Rencontres des Jeunes Physicien•ne•s 2022

Rapport sur les contributions

https://indico.in2p3.fr/e/RJP2022

ID de Contribution: **1** Type: **Oral presentation**

Welcome Speech

mercredi 2 novembre 2022 09:00 (5 minutes)

We welcome all the young physicists to this 2022 edition of the RJP!

Orateur: WERTH, Denis (Sorbonne University – IAP)

Classification de Session: Welcome Speech

ID de Contribution: **3** Type: **Oral presentation**

Neutron detection to improve the neutrino energy resolution in oscillation experiments

mercredi 2 novembre 2022 11:45 (15 minutes)

After the recent discovery of the massive nature of neutrinos, through the observation of their oscillations, we now enter an era of precision measurement of the oscillation parameters. The next long-baseline neutrino accelerator experiments will be crucial for these precision measurements and will need to feature innovative detector technologies that offer high target mass (to acquire large data samples) while reducing the various systematic uncertainties.
In addition, as the oscillation probability of the neutrinos depends on their energy, a precise measurement of their energy is key to the determination of the neutrino oscillation parameters.

In order to fulfill the needs for both a high-target mass and improved neutrino energy resolution, a new design recently arose for highly granular scintillating detectors, such as superFGD that will be part of the T2K Near Detector upgrade. These detectors are composed of scintillating cubes of centimetric-size readout by wavelength-shifting fibers in three directions. They allow the reconstruction of the charged particle tracks, thus giving access to the interaction vertex and neutrino energy. However, a share of the interaction energy goes into neutral particles such as neutrons that are typically not reconstructed in such tracking detectors, thus degrading the neutrino energy resolution.

In this presentation, the neutron detection capabilities of state-of-the-art highly granular scintillating detectors and their usefulness in order to better estimate the neutrino energy will be shown. The detection of the neutrons allows one to directly access their energy by "time of flight"measurements, but also gives access to kinematic variables that can be leveraged to better constrain the event selection and marginalize nuclear effects.

Auteur principal: GRANGER, Pierre (CEA/Irfu)

Orateur: GRANGER, Pierre (CEA/Irfu)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **4** Type: **Oral presentation**

Perturbative quantum field theory techniques applied to fluctuating elastic membranes.

mercredi 2 novembre 2022 16:45 (15 minutes)

Quantum field theory (QFT) was developed in the 1940s as a theoretical framework for particle physics by combining classical field theory, special relativity and quantum mechanics. In the context of elementary particle physics, QFT provides various tools to accurately determine multiple physical quantities. The most used are essentially perturbative calculations via Feynman diagrams, as well as regularization and renormalization techniques, necessary to control the infinities encountered during the calculations. When used properly, this framework allows to theoretically calculate, with a very high accuracy, finite quantities called *probability amplitudes*, which provide answers to questions such as, for example, *"What is the probability of colliding particles A and B and getting particles X and Y as output?"* or, more famously, *"What is, very precisely, the value of the magnetic moment of an electron?"*.

Later in the 70's, it was discovered that QFT was also a very powerful framework to address many-body physics problems encountered in condensed matter and more generally in statistical physics systems. Thanks to the so-called renormalization group approach, the QFT framework now allows a systematic study of the critical properties of many-body systems near their phase transitions and provides a precise recipe for calculating with very high accuracy universal physical quantities called *critical exponents*. This has opened up the possibility of theoretically predicting the answer to a considerable number of new questions such as, *e.g.*, *"What happens to the magnetization of a magnet near its melting point?"* or *"How does the specific heat of a liquid diverge at one of its phase transitions" etc.*

In this talk, I will first briefly introduce the above topics. I shall then explain how we have recently successfully applied QFT techniques in the context of elastic degrees of freedom of fluctuating surfaces, which is an intuitive framework. Our goal was to predict the critical properties of a flat polymerized membrane in the vicinity of its critical (scale invariant) temperature, where it exhibits universal properties. Indeed, these surfaces are ubiquitous in physics, and are used to describe objects in various fields; from brane theory to cell membranes in biophysics or more recently, graphene and graphene-like materials. One could imagine a realization of this model as a free standing graphene sheet, globally flat in shape, close to a precise temperature such that its deformations are scale invariant, *i.e.* locally fractal. This thought experiment would show a universal behavior common to all membranes and would reveal very intriguing properties; anomalous rigidity, negative Poisson's ratio *etc.*

In the work [Metayer, Mouhanna, Teber. '22] we derive very high precision results (third order perturbative renormalization group equations) which describe such a flat membrane phase, following the pioneering first order calculation of [Aronovitz, Lubensky '88] and the more recent second order one [Coquand, Mouhanna, Teber '20]. These allow us to compute analytically, exactly order by order, three main quantities, namely the two mechanical Lamé coefficients μ and λ and an anomalous dimension η. The latter completely characterize the membrane, such that from this three quantities, one can calculate all the desired universal mechanical properties such as, for example, the Young's modulus, the Poisson's ratio, the speed of sound, the roughness properties etc.

