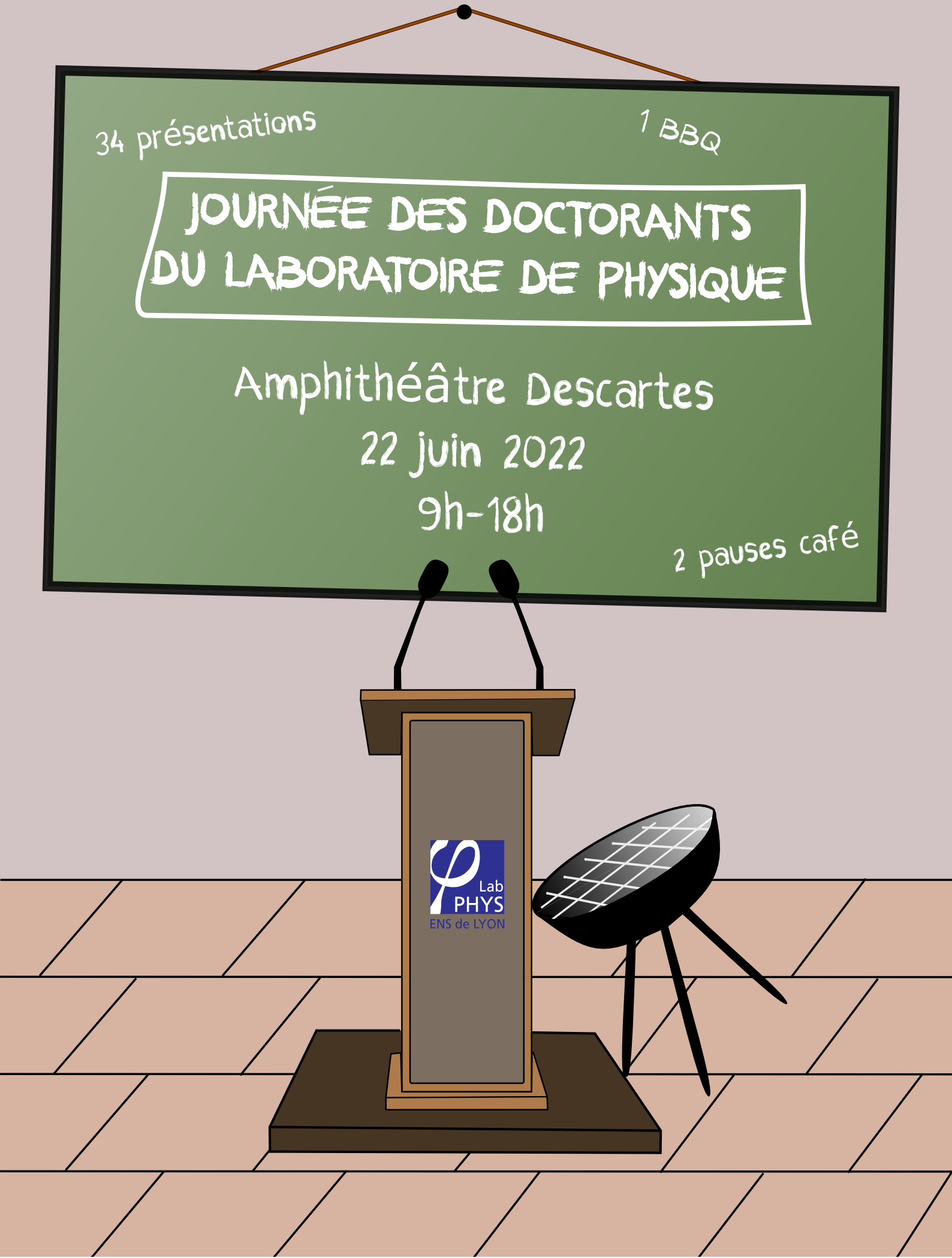
34 présentations
1 BBQ
JOURNÉE DES DOCTORANTS
DU LABORATOIRE DE PHYSIQUE
Amphithéâtre Descartes
22 juin 2022
9h-18h
2 pauses café
Lab
PHYS
ENS de LYON

# Table des matières

# A propos

## Comité d'organisation

| | | |
|---|---|---|
| Thomas BASSET | Saskia BRUGERE | Léa CHAZOT-FRANGUIADAKIS |
| Salambô DAGO | Stéphane GUILLET | Gauthier LEGRAND |
| Charles-Gérard LUCAS | Lucas METHIVIER | Benjamin MONNET |
| | Francis PAGAUD | |

# Programme

Les titres des présentations sont indiquées dans l'ordre de passage. Elles durent $6$ minutes pour les doctorants en $1^{\text{ère}}$ année et $9$ minutes pour ceux en $2^{\text{nde}}$ année (hors question).

