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Collège de France

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Oral presentations session / 4

Welcome speech by RJP / Présentation SFP et Réseau Jeunes

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Oral presentations session / 19

PolarEx, a new facility for on-line nuclear orientation at Alto : Multipolarity mixing ratio data analysis

Auteurs: Rémy Thoer[1]; David Verney[2]; Fadi Ibrahim[2]; CAROLE Gaulard[3]; François LE BLANC[4]; Stephanie Roccia[5]

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Low Temperature Nuclear Orientation (LTNO) experiments allow to probe magnetic properties of polarized exotic nuclei. With this technique, we observe nuclei under extreme conditions, that is to say very low temperatures (~10mK) and very high magnetic field (10-100T). Under such conditions, the radioactive emission is anistropic, and its shape tells us more about the nucleus structure.
Nuclear orientation give access to different observables. The nuclear magnetic moment can be directly measured, using NMR technique. The multipole mixing ratio, proportionnal to the ratio of two multipolarity matrix element, can also be studied and gives acces to structure informations. As a special feature of LTNO, far-reaching studies of fundamental weak interactions and associated symmetries can be made as well as investigations of parity non conservation.
The PolarEx apparatus, located at Alto in Orsay, France, is designed to perform this kind of study. It is a 3He-4He dilution refrigerator, coupled to a magnet and a detection system. The detection system allowed up to 8 detectors, either gamma or particle detector, in the plan perpendicular to the orientaion axis to study the spatial asymmetry of the gamma radiation.
For the moment it is operating off line on long lived nuclei, but it will be ready for on line experiment very soon. The coupling of PolarEx with Alto will open a large range of studies of neutron rich nuclei, thanks to its great versatility.
In this contribution will be presented the status of PolarEx and the on going off-line studies, in particular the new measurements of the multipole mixing ratios in 56 Fe. With our analysis, we have reproduced existing mixing ratios, have improved the precision of some of them, and have also measured unknown mixing ratios.

Field:

Nuclear physics/PolarEx

Language:

English

Oral presentations session / 39

Spectrum analyzer based on NV centers in diamond

Auteurs: Simone Magaletti[None]; Ludovic Mayer[None]; Thierry Debuisschert[None]

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The Nitrogen Vacancy (NV) centers are considered, for their optical and spin proprieties, promising candidates for quantum sensing applications. In this work, the spin-dependent optical proprieties of a NV centers ensemble are exploited in order to realize a spectrum analyzer.
To do that, a static magnetic field gradient, generated by a permanent magnet, induces a spatial dependent Zeeman shift to the NV centers present in the diamond: the NV center resonance frequency is so correlated to a defined position in the diamond. A wide field imaging system collects the fluorescence of the NV centers while they are continuously pumped by a green (532nm) laser. A microwave magnetic field, resonant with the NV center transition, will cause a drop of photoluminescence, visible on the image, at a well-defined position. Knowing the static magnetic field at that position, the microwave frequencies can be deduced.
The device is able to achieve a dynamic range of 30dB, a frequency range of 25 GHz and a limit resolution (frequency dependent) of 1 MHz. The Nitrogen nuclear spin polarization by pure optical means near both ground state and excited state level anti-crossing has been also investigated. A quite large range of polarization efficiency has been observed, allowing a better frequency resolution.

Language:

English

Oral presentations session / 26

Exploring the primordial universe with QUBIC: The Q&U Bolometric Interferometer for Cosmology

Auteur: Louise Mousset[1]

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QUBIC is an experiment dedicated to the measurement of polarization B-modes of the Cosmic Microwave Background (CMB) using the novel technology of Bolometric Interferometry. In this talk, I will start with a brief explanation of the underlying physics: What are primordial B-modes and why it will give us invaluable insights on what happened during the inflation era, right after the Big Bang.
Then, I will present the current status of the project and the instrument architecture. The unique design of QUBIC brings new possibilities to CMB polarization mapping including self-calibration and spectroimaging.

Field:

Cosmology/CMB modes/QUBIC

Language:

English

Oral presentations session / 30

Bacterial portraits: Density shaping of photokinetic E. coli

Auteur: Dario Dell'Arciprete[1]

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In nature, some motile microorganisms have evolved in such a way to respond to environmental light stimuli, essentially allowing them to find better living conditions.
In the lab, it is possible to engineer bacterial cells so as to make them photokinetic, that is, to control their speed by means of the light shone on them: these cells move faster when exposed to high-intensity light, whereas slow down to dim light.