Auteur principal: METAYER, Simon (LPTHE - Laboratoire de Physique Théorique et Hautes Energies)

Co-auteurs: Prof. MOUHANNA, Dominique (LPTMC); Dr TEBER, Sofian (LPTHE - Laboratoire de Physique Théorique et Hautes Energies)

Orateur: METAYER, Simon (LPTHE - Laboratoire de Physique Théorique et Hautes Energies)

Classification de Session: Oral Presentations (second in the afternoon)

ID de Contribution: **7** Type: **Oral presentation**

One ring to rule them all: line-of-sight shear as a new cosmological probe

mercredi 2 novembre 2022 11:30 (15 minutes)

Strong lensing – the effect of light being bent by massive objects such as galaxies and forming circular ring-like images – is one of the most striking phenomena in observational cosmology. If multiple images are observed, they be used to measure cosmological distances and the expansion rate of the Universe. However, strong lensing images are often distorted by other nearby galaxies or clumps of dark matter, which shears them away from perfect circles. In this talk, I will present a new formalism to describe this so-called line-of-sight shear, showing how it can be measured directly from strong lensing images without being spoilt by the degeneracies commonly present between other lens-related quantities, thus revealing a powerful new probe of the distribution of dark matter in our Universe.

Auteur principal: HOGG, Natalie (IPhT CEA-Saclay)

Orateur: HOGG, Natalie (IPhT CEA-Saclay)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **13** Type: **Oral presentation**

Modeling and predicting the overlap of B- and T-cell receptor repertoires in healthy and SARS-CoV-2 infected individuals

mercredi 2 novembre 2022 10:00 (15 minutes)

Adaptive immunity's success relies on the extraordinary diversity of protein receptors on B and T cell membranes. Despite this diversity, the existence of public receptors shared by many individuals gives hope for developing population wide vaccines and therapeutics. Yet many of these public receptors are shared by chance. We present a statistical approach, defined in terms of a probabilis tic V(D)J recombination model enhanced by a selection factor, that describes repertoire diversity and predicts with high accuracy the spectrum of repertoire overlap in healthy individuals. The model underestimates sharing between repertoires of individuals infected with SARS-CoV-2, sug- gesting strong antigen-driven convergent selection. We exploit this discrepancy to identify COVID- associated receptors, which we validate against datasets of receptors with known viral specificity. We study their properties in terms of sequence features and network organization, and use them to design an accurate diagnosis tool for predicting SARS-CoV-2 status from repertoire data.

Auteur principal: RUIZ ORTEGA, Maria

Orateur: RUIZ ORTEGA, Maria

Classification de Session: Oral Presentations (first in the morning)

ID de Contribution: **17** Type: **Oral presentation**

Modelling the Atmosphere of Hot Jupiter-like Exoplanets using a Global Climate Model

mercredi 2 novembre 2022 12:15 (15 minutes)

Understanding the atmospheric circulation, radiative transfer and atmospheric chemistry of exoplanets is crucial for our understanding of these objects. In particular, Hot Jupiters are among the most observed type of exoplanets and have no equivalent in our Solar System. During the last decade, observational and modelling efforts have been made to begin the atmospheric characterisation of these exoplanets.
We set out to use the generic Planetary Climate Model, a 3D Global Climate Model developed for paleoclimate and temperate exoplanets studies to simulate the atmosphere of Hot Jupiter. As a case study, we chose to model WASP-43 b, a Hot Jupiter with an orbital period of 19.5 hours and an equilibrium temperature of 1400 K. This planet has already been observed by the Hubble Space Telescope and the Spitzer Space telescope, yielding crucial information about key atmospheric processes, but also raising substantial questions about cloudiness, chemistry and wind patterns. Moreover, this planet will be observed by JWST on December 1 th 2022, providing astounding data.
Our simulations are able to replicate the already known atmospheric patterns of the atmosphere of Hot Jupiters, that we will present during this talk. We show that cloudless simulations are unable to reproduce the aforementioned data. Thus, we developed and incorporated into our model a scheme to simulate the formation of clouds in the atmosphere, and their radiative effects, in a fully coherent manner. We will discuss our preliminary results using the cloud model and how it could explain the incoming JWST observations.