## Matin

| | | |
|---|---|---|
| 8h30–9h00 | **Bienvenue** | |
| 09h00–10h30 | **Yohann FAURE** | Propagation de ruptures dans un milieu granulaire |
| | **Baptiste Bermond** | Gravitational anomalies and transport properties of topological semimetals |
| | **Benjamin MONNET** | Remontée de bulles en cellule de Hele-Shaw : étude de la transition du régime visqueux au régime inertiel |
| | **Aubin ARCHAMBAULT** | Experimental study of an information ratchet |
| | **Jules PITCHO** | Flots de champs de vecteurs rugueux : une perspective mathématique |
| | **Thibault LEFRANC** | Spinning active matter |
| | **Saskia BRUGERE** | Compétition et sélectivité du transport dans un système nanofluidique biomimétique |
| | **Charles-Gérard LUCAS** | Multivariate self-similarity: counting the number of different scaling exponents |
| 10h30–11h00 | **Pause** | |
| 11h00–12h30 | **Lucien JEZEQUEL** | Topological phenomena in physics |
| | **Antoine MARQUET** | Quantum Error Correction using bosonic codes |
| | **Hector HUTIN** | Counting the photons of a superconducting cavity |
| | **Arne BAHR** | Towards versatile and resilient $\mu$-scale Electronic Spin Resonance |
| | **Dario D'ASARO** | The Biophysics of DNA replication in 3D: Theoretical modeling |
| | **Thomas BASSET** | Lagrangian investigation of particle dispersion in turbulence |
| | **Lise MORLET-DECARNIN** | Gélification et plasticité de nanocristaux de cellulose en suspension aqueuse induites par des stimuli acousto-mécaniques |
| | **Victor DANSAGE** | Influence des interactions sur la condensation de Bose-Einstein |
| | **Camille JORGE** | Frustrating active flows |

## Après-midi

| 12h30–14h30 | **Barbecue** | |
|---|---|---|
| 14h30–16h00 | **Youssef TRIFA** | Dynamics of correlations in cold atom gases: how cats rule the quantum world |
| | **Marc LAGOIN** | Of cats and Maxwell demons. |
| | **Antoine DOP** | Surface instabilities, creep and flow of grains under shear |
| | **Bastien COZIAN** | Extremes of low renewable energy production combined with high energy demand in winter |
| | **Mathilde AUXOIS** | Identification et étude de descripteurs du malaxage d'une pâte de boehmite pour la conception de nouveaux solides |
| | **Corentin PACARY** | Observation of internal waves attractor in an axisymmetric basin |
| | **François GU** | Hydrodynamique des foules et des bancs |
| | **Kennedy Nexon CHAGUA ENCARNACION** | Bacterial motility and early colony formation on a stiffness gradient |
| 16h00–16h30 | **Pause** | |
| 16h30–18h00 | **Elian BERNARD** | Étude des statistiques lagrangiennes de la convection turbulente |
| | **Jacquelin LUNEAU** | Topological pumping in quantum circuit |
| | **Gauthier LEGRAND** | Dynamic study of local rheoelectric properties of colloid-polymer gels under shear |
| | **Hoang Trieu Vy LE** | Multiscale estimation and Interface detection |
| | **Francis PAGAUD** | What drives turbulent transport in a strongly sheared plasma column waves or vortices ? |
| | **Stéphane GUILLET** | Microfluidics in curved space |
| | **Bastien DUBOEUF** | Kaluza Klein compactification, Exceptional Geometry and Holography |
| | **Théophile REMOND** | La physique du rebond au tennis de table |
| | **Ehsan JAFARI** | Adaptive Cooperative Control Strategies to Maximize the Training Effects of Neuromuscular Electrical Stimulation |

# Résumés

1 : Matière et Complexité ; 2 : Ondes, Écoulements et Fluctuations ; 3 : Signaux, Systèmes et Physique ; 4 : Physique Théorique

## Session 1

***Président : Francis PAGAUD***

### Propagation de ruptures dans un milieu granulaire

***Yohann FAURE*** 1

Lorsqu'une rupture se propage le long d'une faille sismique, elle se fraie un chemin au travers des matériaux de natures très différentes, dont des matériaux granulaires. L'objectif de ma thèse est d'étudier cette propagation en milieu granulaire sur un système modèle fait maison, équipé de capteurs de déformation rapides, le tout sous l'oeil affuté (mais pas assez) d'une caméra à très haute vitesse.