I will present some experiments performed with my collaborators [Ref.] in which we observed the dynamics of millions of photokinetic *E. coli* cells and how it has been possible to arrange them into complex and reconfigurable density patterns using a digital light projector.
Such experiments give us insights on the complex biological mechanisms of photokinesis and provide a practical and efficient strategy to achieve spatial and temporal control of cell concentration, for instance by exploiting such living propellers for moving microdevices or drug carrier.

[Ref.] Frangipane et al., eLife 2018;7:e36608 doi: 10.7554/eLife.36608

Field:

Biology/Light

Language:

English

Remise des prix Jeunes Chercheurs/euses 2018 / Talk des 2 Lauréats / 51

Remise des prix Jeunes Chercheurs/euses 2018

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Remise des prix Jeunes Chercheurs/euses 2018 / Talk des 2 Lauréats / 38

Ultrafast Meets Chirality

Auteur: Samuel Beaulieu[1]

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Chirality is a symmetry property of matter, which can emerge at any length scale, from galaxies to snail shells and even to subatomic particles. Chiral light-matter interactions have been investigated for two centuries, leading to the discovery of many chiroptical processes used for discrimination of enantiomers. Whereas most chiroptical effects result from a response of bound electrons, photoionization can produce much stronger chiral signals that manifest as asymmetries in the angular distribution of the photoelectrons along the light-propagation axis (Photoelectron Circular Dichroism, PECD). Before 2012, PECD was mainly studied in synchrotron facilities, in the single-photon ionization regime [1]. In this talk, I will show you the recent advances that we made, during my Ph.D. thesis, by applying the toolbox developed in ultrafast and strong-field physics to chiral molecules. We have demonstrated that PECD is a universal effect that emerges in all photoionization regime [2]. We have also demonstrated the first pump-probe PECD experiments, allowing for monitoring photoinduced ultrafast dynamics in chiral molecules on femtosecond timescale [3,4]. Using similar experimental approaches, but by using pulse sequences with counter-intuitive polarization states, we have demonstrated a novel electric dipolar chiroptical effect, called Photoexcitation Circular Dichroism (PXCD), which emerges as a directional and chirosensitive electron current when multiple excited bound states of chiral molecules are coherently populated with chiral light [5]. Last, we introduced a time-domain perspective on chiral photoionization by measuring the forward-backward asymmetry of photoionization delays in chiral molecules photoionized by chiral light pulses. Our work thus carried chiral-sensitive studies down to the femtosecond and attosecond ranges [6].

[1] Böwering, N. et al., Phys. Rev. Lett. 86, 1187 (2001)
[2] Beaulieu, S. et al., New Journal of Physics 18, 102002 (2016)
[3] Comby, A. et al., The Journal of Physical Chemistry Letters 7, 4514 (2016)
[4] Beaulieu, S. et al., Faraday discussions 194, 325 (2016)
[5] Beaulieu, S. et al., Nature Physics 14,484 (2018)
[6] Beaulieu, S. et al., Science 358, 6368 (2017)

Language:

English

Remise des prix Jeunes Chercheurs/euses 2018 / Talk des 2 Lauréats / 41

Exotic Nuclei for Astrophysics—First Spectroscopy of ^{110}Zr

Auteur: Nancy Paul[1]

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Exotic, extremely radioactive nuclei play a key role in the nucleosynthesis processes responsible for heavy element production in cataclysmic events in the universe, such as recently observed in the binary neutron star merger detected via gravitational waves [1] . The nucleosynthesis yields depend on the details of the underlying quantum structure of these nuclei, largely unknown as such exotic species are difficult to create and study in the laboratory, and theoretical predictions diverge. I will present the first spectroscopy results of one such exotic nucleus, ^{110}Zr, where a stabilization effect in a spherical or pyramidal shape had been predicted which would explain a long-standing discrepancy in nucleosynthesis simulations. The experiment was performed at the Radioactive Isotope Beam Factory (RIBF) in Japan, where ^{110}Zr was created via in-flight fission of a ^{238}U beam and subsequent proton removal on a cryogenic liquid hydrogen target. Gamma rays from nuclear deexcitation were detected with a 4π scintillator array, and Doppler correction enabled via event-by-event vertex reconstruction in a time-projection-chamber developed at CEA-Saclay. Results show no evidence for a spherical or pyramidal shape, but rather suggest that this nucleus is extremely deformed, beyond expectations from mean-field based approaches, and thus cannot explain the deficiencies in nucleosynthesis models in this mass region [2].