Auteur principal: TEINTURIER, Lucas (LESIA/LMD)

Co-auteurs: Dr SPIGA, Aymeric (LMD); Dr CHARNAY, Benjamin (LESIA); Dr BÉZARD, Bruno (LESIA)

Orateur: TEINTURIER, Lucas (LESIA/LMD)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **18** Type: **Oral presentation**

A Chiral Inverse Faraday Effect Mediated by an Inverse-designed Plasmonic Antenna

mercredi 2 novembre 2022 14:45 (15 minutes)

The inverse Faraday effect (IFE) allows the generation of stationary magnetic fields through optical excitation only [1,2]. This light–matter interaction in metals results from the creation of drift currents via nonlinear forces that light applies to the conduction electrons [1]. The IFE was believed, until now, to be a symmetrical phenomenon, meaning that a right-handed circularly polarized wave will create a magnetic field oriented toward light propagation. In contrast, excitation by a left-handed circularly polarized wave will generate a magnetic field opposite this propagation. Here we demonstrate, via the manipulation of light in the near field of a plasmonic nanostructure, the generation of a chiral IFE. Specifically, using an inverse design algorithm based on evolutionary optimization, we generate a chiral plasmonic nanostructure creating a stationary magnetic field by IFE for one specific light helicity. This chiral behavior is due to the generation of a non-zero spin density for the chosen helicity only. Furthermore, we demonstrate that using the enantiomer opposite to the optimized structure generates a magnetic field for an opposite helicity of light. Moreover, at the optical powers considered here, the amplitude of the magnetic field generated is 500 mT. The results presented here are remarkable since the plasmonic approach is today the only one allowing the generation of stationary magnetic fields at the nanometer scale and at extremely short time scales [3]. Therefore, using chiral plasmonic nanostructures to generate a chiral IFE opens the door to producing a stationary magnetic field by non-polarized light. The outcomes of these results are multiple, in particular the manipulation of magnetic processes at ultrashort timescales, such as spin precession, spin currents, and skyrmions become possible. This would find applications, for instance, in data storage at an ultrahigh rate.

References

[1]. Hertel, Riccardo. "Theory of the inverse Faraday effect in metals". Journal of Magnetism and Magnetic Materials 303. 1(2006): L1-L4.

[2]. Athavan Nadarajah, et al. "Optoelectronic phenomena in gold metal nanostructures due to the inverse Faraday effect". Opt. Express 25. 11(2017): 12753–12764.

[3]. Yang, Xingyu et al. "Tesla-Range Femtosecond Pulses of Stationary Magnetic Field, Optically Generated at the Nanoscale in a Plasmonic Antenna". ACS Nano 16. 1(2022): 386-393.

Auteur principal: M. MOU, Ye (Institut des NanoSciences de Paris - Sorbonne Université)

Co-auteurs: M. YANG, Xingyu (Institut des NanoSciences de Paris - Sorbonne Université); Dr GALLAS, Bruno (Institut des NanoSciences de Paris - CNRS); Dr MIVELLE, Mathieu (Institut des NanoSciences de Paris - CNRS)

Orateur: M. MOU, Ye (Institut des NanoSciences de Paris - Sorbonne Université)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **20** Type: **Oral presentation**

Optomechanical measurement of individual nanoparticles: towards the analysis of a single virus

mercredi 2 novembre 2022 09:15 (15 minutes)

We demonstrate the effectiveness of optomechanical devices for the measurement of individual nanoparticles. A semiconductor optomechanical disk resonator is optically driven and detected under ambient conditions, as nebulized nanoparticles land on it. Multiple mechanical and optical resonant signals of the disk are tracked simultaneously, providing access to several pieces of physical information about the landing analyte in real time. Thanks to a fast camera registering the time and position of landing, these signals can be employed to weigh each nanoparticle with a sensitivity down to 30 attograms. Sources of error and deviation are discussed and modelled, indicating a path to evaluate the elasticity of the nanoparticle on top of its mere mass. The device is optimized for the future investigation of nanometric objects such as sessile nanodroplets and biological particles in the high megadalton range, including the class of large viruses.

Sbarra, S., **Waquier, L.**, Suffit, S., Lemaître, A., & Favero, I. (2022). Multimode optomechanical weighting of a single nanoparticle. *Nano Letters*, *22(2)*, 710-715.