### Gravitational anomalies and transport properties of topological semimetals

***Baptiste BERMOND*** 4

I work on thermal transport and study how gravitational anomalies modify conventional properties of transport in topological semimetals. Historically, Luttinger proposed the gravitational potential as the potential associated to thermal transport. Thermal transport can therefore be described either by a non homogeneous temperature profile in flat space time or by a constant temperature profile in a curved space time. But massless theories in a curved space time are modified in presence of strong curvature by the so-called "gravitational anomalies". I therefore study the possible implication of these anomalies on thermal transport.

### Remontée de bulles en cellule de Hele-Shaw : étude de la transition du régime visqueux au régime inertiel

***Benjamin MONNET*** 2

J'étudie la remontée d'une bulle unique de gaz dans des liquides newtoniens confinés (et plus spécifiquement en cellule de Hele-Shaw). Je me suis intéressé à la transition entre le régime visqueux (viscosité élevée, vitesse faible) et le régime inertiel (viscosité faible, vitesse élevée). Pour ce faire, je me suis concentré sur le comportement de la forme et de la vitesse de ces bulles.

### Experimental study of an information ratchet

***Aubin ARCHAMBAULT*** 2

Stochastic thermodynamics tries to extend to the micro scale results from macro scale thermodynamics by study cases where thermal fluctuations are of the same order of magnitude as the interest phenomenon. By applying a fast feedback to a Brownian system, we can extract work at apparently no cost, thus violating the second principle of thermodynamics. Many recent theoretical works solve this paradox of the so-called Maxwell Demon by taking into account the information exchanged with the system. My aim during my PhD is to measure and characterise work exchanges with such a system and try to give a meaning to the notion of information in an experimental system where inertia cannot be neglected.

## Flots de champs de vecteurs rugueux : une perspective mathématique

***Jules PITCHO***

2

Un fluide turbulent peut être modélisé par un champ de vecteurs rugueux. La turbulence lagrangienne se donne les flots associés à de tels champs de vecteurs comme objet d'étude. Leur compréhension mathématique reste cependant embryonnaire.

## Spinning active matter

***Thibault LEFRANC***

1

One of the remaining challenges in experimental synthetic active matter is to go from 2D to 3D. During this talk, I will present the first steps towards the realization of a 3D active material, namely the fabrication of its elementary constituents, and the first observations we made with these active particles.

## Compétition et sélectivité du transport dans un système nanofluidique biomimétique

***Saskia BRUGERE***

1

Le pore nucléaire est un pore biologique permettant les échanges entre le noyau et le cytoplasme de la cellule. C'est un canal très sélectif qui ne laisse passer que certaines molécules. Dans ce projet, j'utilise une approche mimétique du pore nucléaire, grâce à des membranes nanoporeuses artificielles, afin d'étudier la sélectivité du pore en fonction de différentes fonctionnalisations de la membrane.

## Multivariate self-similarity: counting the number of different scaling exponents

***Charles-Gérard LUCAS***

3

Scale invariance, well modeled by self-similarity, is a structuring property of the temporal dynamics of many signals. So far, it has been mainly studied in a univariate way (signal by signal). In modern applications, one system is often monitored from multivariate data collected on multiple sensors. The core of my thesis work aims to analyse multivariate (joint study of a collection of signals) self-similarity built on wavelet representations. My presentation will focus on counting how many actually different self-similarity parameters drive the temporal dynamics of a collection of signals.

# Session 2
***Président : Gauthier LEGRAND***

## Topological phenomena in physics
***Lucien JEZEQUEL*** 4

In this talk I will present briefly why topology could be a useful tool to describe some physical phenomena. Through a (basic ?) model, I will try to show how we can extract topological phenomena from it and why it has some interesting and robust consequences.

## Quantum Error Correction using bosonic codes
***Antoine MARQUET*** 2

There are several challenges to building a quantum computer, one of which being to simply protect the quantum information from decoherence. To do so, one of the key techniques of Quantum Error Correction is to redundantly encode the same information multiple times so that if one of the copies gets corrupted, the information can still be recovered by looking at the ensemble. While it is possible to use multiple two-level system to obtain such redundancy, another approach is to directly use resonators and use their infinite-dimension Hilbert space, corresponding to bosonic codes.

