robust “topological” state at the TPT has significant implications for applications like robust quantum computing and prompts intriguing questions for the theoretical understanding of topological phenomena like bulk-edge correspondence.

- Author: **Adrien Moncomble**
Title: “Deep Learning Assisted Denoising of in situ Liquid STEM Movies of Nanoparticles Nucleation and Growth”
Affiliation: *Matériaux et Phénomènes Quantiques (MPQ)*

- Author: **Yassine Oubaid**

Title: “New insights on the Iron based superconductor BaFe₂S₃”

Affiliation: *University Paris Saclay, Synchrotron SOLEIL*

The discovery of iron-based superconductors had a huge impact on condensed-matter physics and led to extensive studies. Recently, a family of quasi-1D Fe-based spin ladders, BaFe₂X₃ (X=Se, S), has been found to present superconductivity (SC) : a SC dome between 10-17 GPa and T_c between 11 and 26 K has been evidenced [1,2]. The (Pressure, Temperature) phase diagram also presents a magnetic order at ambient pressure below T_N ≈ 120 K (X=S) or 250 K (X=Se), which can compete or coexist with the SC state. The interest of this series of compounds is its low dimensionality which contrast with usual 2D superconductors (iron-based, cuprates and recently nickelates) and simplify the theoretical approaches. The crystal structure of these compounds consists of Fe(2+) ladders, formed by edge-sharing FeS₄ tetrahedron separated by Ba ions. There are two ladders by unit cell. The symmetry between ladders in the unit cell is lower for BaFe₂Se₃ (Pm space group [3]) than for BaFe₂S₃ (Cmcm space group). The magnetic structure stabilized below T_N is characterized by an unusual block-type AFM order with a $q_b=(\frac{1}{2} \ \frac{1}{2} \ \frac{1}{2})$ propagation wave vector for the Se compound [3,4] while a standard stripe-like order with a $q_s=(\frac{1}{2} \ \frac{1}{2} \ 0)$ is stabilized for the S member [5]. This difference in magnetic ordering for systems with such comparable structures remains to be understood.

To help us understand this difference, my group started to investigate the X=Se sample, both the structural [4], dynamical [6], and magnetic [7,8] point of view at ambient pressure, and later under pressure [9]. They have also performed inelastic neutron scattering on BaFe₂Se₃ single crystal (1g) to measure the spin dynamics [10]. By comparing the dispersion to spin-wave calculation, they extracted a set of magnetic exchange interaction. The purely antiferromagnetic Heisenberg model obtained show a strong second neighbor interaction within the ladder, resulting in a strong frustration. This strong frustration is at the origin of the exotic block-like magnetic order present in this member. In my talk i am gonna present our new insights concerning an interesting phase transition occurring at low temperature which may be correlated with the magnetic ordering using different big instruments techniques including Synchrotron radiation (Xray diffraction and Infrared) and neutron source both under extreme conditions (Low temperature and High pressure).

[1] H. Takahashi et al. Nature Materials, 14(10), 1008–1012 (2015)

[2] J. Ying et al. Phys. Rev. B 95, 241109 (R) (2017)

- [3] J.M. Caron et al, Physical Review B 84, 180409(R) (2011)
- [4] W. Zheng, V. Balédent et al. Physical Review B 101, 020101(R) (2020)
- [5] S. Chi et al, Physical Review Letter 117, 047003 (2016)
- [6] M. J. Weseloh, V. Balédent et al. Journal of Physics : Condensed Matter 34, 255402 (2022)
- [7] W. G. Zheng, V. Balédent et al. Physical Review B 107, 024423 (2023)
- [8] W. G. Zheng, V. Balédent et al. Physical Review B 106, 134429 (2022)
- [9] W. G. Zheng, V. Balédent et al. Nature Communication Physics 5, 183 (2022)
- [10] A. Roll, V. Balédent et al. Physical Review B 108, 014416 (2023)

- Author: **Soufiane Oukassi**
Title: “Counting mobile using integrable systems”
Affiliation: *IPHT*

Mobiles are a particular class of decorated plane trees which serve as codings for planar maps. Here we address the question of enumerating mobiles in their most general flavor, in correspondence with planar Eulerian (i.e., bicolored) maps. We show that the generating functions for such mobiles satisfy a number of recursive equations which lie in the field of integrable systems, leading us to explicit expressions for these generating functions as ratios of particular determinants.