Auteurs principaux: LEMAÎTRE, Aristide; FAVERO, Ivan; WAQUIER, Louis (Laboratoire MPQ - Université Paris Cité - CNRS); SBARRA, Samantha; SUFFIT, Stephan

Orateur: WAQUIER, Louis (Laboratoire MPQ - Université Paris Cité - CNRS)

Classification de Session: Oral Presentations (first in the morning)

ID de Contribution: **24** Type: **Oral presentation**

Morphogenesis and ultrastructure of condensed DNA toroids

mercredi 2 novembre 2022 15:30 (15 minutes)

DNA toroids are complex liquid crystalline objects that form spontaneously in vitro by condensation of DNA, a general behaviour of semi-flexible polyelectrolytes. These structures have intrigued biophysicists and physicists, both experimental and theoretical, because of the intrinsic beauty of these toroidal objects, and because they provide models for understanding the packaging of DNA in many biological systems such as viruses, spermatozoa or bacterial nucleoids.

Within these structures, the DNA chains locally form a hexagonal lattice, but topological defects are required to resolve the frustration resulting from several phenomena: (i) the continuity of the DNA chain and the morphogenesis of the object imposing the path of the chain within the torus [1-3]; (ii) the competition between the parallelism imposed by the compact hexagonal lattice and the tendency to twist resulting from the helicity of DNA [4-6]; and (iii) the correlations between neighbouring DNA helices (or 'electrostatic zipper' [7]).

To understand these phenomena, we analyse their ultrastructure by cryo-electron microscopy and follow their nucleation and evolution on time scales of 30 sec to several tens of minutes. We show the formation of toroidal and rod-like structures, which evolve towards equilibrium forms that are all toroidal. We show the existence of an internal phase separation, between a disordered sparse zone that would concentrate the defects of the structure and an ordered compact zone that would optimise the correlations between DNA helices everywhere else. Finally, the analysis of these correlations shows the existence of a complex link between curvature, conformation of the molecule (variation of the helical pitch) and phase of the order between helices (ferro/antiferro magnetic type order).

Auteur principal: VERTCHIK, Kahina (Laboratoire de Physique des Solides d'Orsay)

Orateur: VERTCHIK, Kahina (Laboratoire de Physique des Solides d'Orsay)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **25** Type: **Oral presentation**

PtSe2 films grown by molecular beam epitaxy for high frequency optoelectronics

mercredi 2 novembre 2022 15:00 (15 minutes)

PtSe2 is a promising 2D material for high frequency IR optoelectronics [1], its bandgap varying from 1.2 eV (monolayer) to 0.2 eV (bilayer) [2]. We have grown 2D PtSe2 films on sapphire(0001) substrates by molecular beam epitaxy. In particular, we used sapphire substrates with a 0.25° miscut to generate, after high temperature (1135℃) annealing, stepped structures. Indeed, we demonstrated that a stepped substrate improves the crystalline quality of the films and also increases the charge carrier mobility. We characterized the films using Raman spectroscopy, Grazing Incidence X-ray Diffraction, Transmission Electron Microscopy, Atomic Force Microscopy and their transport properties were evaluated using Van der Pauw experiments.
To fabricate optoelectronic devices, we synthesized a 15 layer thick PtSe2 film on a 2 inches sapphire substrate. In particular, coplanar waveguides integrating a 4x4µm PtSe2 channel were realized to perform high frequency photodetection and optoelectronic mixing. The channel was illuminated with a 1.55µm laser beam modulated in intensity at frequencies varying between 2 and 67 GHz. Our PtSe2 photodetector exhibits a record 3dB bandwidth of 60GHz. These results show that PtSe2 is a highly promising material for high frequency optoelectronics.

References

[1] Y. Wang et al., Appl. Phys. Lett. 116 (2020), 211101.
[2] Y. Wang et al., Nano Lett. 15 (2015) 4013.

Auteurs principaux: DESGUÉ, Eva (THALES Research & Technology); M. LEGAGNEUX, Pierre (THALES Research & Technology)

Orateur: DESGUÉ, Eva (THALES Research & Technology)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **26** Type: **Oral presentation**

3D dynamic study for the 450th anniversary of Tycho supernova remnant

mercredi 2 novembre 2022 11:00 (15 minutes)

In November 1572, a nearby star exploded in a supernova and was observed at the time by Tycho Brahe. Exactly 450 years later, we can study its remnant, the huge cloud made of all the matter of the star ejected at high speeds. The ejected material is heated to tens of millions Kelvin and radiates most of its energy in the X-ray (0.1-10 keV) band.

Currently, the Chandra X-ray telescope measures the photons one by one from this object and we obtain data cubes (x, y, E). This study consists in analyzing these data cubes using innovative methods to understand the remnant's dynamics in three dimensions (x, y, z).

Knowing precisely these dynamics gives information about the original supernova: was the explosion asymmetric? Was matter ejected beforehand and thus formed obstacles on the path of the remnant? We can therefore constrain a phenome 450 years after it took place.