## Counting the photons of a superconducting cavity
***Hector HUTIN*** 2

In the low temperature regime, the excitation of the electromagnetic field in a microwave superconducting cavity are described by the model of the quantum harmonic oscillator, whose elementary excitations are called photons. We can extract information on the number of photons in such a device by coupling it to a two-level system called quantum bit in the right regime of parameters : the dispersive regime. Such a quantum bit can be obtained by addressing the first two levels of a sufficiently anharmonic system, a transmon, created thanks to a Josephson junction, the key element to quantum superconducting circuits.

## Towards versatile and resilient $\mu$-scale Electronic Spin Resonance
***Arne BAHR*** 2

Electron spin resonance is usually performed on spins embedded within a microwave resonator matching their Larmor precession frequency to gain information about the spin structure of the sample. These measurements are typically limited by the spin microwave coupling and the quality factor of the resonator. We are working on increasing the spectrometer sensitivity by implementing the experiment using quantum circuits.

## The Biophysics of DNA replication in 3D: Theoretical modeling
***Dario D'ASARO*** 3

In Eukaryotes, DNA is tightly packed into a polymer-like structure called chromatin. The highly efficient mechanisms which regulate its faithful replication in such crowded environment remain elusive. For this reason, we aim to investigate the interplay of 3D chromosome organization and 1D replication dynamics through polymer modelling. This new computational framework will allow us to address how replication may mechanically impact genome's assembly and conversely how a heterogeneous accessibility landscape may modulate replication's temporal patterns.

## Lagrangian investigation of particle dispersion in turbulence

***Thomas BASSET***

2

I am working on how particles disperse in various turbulent flows through experiments, data analysis and some modelling. For this talk, I will present the experimental method known as Particle Tracking Velocimetry to reconstruct 3D particle trajectories in turbulent flows. Then I will focus on one of my main result regarding the Lagrangian conditioning of Eulerian fields in a turbulent round jet.

## Gélification et plasticité de nanocristaux de cellulose en suspension aqueuse induites par des stimuli acousto-mécaniques

***Lise MORLET-DECARNIN***

1

Cellulose nanocrystals (CNCs) are rodlike biosourced colloidal particles used as key building blocks in a growing number of materials with innovative mechanical or optical properties. While CNCs form stable suspensions at low volume fractions in pure water, they aggregate in the presence of salt and form colloidal gels with time-dependent properties. For now, we have studied the impact of salt concentration and type of salt on the recovery dynamics of CNC gels following the cessation of a high-shear flow. We have shown that this aging dynamics presents universality that calls for microstructural investigations as well as theoretical modelling of this time-composition superposition in rodlike colloids.

## Influence des interactions sur la condensation de Bose-Einstein

***Victor DANSAGE***

4

La condensation de Bose-Einstein, prédite il y a plus d'un siècle, est un pur effet de statistique quantique en l'absence d'interactions et observé pour la première fois il y a près de 30 ans. J'étudie donc l'influence des interactions sur la condensation, est-elle modifiée ? Détruite ? Pour cela nous utilisons différents formalismes : la diagrammatique de Feynman, les équations de la hiérarchie et le formalisme du gaz de boucles/filaments qui présentent tous certains avantages et inconvénients, et c'est pourquoi nous combinons ces différentes approches.

## Frustrating active flows

***Camille JORGE***

1

I work on model experiments based on Quincke roller fluids. I reveal and elucidate two qualitatively different classes of flow degeneracy when active fluids explore honeycomb lattices. My work explains how the local strategies used by active flows to resolve geometrical frustration determine the large scale morphology of their flow fields.

## Session 3
***Président : Benjamin MONNET***

### Dynamics of correlations in cold atom gases: how cats rule the quantum world
***Youssef TRIFA*** 4

By studying (very) small ensembles of large-spin magnetic atoms, we show that with the proper initial state the dipolar interactions lead to the formation of cat states. These states are known to be very fragile to decoherence effects, but also very useful for metrology, hence the interest in having a robust way to produce such states. We show that the cat state formation is closely related to a generic class of Hamiltonians known as One Axis Twisting models and we propose new numerical methods to go beyond exact diagonalization.