Posters

- Author: **Caroline Parent**
Title: “Droplet microfluidic platform for drug screening on cancer spheroids”
Affiliation: *Institut Curie*

- Author: **Ankul Prajapati**

Title: “Realisation of the long-lived chain of circular Rydberg atoms for quantum simulation”

Affiliation: *LKB-ENS*

The dynamics of many-body systems, e.g., large arrays of interacting spin-1/2 particles, is one of the most challenging theoretical problems to solve. Quantum simulations, emulating the evolution of a real system, is a promising approach to overcome this difficulty. Recently, experiments using low angular momentum Rydberg atoms trapped in optical tweezers have shown promising results for simulating systems of up to 100 spins. Despite the long lifetime of Rydberg states on the order of 100s microseconds, the overall lifetime of large arrays of particles reduces significantly, thus limiting simulation to shorter evolution times for larger arrays. Our approach is to use atoms in circular Rydberg (cRy) states that are characterized by maximal orbital and magnetic quantum numbers. They exhibit even longer lifetimes on the order of several tens milliseconds and spontaneously decay only to a single lower cRy state. This microwave emission can be inhibited by placing them between millimeter-spaced inhibition capacitor plates. It gives us an exceptionally long lifetime of the order of minutes, which is essential for simulating a long system’s dynamics. We are currently building an experimental setup for preparing and trapping long chains of cRy atoms inside an inhibition capacitor in the cryogenic environment. I will discuss the basic principles and experimental progress.

- Author: **Ulysse Rémond**

Title: “Spin gauge invariance of the Dirac equation and minimal quantum walk simulation”

Affiliation: *Sorbonne Université - LERMA*

The quantum walk simulation of Dirac fermions is revisited in (1+2)D space times. The invariance of the Dirac equation is used to allow for expressing it in a connection-less form, by choosing independently the coordinates, the local tangent basis and the spin basis. A transformation law for the spinorial connection operator is introduced. Wave functions are discretized and simulated using the same number of components as the standard Dirac spinors - in particular, in (1+1)D and (1+2)D, only one qubit is required per spacetime point, which means that simulation on current NISQ devices is possible with regard to space complexity. Numerical simulations are then presented on the (1+1)D Rindler spacetime, Minkowski spacetime using spherical coordinates and (1+2)D Schwarzschild spacetime.

- Author: **Romain Rescanieres**

Title: “Light transmission and energy deposition in resonant disordered media”

Affiliation: *Institut Langevin - ESPCI*

Recent advances in wavefront shaping techniques have made it possible to measure the scattering matrix of highly complex media, such as disordered materials made up of dielectric particles or chaotic cavities. These works have revealed the existence of open channels, reflectionless states, and optimized dwell-time eigenstates, even in the diffusive regime where light-matter interaction is strong. Until now, these discoveries have been made using complex non-resonant media. However, resonant systems are widely used in nanophotonics and atomic optics. The aim of this work is to evaluate the influence of material resonance on the statistical properties of the scattering matrix and the energy storage (or dwell-time) operator.

We study a set of resonant light scatterers, which can be considered as individual atoms or high-Q dielectric particles, randomly dispersed in a two-dimensional waveguide. By solving the wave equation, we compute the transmission matrix and the dwell-time operator, and evaluate the statistical properties of their spectra by simulating a large number of disorder configurations. This procedure is repeated for different incident field frequencies, in order to characterize the impact of the material's resonance.