This study allows us to develop tools that can be adapted for other data cubes, coming from other spectro-imaging telescopes or even from other domains, like videos. The complex data involved also raises questions about the scientific representation, especially in 3D, of our results.

Auteur principal: GODINAUD, Leïla (CEA Saclay / IRFU / AIM)

Co-auteur: ACERO, Fabio (CEA/Saclay)

Orateur: GODINAUD, Leïla (CEA Saclay / IRFU / AIM)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **28** Type: **Oral presentation**

Electronic structure of the metal-to-insulator transition in VO2: the chicken-and-egg dilemma of condensed matter

mercredi 2 novembre 2022 14:30 (15 minutes)

The strongly correlated material VO_2 displays a metal-to-insulator (MIT) transition when going below $T_{MIT} = 280K$. Alongside this electronic transition, the material undergoes a structural transition from a rutile structure in the metallic phase to a monoclinic structure in the insulating phase. These simultaneous transitions have created a long-lasting debate within the community: is the electronic transition induced by the structural changes (Peierls transition) or is it happening alongside it (Mott transition) [1]? This question has been nicknamed the chicken-and-egg dilemma [2] of condensed matter.

Recent ARPES studies addressed the changes of the electronic structure of VO_2 across the transition [3]. However, a detailed imaging of the evolution of the conduction band spectral function in the transition regime is still lacking.

I will present our ongoing ARPES studies on VO_2 where we were able to observe a progressive transfer of spectral weight between two distinct states composing the conduction band.

References:

[1] Dynamical Singlets and Correlation-Assisted Peierls Transition in VO2, Silke Biermann *et al.*, Physical Review Letters (2005)
[2] Resolving the VO2 controversy: Mott mechanism dominates the insulator-to-metal transition, O. Nájera *et al.*, Physical Review B. (2017)
[3] Photoelectron dispersion in metallic and insulating VO2 thin films, Viktor Jonsson *et al.*, Physical Review Research (2021)

Auteur principal: DAVID, Emma (ISMO, Université Paris-Saclay)

Co-auteurs: SHIGA, Daisuke (KEK Photon Factory, Japan); JHA-THAKUR, Amitayush (ISMO, Université Paris-Saclay); THEES, Maximilian (ISMO, Université Paris-Saclay); HENRIQUE REZENDE GONÇALVES, Pedro (ISMO, Université Paris-Saclay); ANTEZAK, Alexandre (ISMO, Université Paris-Saclay); CHENG, Xianglin (KEK Photon Factory, Japan); KIM, Taehyun (KEK Photon Factory, Japan); KANDA, Tatsuhiko (KEK Photon Factory, Japan); FRANTZESKAKIS, Emmanouil (ISMO, Université Paris-Saclay); FORTUNA, Franck (ISMO, Université Paris-Saclay); KUMIGASHIRA, Hiroshi (KEK Photon Factory, Japan); SANTANDER-SYRO, Andres (ISMO, Université Paris-Saclay)

Orateur: DAVID, Emma (ISMO, Université Paris-Saclay)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **29** Type: **Oral presentation**

SQUID interferometry, higher order topology and mesoscopic transport.

mercredi 2 novembre 2022 15:15 (15 minutes)

WTe2, a transition metal dichalcogenide, is predicted to have striking topological properties that combine the characters of type II Weyl semimetal and second-order 3D topological insulator (SOTI). SOTIs are characterized by topologically protected helical 1D states at their hinges. 1D states located at certain edges of multilayer WTe2 have indeed been demonstrated in Josephson interferometry experiments. However, more experimental evidence confirming their ballistic nature is needed.
We have design a WTe2-based Superconducting Quantum Interference Device (SQUID) in which the supercurrent through one edge of the crystal interferes with the supercurrent far from the edge. The critical current of this asymmetric SQUID yields the supercurrent-versus-phase relation of the edge states. Its sawtooth shape is a tell-tale sign that the supercurrent through the edge flows ballistically over 600 nm (which is ten times the estimated normal state mean free path). Combining behaviours of the supercurrent at various temperatures and magnetic fields, we identify the existence of a highly ballistic hinge channel which further supports the SOTI properties of WTe2.