[1] Abbott et al, Phys. Rev. Lett. 119, 161101 (2017).
[2] N. Paul et al, Phys. Rev. Lett. 118, 032501 (2017).

Language:

English

Oral presentations session / 32

B0 -> K*e+e- angular analysis at LHCb: an indirect search for New Physics

Auteur: Fabrice Desse[1]

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The conflicts between cosmological observations (dark matter, matter/anti-matter asymmetry …) and the predictions of the Standard Model (SM) calls for New Physics (NP) beyond the SM, i.e. new interactions or new particles. Collider experiments such as the LHC at CERN is a privileged place for NP searches. Indeed, by smashing together two protons at nearly the speed of light, one can try to pop up a massive NP particle. But these direct searches are limited by the energy of the proton beam (E=mc2). Instead of directly creating the particle, one can try to pop up a virtual NP particle. Indeed, when a b quark transforms to an s quark, the process involves the exchange of a virtual (very short lived) particle, whose energy (mass) is allowed to exceed by far the energy (mass) of the initial b quark thanks to quantum mechanics (roughly speaking, due to Heisenberg's uncertainty principle). Thus, indirect searches can access much higher energies than direct searches for NP.
At LHCb, a large amount of B mesons (containing a b quark) are created. Some of them decay to a K*meson (containing an s quark) and two electrons. This type of b to s quark transition is very suppressed in the SM and thus any NP appearing in the process should be dominant. In particular, the presence of NP could modify the angular distribution of the final states particles detected in the LHCb detector, motivating the measurement of B0 -> K*e+e- angular distributions.*

Field:

Particle physics/LHCb

Language:

English

Oral presentations session / 45

Neural networks for Quantum Physics

Auteur: Filippo Vicentini[1]

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The state of a quantum system is completely determined by its wave-function or density-matrix, which evolve according to an equation of motion. When the system is composed of many interacting particles, the many-body problem increases exponentially the size of those objects, which eventually cannot be stored in the memory of a computer. For decades researchers approached the issue by constructing approximations based on our physical understanding that could reduce the complexity. This approach, while successful, requires a through study of every system. In the field of machine learning a different technique has been developed: Neural-Networks are a general class of functions which are able to represent the solutions to very disparate problems. By combining a quantum variational principle with an iterative procedure, we show that it is possible to optimize neural-networks in order to encode the ground- (or steady-)state of a quantum system. Such procedure, similar in spirit to supervised learning, can be performed efficiently by means of a Montecarlo sampling, which sidesteps the problem of exponential complexity. In this talk we will also showcase several other applications of machine learning to quantum physics.

Field:

Machine learning/Quantum physics

Language:

English

Oral presentations session / 25

D3DT : an innovative TPC for muon tomography

Auteur: Marion Lehuraux[1]

Co-auteurs: David Attie [1]; Hector Gomez [1]; Sébastien Procureur [1]; Irakli Mandjavidze [1]; Patrick Magnier [1]

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Muon tomography consists in using cosmic muons to probe structures in a non-invasive nor destructive way. The successful development of muon telescopes using Micro-Pattern Gaseous Detectors over the past decades triggered the interest of many industrials for such technology. However, telescopes are limited in terms of compacity and angular acceptance which are performances with high requirements for applications such as geology or oil prospection. This motivated the development of a new instrument that meets such requirements.
The use of a Time Projection Chamber (TPC) allows for a full track reconstruction in a quasi-isotropical way. In order to keep a good resolution while reducing the number of electronic channels (for a better compacity), the readout plane is 2D-multiplexed which makes the reconstruction challenging.
This talk will present the first prototype that has been developed and the first steps of track reconstruction that have been implemented.

Field:

Particle physics/Muon tomography

Language:

English

Oral presentations session / 33

Hunting for the Majorana fermion in magnet/superconductor heterostructures

Auteur: Maxime Garnier[None]

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The Majorana fermion, initially theoricized in high-energy physics, has the particularity of being its own antiparticle. In 2001, Kitaev [1] proposed that Majoranas could be realized as low energy excitation in something called a *topological superconductor* triggering a huge number of theoretical and experimental studies, especially due to interesting possibilities in quantum computing. Eventhough major advances have been realized on the experimental side, the Majorana has not been unambiguously identified so far.