Our results reveal that when we approach the scatterer resonance by simply changing the frequency, the transmission eigenvalue distribution changes from a single-peak distribution, where light is mainly transmitted through the system, to a bimodal distribution in the diffusive regime, and then to a long-tailed distribution in the Anderson localization regime. Furthermore, by investigating the distribution of dwell-times, we gain access to the energy that each eigenchannel can deposit within the medium. We show that these distributions are strongly affected by the transport regime of light in the sample.

This study demonstrates the potential of resonators to modulate the transparency of complex media and to store large amounts of energy within them.

- Author: **Aurélien Ricard**
Title: “Corrosion-driven spreading on iron nanolayers”
Affiliation: *Laboratoire de Physique des Solides*

Iron corrosion has been widely studied in the context of materials science [1][2]. It is most often associated with pits that originate from defects in oxide passive layers, inducing localized corrosion on bulk metal [2]. The classical experiment, named Evans’ drop, consists in depositing an electrolyte droplet on a metal surface and following its corrosion with time. [3] This kind of experiment can lead to iron dissolution at the droplet center, and oxygen reduction at the periphery (see for instance [4]).

As corrosion mostly involves surface reactions, we are interested in two-dimensional (2D) corrosion on the first nanometers of metal. This nanolayer is also of interest in corrosion prevention by coating [5]. By thermal evaporation, we deposit a 10 nm thin iron film over large areas (4 cm²) on a transparent glass substrate and then reproduce the Evans’ drop experiment. The iron nanolayer being semi-transparent, we monitor by simple optical means both iron corrosion and electrolyte droplet behavior. Several pits appear at the same time once the droplet is deposited. They propagate quasi instantaneously across the 10 nm-iron thickness leading to bright areas in the picture taken by a camera placed below the substrate (see the bottom view below). These pits widen radially and propagate in 2D at a mean velocity of 0.80-0.90 mm/h. When this 2D corrosion front reaches the droplet periphery, the droplet starts spreading with contact angles far different from those measured on the nanofilm without corrosion. The front pins the triple line and drives progressively the spreading of aqueous droplets containing salt. These results require further explanation, but they clearly demonstrate the difference between 3D pitting corrosion on bulk metal and 2D corrosion on metal nanolayer and how electrochemical reactions at the nanometer level such as corrosion on nanofilms can lead to substrate wetting. Such phenomenon should also be of interest in the area of corrosion inhibition by coating [5].

[1] Davison, R.M. et al. *Mater. Des.* 1986, 7, 111-119

[2] Lu, Y. et al. *Corros. Mater. Degrad.* 2022, 3, 454-469.

[3] Li, S.; Hihara, L.H. *Corros. Sci.* 2016, 108, 200-204

[4] Sainz-Rosales, A. et al. *Corros. Mater. Degrad.* 2022, 3, 270-280.

[5] Nurdiwijayanto, L. et al., *Nano Lett.* 2021, 21, 7044-7049."

- Author: **Paul Saighi**

Title: “Spontaneous Recollections: Continuous Learning in Neuromorphic Substrat Through Memory Rehearsal”

Affiliation: *Paris Saclay CNRS*

The brain’s ability to assimilate and retain information, to gain new insights without losing valuable past understanding, remains largely a mystery. In the Artificial Intelligence (AI) field, the state of the art reflects the theoretical limitations encountered in neuroscience as Continuous Learning (CL) is still largely an unsolved technical challenge. In this work will be explored a potential solution to CL in a highly biologically plausible setup. A neuromorphic implementation, demonstrating the hardware friendly nature of this solution, will be done using CMOS electronics.