Auteur principal: BALLU, Xavier (Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS)

Co-auteurs: DOU, Ziwei (Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS); BERNARD, Alexandre (Laboratoire de Physique des Solides, Université Paris-Saclay); DELAGRANGE, Raphaëlle (Laboratoire de Physique des Solides, Université Paris-Saclay); DEBLOCK, Richard (Laboratoire de Physique des Solides, CNRS); GUÉRON, Sophie (Laboratoire de Physique des Solides, CNRS); CAVA, Robert (Princeton University); SCHOOP, Leslie (Princeton University); BOUCHIAT, Hélène (Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS); FERRIER, Meydi (Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS)

Orateur: BALLU, Xavier (Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **30** Type: **Oral presentation**

The Quest for Understanding Star-Formation and Galaxy Growth with JWST

mercredi 2 novembre 2022 11:15 (15 minutes)

Nearly a year ago, the most expensive space telescope ever built was launched into space. After traveling for 6 months, it began to explore the infra-red universe in June. In 4 months, JWST's extraordinary spatial resolution already allowed groundbreaking discoveries in the field of galaxy formation and evolution. From the first detection of extremely old galaxies (back when the universe was just a few hundred million years old), to the demonstration that the Hubble Sequence was settled much earlier than previously thought and the revelation of dust attenuated star-forming regions, the JWST forces us to rethink the history of galaxies. In my research, I use the JWST images to study the dustiest star forming galaxies as they were 10 billion years ago (aka 'cosmic noon'). Using JWST resolution, I was able to study the gradient of star formation rates and dust attenuation across each galaxy. The main findings are that every galaxy has a compact dusty star forming core, with an accretion-fed disk around it. The disk is usually showing a dust gradient, sign of a perturbed history. Some disks are even quiescent, they don't form new stars. It appears that an important fraction of galaxies grows lopsided accretion-fed disks that at some point trigger a nuclear starburst (probably torque-induced) and finally get devoid of gas in the outskirts. This work demonstrates the major impact JWST will have on the understanding of galaxy mass growth at cosmic noon.

Auteur principal: LE BAIL, Aurélien (CEA-Saclay)

Orateur: LE BAIL, Aurélien (CEA-Saclay)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **31** Type: **Oral presentation**

Tabletop Experiment for beyond Standard Model Physics: Electron EDM in a Cryogenic Matrix

mercredi 2 novembre 2022 15:45 (15 minutes)

To explain the open questions in the fundaments of physics, new theories that reach beyond the standard model of particle physics are needed. A great number of these indirectly predict electric dipole moments (EDM) of fundamental particles in ranges that are just within reach for modern atomic and molecular physics experiments. While measurements in atomic and molecular beams provided the most successful null measurements of the electron EDM over the past decades, only quite recently did the method of matrix isolation spectroscopy arise. It has the potential advantage of performing spectroscopy on unprecedented numbers of atoms/molecules at once. To enable a high-precision measurement with this novel technique, it is first necessary to gain an understanding of possible systematic effects.

In this presentation, I will show some of the results we have made so far in studying our particular system of Cs and Rb atoms doped into a cryogenic Ar matrix.

Auteur principal: LAHS, Sebastian (Laboratoire Aimé Cotton)

Co-auteurs: M. BATTARD, Thomas; COMPARAT, daniel (Laboratoire Aimé Cotton (CNRS))

Orateur: LAHS, Sebastian (Laboratoire Aimé Cotton)

Classification de Session: Oral Presentations (first in the afternoon)

ID de Contribution: **34** Type: **Oral presentation**

Dragonflies flight: Mechanical study of the wings

mercredi 2 novembre 2022 09:30 (15 minutes)

Odonata (dragonfly and damselfly) exhibit impressive flight ability. They are able to perform many different maneuvers such as zigzag, linear motion back and forth, sharp turn, quick acceleration. These trajectories are the result of complex fluid-structure interactions. Wing morphology has a main role in this interaction as shown in previous studies.
Insect wings, including dragonfly wings, are heterogeneous structures composed of an elastic membrane and a network of veins that control the local stiffness of the wing.
The characteristics of these wings (size, geometry, vein pattern. . .) strongly vary within the different phylogenetic lineages. Currently, there are about 6500 species of Odonata distributed on all continents, except Antarctica. We aim at understanding the role of the different parameters and structures of the wings on the aerodynamic force production . One of our goals is to give a physical description of the relation between wing morphology and flight mode over the range of existing dragonflies species and from an evolutionary perspective, starting from early apparitions of the first Odonatoptera (super order that includes Odonata) in the early late Carboniferous.
In this work, we perform a comparative study of wings of different species with different living modes. We focus on wing characteristics such as the aspect ratio, the relative position of the nodus and the position of pterostigma and the distribution of veins and the corrugation they allow. A first step for this study is to have a common measurement for all our wings, to be able to perform a quantitative comparison. We have chosen for this to perform mechanical tests based on a shaker which allows to excite the wing at different frequencies.