### Of cats and Maxwell demons.
***Marc LAGOIN*** 2

In my thesis, I explore statistical thermodynamics at cat size. Indeed, Antoine and I realized a centimetric Maxwell demon analogous to the Feymann's Ratchet and pall toy model. It is able to select speed fluctuations of a blade subject to isotropic random force accounting for thermal fluctuations.

### Surface instabilities, creep and flow of grains under shear
***Antoine DOP*** 1

Under some conditions, a slider pulled across a granular bed can be unstable and start oscillating about its pitch axis, thus generating a corrugated surface in its wake. This surface instability is studied numerically by discrete element method simulations of soft spheres in order to characterize the dependance of its amplitude and wavelength to the various parameters of the problem. The phenomenon is also studied experimentally, including in a conveyor belt configuration where the grains are displaced under a 3D printed slider.

### Extremes of low renewable energy production combined with high energy demand in winter
***Bastien COZIAN*** 2

Europe plans an increase of renewable energy generation, mainly solar photovoltaic and wind. In 2050, the power system management will be very different due to the large share of weather-dependent electricity production, combined with weather-dependent electricity demand. In particular, the winter extremes of low production and high demand need to be understood in order to design an electricity system that can cope with these events. However, historical data on weather and renewable energy is too short to sample and study the statistics of these rare events. Therefore we need to rely on climate models. I will present my work on these events, which I study with a very long climate simulation (1000 years) coupled with a simple energy model.

## Identification et étude de descripteurs du malaxage d'une pâte de boehmite pour la conception de nouveaux solides

***Mathilde AUXOIS*** 1

Mon sujet de thèse, porté par l'IFP Energies nouvelles en collaboration avec l'ENS de Lyon, porte sur l'étape de malaxage dans le processus de fabrication des supports de catalyseurs. Celle-ci consiste à mélanger une poudre d'oxyde d'aluminium à de l'eau, de l'acide et de la base dans un équipement dédié, pour former une pâte à la rhéologie complexe et à la structure poreuse. L'objectif de cette thèse est de caractériser puis de modéliser l'influence de l'étape de malaxage sur la structure de la pâte obtenue.

## Observation of internal waves attractor in an axisymmetric basin

***Corentin PACARY*** 2

Inertia-gravity waves propagate in the ocean and the atmosphere, contributing to the dissipation of the tidal energy. We use their peculiar dispersion relation with a conical tank to focus them on so called attractors, in order to increase the energy density to a point where non-linear effects kick in. Triadic resonant instability and vortex generation are at play to dissipate more energy as we increase the forcing amplitude.

## Hydrodynamique des foules et des bancs

***François GU*** 1

L'objectif de la thèse est de fournir une description hydrodynamique des mouvements de foules humaines denses et de bancs de poissons. Pour y parvenir nous réaliserons des mesures quantitatives de la structure et de la dynamique de deux systèmes modèles. En utilisant des méthodes spectrales et des techniques de type machine learning nous infèrerons alors une description théorique des foules et des bancs décrits comme des milieux continus actifs.

## Bacterial motility and early colony formation on a stiffness gradient

***Kennedy Nexon CHAGUA ENCARNACION*** 1

My objective is to explore how a polyacrylamide stiffness gradient influences the individual (mainly the twitching motility) and collective (microcolony formation) behavior of Pseudomonas Aeruginosa bacteria. For this purpose we perform a multidisciplinary approach using microfluidics (adhesion and growth take place in flow cells), soft matter (photopolymerization method is used for the elaboration of the stiffness gradient), microscopy (bacteria are imaged in situ by phase contrast) and machine learning (Weka plugins of ImageJ for bacterial segmentation). We elaborate substrates of controlled stiffness (1 - 100 kPa) and mm-sized spatial (0.5-1.5 mm) gradients, as well as carry out studies at an individual and collective level.

# Session 4
***Président : Thomas BASSET***

## Étude des statistiques lagrangiennes de la convection turbulente
***Elian BERNARD*** 2

La convection thermique est un phénomène omniprésent dans la nature et dans l'industrie, c'est pourquoi elle a été très étudiée au cours des décennies précédentes. Cela dit, les mécanismes à petites échelles telle que la dynamique des panaches restent mal connus. L'objectif de cette thèse expérimentale est donc d'améliorer la compréhension de l'écoulement en utilisant la PTV (particle tracing vélocimétrie) afin d'étudier les statistiques lagrangiennes (fonctions de structures, corrélation, dispersion de paires…).