Posters

- Author: **Émilie Su**
Title: “Mitochondria: a comic journey through mechanics”
Affiliation: *MSC*

- Author: **Tamizhmalar Sundararajan**
Title: “Phase separation kinetics of bio-inspired condensates under passive and active conditions”
Affiliation: *Laboratoire Physique de Solides, Université Paris Saclay*

- Author: **Kaouther Tlili**

Title: “Exciton in halide perovskite nanoplatelets : role of dielectric effects and environment”

Affiliation: *INSP*

Recent advances in the field of halide perovskite (HP) nanoplatelets (NPLs) have demonstrated their immense potential for improving photonic and optoelectronic applications. Our research addresses the excitonic properties of quasi-two-dimensional HP NPLs and focuses on how their thickness affects the excitonic and electronic properties. Using the variational wavefunction and the k-p method, we study the Hamiltonian of the system, taking into account aspects such as quantum confinement, dielectric effects, Coulomb interactions and the effects of finite barriers. Our work shows that the dielectric environment and the barrier effects crucially determine the excitonic properties such as the exciton energy, the binding energy and the reduced mass. We investigate these effects specifically in inorganic lead halide perovskites such as CsPbBr₃ and closely matches the theoretical predictions with experimental observations, especially with respect to the exciton energy and its dependence on the NPL thickness. The results highlight the potential to manipulate the excitonic properties by carefully tailoring the environmental and structural parameters, opening avenues for the customized design of NPL-based optoelectronic devices.

- Author: **Thibaud Vernier**
Title: “Matrix approach for harmonic ultrasound imaging”
Affiliation: *Institut Langevin - Supersonic Imagine*

Conventional ultrasound imaging assumes a constant speed of sound in the medium of interest. Yet, in reality, the ultrasonic waves go through different tissues that can display distinct wave velocities. The mismatch between this heterogeneous speed-of-sound distribution and the homogeneous speed-of-sound model induces strong aberrations that can heavily degrade the ultrasound image resolution. A reflection matrix approach of ultrasound imaging has been developed to overcome this issue. Due to the linearity of the wave equation, a set of operations can be applied to the reflection matrix in post-processing in order to mimic adaptive focusing schemes and converge towards focusing laws that optimally compensate for aberrations [1], [2]. Nevertheless, the image resolution remains intrinsically limited by diffraction, i.e. $\lambda/2$ at best. To improve the image resolution, the harmonic mode is now routinely used by practitioners. Yet, a higher frequency content goes in hand with a larger sensitivity to high-order aberrations. The objective of this work is to extend the principle of matrix imaging to the harmonic mode, despite its intrinsic non-linear feature.

[1] W. Lambert, L. A. Cobus, T. Frappart, M. Fink, and A. Aubry, ‘Distortion matrix approach for ultrasound imaging of random scattering media’, *Proc. Natl. Acad. Sci. U.S.A.*, vol. 117, no. 26, pp. 14645–14656, Jun. 2020, doi: 10.1073/pnas.1921533117.

[2] F. Bureau, J. Robin, A. Le Ber, W. Lambert, M. Fink, and A. Aubry, ‘Three-dimensional ultrasound matrix imaging’, *Nat Commun*, vol. 14, no. 1, p. 6793, Oct. 2023, doi: 10.1038/s41467-023-42338-8.

- Author: **Dmitry Yakovlev**
Title: “NbN thin films for superconducting single-photon detectors”
Affiliation: *ESPCI Paris*

We investigate the characteristics of niobium nitride thin films for single-photon detector applications. The films were sputtered on different substrates, such as Sapphire, Silicon, Gallium-Arsenide, and glass. We show different temperature-dependent behavior and critical temperature. We also demonstrate the operation of a single-photon detector.

- Author: **Homero Zapata**

Title: “All-Optical Generation of Drift Currents Through Inverse Faraday Effect”

Affiliation: *Institut de NanoSciences de Paris (INSP)*

The inverse Faraday effect allows the generation of stationary magnetic field through optical excitation only. This light-matter interaction in metals results from creating drift photocurrents via non-linear forces that light applies to the conduction electrons. In our group, we recently described the theory underlying the generation of drift currents in metals, particularly its application to plasmonic nanostructures using numerical simulations. We have also recently demonstrated that drift currents in a gold nanorod can be controlled by manipulating the polarization of light incident on the photonic nanostructures [1]. In this work, we used this property to generate and control drift photocurrents in a gold strip with nanorods placed next to it. We demonstrate theoretically and experimentally that by controlling the linear polarization incident on these structures we can manipulate the direction of the created photocurrents in the gold strip. The ability to generate photocurrents at nanoscale and potentially at ultra-fast timescales opens the way to the generation of nanoscale THz sources, with possible applications in the detection and recognition of molecules in extremely small volumes, or in the design of nanodevices with electric circuitry but optically driven. [1] X. Yang, Y. Mou, R. Zapata, B. Reynier, B. Gallas, and M. Mivelle, *Nanophotonics*, Volume 12, pages 687–694 (2023).