Auteurs principaux: M. NEL, André (ISYEB (MNHN)); M. THIRIA, Benjamin (PMMH (ESPCI)); Mlle ARACHELOFF, Camille (PMMH (ESPCI) ISYEB (MNHN)); M. GODOY-DIANA, Ramiro (PMMH (ESPCI)); M. GARROUSTE, Romain (ISYEB (MNHN))

Orateur: Mlle ARACHELOFF, Camille (PMMH (ESPCI) ISYEB (MNHN))

Classification de Session: Oral Presentations (first in the morning)

ID de Contribution: **38** Type: **Oral presentation**

The causal set approach to quantum gravity

mercredi 2 novembre 2022 17:00 (15 minutes)

Quantum gravity is one of the biggest riddle of our time. One approach to it is the Causal Set Theory (CST) that aims to unify the framework of General Relativity and Quantum Mechanics by the concept of proto-causality. We will explore how the classical spacetime continuum can emerge from the discrete structure of a network of fundamental elements, and how reasoning at this smallest scale of reality gives insights on new notions of kinematics and dynamics. This paradigm has the potential to explain the interactions of strong gravitational fields with quantum fields, is useful for computations, and even show an explanatory potential for some objects in cosmology and philosophy.

Auteur principal: Mlle SURYA, Sumati (Raman Research Institute)

Co-auteur: EMERY, Emile (CEA)

Orateur: EMERY, Emile (CEA)

Classification de Session: Oral Presentations (second in the afternoon)

ID de Contribution: **39** Type: **Oral presentation**

Dissecting the interstellar medium of extremely distant galaxies with Gamma-ray bursts

mercredi 2 novembre 2022 12:00 (15 minutes)

Gamma-ray bursts (GRBs) are an amazing class of transient phenomena in the Universe. GRBs are detected from space by satellites thanks to the flash of gamma-ray photons released within an ultra-relativistic jet. The jet is thought to be produced by a new-born accreting black hole formed after the collapse of a massive star, Long-GRBs (LGRBs), or the merger of two compact objects, Short-GRBs (SGRBs). The gamma-ray prompt emission is followed by an afterglow, detectable from the X-ray to the radio wavelengths. The afterglow emission is believed to be caused by the shock of the jet with the external medium (composed by dust and gas) surrounding the GRB progenitor.

LGRBs are unique tools to probe distant galaxies. Their bright afterglows can be used as powerful background sources capable of unveiling the gas along their line-of-sight that absorbs their light, like shadow puppetry. This includes also the gas of the host galaxy of the GRB, independently of the galaxy luminosity.

In this talk, I will show the results obtained with the extremely powerful spectrograph X-shooter installed on one of the larger telescope on Earth, the Very Large Telescope (VLT) of the European Southern Observatory (ESO) located in Chile. This observation allowed us to dissect a galaxy when the Universe was only 0.9 Gyr old in an unprecedented fashion. Such studies give unique informations to understand the first galaxies and their chemical enrichment.

Auteur principal: SACCARDI, Andrea (GEPI, Observatoire de Paris, Université PSL, CNRS)

Orateur: SACCARDI, Andrea (GEPI, Observatoire de Paris, Université PSL, CNRS)

Classification de Session: Oral Presentations (second in the morning)

ID de Contribution: **40** Type: **Oral presentation**

A time reversal metasurface for mimicking the cocktail party effect

mercredi 2 novembre 2022 09:45 (15 minutes)

The cocktail party effect is the capability to focus one's auditory attention on particular audio sources while ignoring other audio sources. We propose an experimental setup reproducing the cocktail party effect by designing a time dependent metasurface composed of independent active mirrors. Each active mirror is a programmable acoustical unit cell capable of hearing, computing and emitting acoustic signals: each of them acts as a convolution filter. The proper metasurface temporal filters configuration allows us to establish acoustic communication between groups of individuals immersed in a noisy environment: we have designed a multi-user, multi-input and multi-output (MU-MIMO) acoustic system.

The experiment based on underwater ultrasonics consists in prerecording a set of Green's function between N_e emitters and N_j active mirrors, and a second set Green's functions between the N_j active mirrors and N_r receivers. In order to increase the spatio-temporal degrees of freedom (Lemoult et al., PRL 103 (2009)), we place a forest of steel rods in between the active mirrors and both the emitters and the receivers. These data are then used to compute each active mirror's temporal filter using time reversal properties to establish a proper predefined MU-MIMO configuration. The N_e emitters now emits simultaneously uncorrelated noises, hence reproducing the cocktail party situation. These signals propagate through the disordered medium to the metasurface, then each active mirror of the metasurface hears, convolutes with his temporal filter and emits another signal which propagates back through the disordered medium towards the N_r receivers. In the end we establish a correlation matrix by comparing emitted and received signals and we demonstrate how the time reversal based metasurface allows to focus signals coming from specific emitters towards their dedicated receivers.