My theoretical work aims at studying novel platforms based on magnets and superconductors brought in close proximity to one another. More specifically, I have been looking in details at the properties of the induced superconductivity close to a magnetic skyrmion [2, 3], a nanoscale magnetic texture that is now routinely created and manipulated.

In this talk, I will introduce the basics of superconductivity and topology needed to understand the nature of the Majorana fermion and why it is searched for so intensively. I will then explain why the skyrmion/superconductor setup (and more generally magnet/superconductor heterostructures) is theoretically interesting to remedy some problems currently encountered while emphasizing the experimental relevance of such setups.

[1] A. Y. Kitaev, Unpaired Majorana fermions in quantum wires, *Fiz. Usp.* **44**, 2001.
[2] M. Garnier, A. Mesaros & P. Simon, Topological superconductivity with deformable magnetic skyrmions, *Communications Physics* **2**, 126, 2019.
[3] M. Garnier, A. Mesaros & P. Simon, Topological superconductivity with orbital effects in magnetic skyrmion based heterostructures, arXiv:1909.12671, 2019.

Field:

Solid-state physics

Language:

English

Oral presentations session / **29**

Pendulum in a Flow: case of a Balanced Pendulum

Auteurs: Ariane GAYOUT[1]; Armann Gylfason[2]; Nicolas Plihon[3]; Mickaël Bourgoin[3]

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[2] *Reykjavik University, Iceland*

[3] *Laboratoire de Physique - ENS de Lyon - CNRS*

Auteur correspondant ariane.gayout@ens-lyon.fr

Fluid-structure interactions are the basics of the complexity of Aerodynamics, enhancing resonance in structures and turbulence in flows. Even simple systems like a pendulum can become more complex, as a hysteretic bistability shows up for a range of flow velocities when the pendulum confronts a flow. This is predicted by a simple balance of weight and aerodynamical forces, but non stationary response can be seen through spontaneous transitions between both stable positions.
This dynamic can also be observed when substracting the weight of the pendulum.
By analyzing trajectories in different phase spaces, we recover a stochastic measurement of the drag and lift coefficients. Moreover, the pendulum oscillates around the horizontal at a frequency that is linked to the evolution of the normal drag coefficient with the angular position of the pendulum. The instantaneous lift and drag coefficients inferred from the dynamical behavior of the pendulum seems to be governed by the dynamical vortex shedding phenomena, which we currently investigate experimentally.

Field:

Fluid mechanics

Language:

English

Oral presentations session / **3**

From gravitational black holes to analogue gravity

Auteurs: Mathieu Isoard[1]; Nicolas Pavloff[1]

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Auteur correspondant mathieu.isoard@u-psud.fr

Black holes are intriguing and singular objects; Einstein did not even believe in their existence. However, the first observation of a rotating black hole in our universe has been recently reported and is an undeniable confirmation of their presence.

In 1974, Hawking predicted that black holes are not completely black, but emit a thermal radiation at a certain temperature T_{H}, the so-called Hawking temperature[1]. However, the Hawking radiation is very faint and would be completely lost in the Cosmological Microwave Background.
A new breakthrough occurred in 1981, when Unruh showed that the dynamics of sound waves propagating in a convergent fluid flow was equivalent to the one of a massless scalar field propagating in a curved spacetime[2]. He then suggested to use hydrodynamic analogues of gravitational black holes to detect the elusive Hawking radiation.

In this talk, we pedagogically present how the transition from a subsonic to a supersonic flow can mimic an acoustic black hole for sound waves. Then, we discuss the recent experimental detection of spontaneous Hawking radiation in a Bose-Einstein condensate[3]. We show in particular how quantum fluctuations in these quantum systems can be related to emission of analogue Hawking pairs. We finally provide a theoretical interpretation of experimental observations[4].

References

1. S. W. Hawking, *Black holes explosions?*, Nature **248**, 30 (1974); *Particle Creation by Black Holes*, Comm. Math. Phys. **43**, 199 (1975).
2. W. G. Unruh, *Experimental Black-Hole Evaporation?*, Phys. Rev. Lett. **46**, 1351 (1981).
3. J. R. M. de Nova, K. Golubkov, V. I. Kolobov, and J. Steinhauer, *Observation of thermal Hawking radiation and its temperature in an analogue black hole*, Nature **569**, 688 (2019).
4. M. Isoard, N. Pavloff, *Departing from thermality of analogue Hawking radiation in a Bose-Einstein condensate*, arXiv:1909.02509 (2019).