- Author: **Aifei Zhang**

Title: “Disorder induced local quantum Hall breakdown on spin-, valley-, and cyclotron-gapped states in graphene”

Affiliation: *Nanoelectronics group, SPEC*

The Quantum Hall effect (QHE) is known to be stabilized by disorder, thanks to the emergence of bulk localized states that do not participate in quantized transport along the edge. However, disorder also induces the loss of QHE quantization: if a large enough energy (called hopping energy) is provided, charge carriers trapped in a localized state will have the possibility to tunnel from state to state, making the bulk conducting. This phenomenon occurs even at temperatures much lower than the Landau level (LL) spacing, and is usually described in the framework of variable range hopping (VRH) [1], and corresponds to a rich physics governed by universal scalings [2, 3].

The competition between these two antagonistic effects of disorder is set by the interplay between two energy scales (LL spacing and disorder broadening), and two length scales (magnetic length and characteristic disorder length) [4]. To explore this interplay, we have probed the temperature dependence of QH states in graphene in a Corbino geometry [5], over three orders of magnitude. The fourfold spin and valley symmetry of graphene is lifted at high magnetic field, providing two well-separated scales for the energy level spacings [6]: cyclotron gap for a fully filled LL, and spin/valley gaps for the symmetry broken states. Tuning the carrier density with an electrostatic gate allows us to probe states with vastly different gaps at otherwise fixed magnetic length and disorder. We observe a difference of two orders of magnitude in the extracted hopping energies between cyclotron gap states and symmetry broken states; we propose a scenario, based on local breakdown of the QHE modifying the effective disorder potential landscape and hence the energy scales involved in the VRH.

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Title: “Towards an alternative approach to achieve superconducting infinite-layer nickelate thin films”

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In 1986, the discovery of high-temperature superconductivity in cuprate-based compounds marked a breakthrough in the field of solid-state physics, but understand the physics underlying its superconductivity remains puzzling. After three decades of research, a cuprate analog was finally found in the family of layered nickelate compounds by H. Hwang’s group in 2019. They reported superconductivity in thin films of hole-doped infinite-layer nickelates ($\text{Nd}_{1-x}\text{Sr}_x\text{NiO}_2$, x =dopant concentration) with a $T_C \approx 10\text{-}15\text{ K}$ [1]. The superconducting phase is obtained after selectively removing (reduce) all the apical oxygens from the perovskite phase ($\text{Nd}_{1-x}\text{Sr}_x\text{NiO}_3$) using a complex chemical topotactic reduction [2]. Such a method is subject to problems of irreproducibility, preventing the development of the field. Nonetheless, an alternative in-situ technique was proposed by W. Wei’s group to get superconducting infinite-layer phases [3,4], consisting in the deposition of a few nanometers thick aluminum layer, acting as an oxygen scavenger to reduce the perovskite phase.

I will present my recent PhD work focused on the reduction of the perovskite phase by using in-situ aluminum sputtering deposition to attain the superconducting nickelate samples. I will present the whole optimization process of the $\text{Pr}_{0.80}\text{Sr}_{0.20}\text{NiO}_3$ thin films grown on STO (001) substrates by Pulsed Layer deposition technique (PLD) and the subsequent optimization of the aluminum overlayer growth by sputtering, discussing the key parameters to get superconducting infinite-layer thin films. Our findings could help to improve sample reproducibility, opening the way to obtain superconducting infinite-layer samples by using a more reproducible method.

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Posters

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