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Classification de Session: Oral Presentations (first in the morning)

ID de Contribution: **42** Type: **Oral presentation**

A new photonic crystal platform for interfacing slow light and trapped cold atoms

mercredi 2 novembre 2022 16:30 (15 minutes)

Trapping cold neutral atoms in close proximity to nanostructures has raised a large interest in recent years, pushing the frontiers of cavity-QED and boosting the emergence of the waveguide-QED field of research. Such platforms interfacing trapped cold atoms and guided light in nanoscale waveguides are a promising route to achieve a regime of strong coupling between light and atoms, and implement non linear quantum optics protocols [1]. In this context, we propose to interface ^{87}Rb atoms with a GaInP waveguide based on a 2D photonic crystal waveguide (PCW) [2]. The periodic arrangement of holes allows to shape the dispersion relation and engineer slow-modes, whose interaction with quantum emitters would be enhanced, allowing for strong coupling even in single pass. At the same time, guided modes are used to form dipole traps for the atoms, a crucial requirement for achieving strong coupling. The asymmetry of the proposed waveguide offers more control on the shape of the dispersion bands as well as an increased optical access, critical to bring the atoms close to the surface.

The coupling of the atoms to the waveguide can be characterized by the Purcell factor, which relates the decay rate of the atoms into the guided mode to the one into free space. Dispersion engineering by tuning the geometrical parameters of the PCW via systematic optimization, can lead to a high constant group index $n_\mathrm{g} \sim 30$ over a range of 10 nm, centered around $\lambda_{Rb}^{D2} = 780$ nm. This constant index over a large range makes the design more robust to fabrication imperfections. With this robust design, at realistic distances of ~ 100 nm from the waveguide surface, 3D FDTD calculations reveal that Purcell factors of 2 can be expected (meaning $\frac{\Gamma_{\mathrm{1D}}}{\Gamma_{\mathrm{TOT}}} \geq 70\%$).

We introduce a stable and compensated trapping scheme around our PCW for ^{87}Rb atoms based on an evanescent two-color dipole trap formed by fast guided modes, with powers under the milliwatt. This configuration was computed thanks to \texttt{nanotrappy} [3], a Python package developed by our group, to design, calculate and optimize dipole traps around nanoscale waveguides, making the search process faster and more systematic.
Experimental realization of the cold atoms system is ongoing and promising first structures have been fabricated.

[1] D. E. Chang, et al., *Rev. Mod. Phys.*, **90**, 031002 (2018)
[2] X. Zang, et al., *Phys. Rev. Appl.*, **5**, 024003 (2016)
[3] J. Berroir*, A. Bouscal*, et al., *Phys. Rev. Res.*, **4**, 013079 (2022)

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Classification de Session: Oral Presentations (second in the afternoon)

ID de Contribution: **50** Type: **Oral presentation**

Approximate symmetries in hydrodynamics

mercredi 2 novembre 2022 17:15 (15 minutes)

One of the main goals of physical theories is to provide a useful, universal, effective description of many-body quantum systems at macroscopic scales, regardless of the complicated microscopic dynamics. This is achieved in the context of hydrodynamic effective field theories at finite temperature, by focussing on the dynamics of conserved charges, corresponding to symmetries of the theory, and the Goldstone modes coming from spontaneously broken symmetries. However, in realistic systems most symmetries are only approximate. Then, in ordered phases, the Goldstone modes acquire a small mass as well as a damping rate.

In this talk, after a short introduction to hydrodynamic EFTs, I will explain how locality of hydrodynamics implies that the damping of pseudo-Goldstones is completely determined by their mass and certain diffusive transport coefficients. I will also briefly talk about how such consistency conditions are derived in holographic field theories.

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Classification de Session: Oral Presentations (second in the afternoon)

ID de Contribution: **51** Type: **Oral presentation**

Fluid Dynamics on Logarithmic Lattices

mercredi 2 novembre 2022 10:15 (15 minutes)

A great challenge in numerical simulations of geophysical systems (such as in climate models) is the important range of relevant scales. In particular in fluid dynamics, it is impossible to do Direct Numerical Simulations of the whole system, and one has to resort to a variety of numerical tricks.

We present a new method, "Logarithmic Lattices", which aims at simulating very important ranges of scales with minimal numerical footprint. In our presentation we focus on the motivation behind this model, the details of the model, a small concrete use case, and future developments.

This method is totally new from a theoretical point of view; as it significantly reduces the memory, computation and storage impact of our numerical simulations, we believe it to be of great interest outside the field of turbulence, since its core principles can easily be generalized.

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Classification de Session: Oral Presentations (first in the morning)