## Topological pumping in quantum circuit
***Jacquelin LUNEAU*** 4

I work on topological pumping, a pumping phenomenon of energy between components of a slow environment mediated by a fast quantum system. This pumping originates from a topological property of the quantum system, leading to quantization and robustness of the pumping rate. I present an experimental proposal of such a topological pump where energy is transferred between microwaves modes coupled to a superconducting quantum circuits. I consider now topological pumping between quantum cavities, focusing on the entanglement between the degrees of freedom.

## Dynamic study of local rheoelectric properties of colloid-polymer gels under shear
***Gauthier LEGRAND*** 1

Indian ink is a water solution composed of soot (carbon black nanoparticles) and polymers as stabilizer. In very concentrated regime it becomes a gel that exhibits solid-like and liquid-like behaviors. This yield stress fluid is mainly used as electrolyte in flow batteries thanks to the high conductivity of carbon black. During my PhD we aim at studying simultaneously the mechanical and electrical properties of this gel in order to understand better the intertwined roles of both nanoparticles and polymers.

## Multiscale estimation and Interface detection
***Hoang Trieu Vy LE*** 3

Interface detection is a challenging question in image processing, and more generally in graph processing, leading to a large panel of applications going from geophysics research to societal studies. The common point to these applications is the willingness to have an interface detection at a fine scale, possibly with subpixel accuracy, in order to extract interpretable parameters (e.g. physical or societal), from high resolution data.

## What drives turbulent transport in a strongly sheared plasma column: waves or vortices ?

***Francis PAGAUD*** 2

The origin of transport in fluid turbulence has clearly been proven since Richardson demonstrated the crucial importance of nonlinear interactions between vortices in neutral fluids in 1922. However, the situation gets complex in the case of plasmas, especially since dispersive waves propagate in such media. It results in nonlinear interactions that lead to additional turbulent transport. The goal of my PhD is to experimentally demonstrate whether transport is mainly achieved through interacting waves or vortices in plasmas. An experimental setup called Von-Kármán Plasma is already operating and is planned to be completed soon. This new experiment enables to sustain waves and vortices via a Kelvin-Helmholtz instability in a sheared cylindrical plasma.

## Microfluidics in curved space

***Stéphane GUILLET*** 1

In this talk, I will present my first step in designing curved Hele-Shaw cells. Combining 3D printing techniques and microfluidics, my long term objective is to decipher how geometry could interfere with mono or multiphase flows. In particular how a localized source of curvature could modify the path of soft crystals and mobility of dislocations.

## Kaluza Klein compactification, Exceptional Geometry and Holography

***Bastien DUBOEUF*** 4

One intriguing aspect of maximal Supergravity theories is the emergence of exceptional symmetry upon compactifying internal dimensions. Exceptional Field Theory is an exceptional covariant reformulation of Supergravities making those global exceptional symmetries manifest. In fact, Exceptional Field Theory provides a framework in which one can access the entire spectrum of Kaluza-Klein towers when compactifying higher dimensional supergravities, which normally would have been very hard to compute. On top of the spectrum of the compactified theory, ExFT provides a new way to compute couplings between Kaluza-Klein towers, and hence, using Holography, a new way to compute 3-point functions in Conformal Field Theory dual to the Supergravity we are considering.

## La physique du rebond au tennis de table.

***Téophile REMOND*** 1

The rebound of the table-tennis ball off the paddle is among the common examples of the impact of a hollow structure onto a solid body, more or less rigid. In this talk I will explain how the properties of the paddle surface and of the ball shell may affect the spin and the linear velocity of the ball.

## Adaptive Cooperative Control Strategies to Maximize the Training Effects of Neuromuscular Electrical Stimulation

***Ehsan JAFARI*** 1

Functional Electrical Stimulation (FES) is used as an early rehabilitation tool for people with motor disabilities due to a dysfunction of the central nervous system. FES therapy can improve the quality of life by reducing the secondary medical complications that arise from the sedentary lifestyle imposed by the injury aftermath. Within this Ph.D. project, we aim to use adaptive and cooperative control of the motor assistance for FES-cycling, FES-rowing, and FES-walking.

# Informations

Les **exposés** auront lieu à l'**amphithéâtre Descartes** sur le site Descartes de l'ENS LYON. Cet amphithéâtre se situe au premier étage sur la droite de l'entrée principale.

Un **barbecue** aura lieu dans les jardins Descartes.