Field:

Black holes/acoustic flow

Language:

Oral presentations session / **22**

Reducing quantum noise in gravitational-wave detectors using squeezed states of light

Auteur: Catherine Nguyen[1]

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Gravitational waves (GW) are ripples in the fabric of spacetime, emitted by compact accelerating objects. On September 2015, the first direct detection of GW from a binary black hole merger initiates the field of GW astronomy and opened a new window on the Universe. On August 17, 2017, Advanced LIGO and Advanced Virgo detectors jointly detected gravitational-waves resulting of the merger of two neutron stars, with the best localization precision ever obtained.
In order to increase the science reach of LIGO and Virgo, it is essential to reduce quantum noise (QN), one of the fundamental sensitivity limits of the detector. QN is originated by the quantum nature

of light, and is attributed to the Heisenberg Uncertainty Principle, stating that it is not possible to know simultaneously and with an infinite precision the phase and the amplitude of the light. Since the quantum noise is generated by vacuum fluctuations entering from the dark port of the detector, the injection of non-classical vacuum states of light (or squeezed states) enables the reduction of quantum noise. This technique is now routinely used in LIGO and Virgo to increase the sensitivity in a fraction of their frequency spectrum.
Achieving a broadband reduction of quantum noise requires the use of "frequency-dependent squeezing (FDS)"techniques, where the squeezing ellipse rotates as a function of the frequency before entering the detector. After a general introduction about squeezing, I will present my work on the experimental demonstration of a FDS technique using entangled photons, and known as Einstein-Podolsky-Rosen (EPR) squeezing technique.

Field:

GW/Squeezing

Language:

English

Oral presentations session / 48

Quark Gluon Plasma at LHCb

Auteur: Felipe Garcia[1]

[1] *LLR, LAL*

Auteur correspondant f.garcia@cern.ch

Quarkonia, bound states between a heavy quark and its own antiquark, are of particular interest when it comes to probing the Quark Gluon Plasma (QGP), a very special state of matter believed to have been in existence during the first moments after the Big-Bang. This state of matter can be recreated in high energy heavy ion collisions and one of the ways it can be studied, is through the observation of how the quarkonia production is affected when the QGP is present, specifically, the quarkonia suppression. At the LHCb experiment, we can access a unique energy regime, that will allow us to further understand the QGP. Current status and prospects will be presented.

Field:

Particle physics/LHCb/QGP

Language:

English

Oral presentations session / 28

Low frequency waves in a magnetically confined plasma column

Auteurs: Simon Vincent[1]; Victor Désangles[2]; Vincent Dolique[1]; Nicolas Plihon[1]

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[2] *Onera*

Auteur correspondant simon.vincent@ens-lyon.fr

Low frequency waves turbulence developing in magnetized plasma columns are well known to trigger important radial transport, a major issue for fusion devices. We present here analysis from very fast imaging of low frequency waves in a magnetically confined plasma column.

Our experimental set-up consists in a cylindrical chamber containing an Argon plasma column of 10 cm diameter of ionization rate 20 % and at low pressure ~ 1 mTorr generated via an electromagnetic induction source of power 1 kW. The plasma is confined by a magnetic field ranging from 0.01 T to 0.15 T.

A very fast camera records images of spontaneous radiated light fluctuations in a plane transverse to the plasma column axis, at a 200 kfps rate, showing the presence of azimuthally rotating waves at frequencies of order the kHz. These images are analysed using a Proper Orthogonal Decomposition technique which is compared to 2D axisymmetric Fourier transform analysis. The POD results exhibit m-modes closely following the exp(i m \theta) spatial form of the modes extracted by 2D Fourier transform.

Finally, the impact of an emissive cathode inserted at the center of the plasma column on the waves properties is investigated.

Field:

Plasma

Language:

English

Lunch & Posters session / 46

Elastic and Inelastic Diffraction of Fast Atoms

Auteur: Peng PAN[1]

Co-auteur: Philippe RONCIN [2]

[1] *ISMO-CNRS-UniversitéPariSaclay*

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Schematic representation of grazing incidence diffraction (GIFAD) discovered in the group by Patrick Rousseau. At grazing incidence, the fast He projectile with keV energy is diffracted by the well-ordered rows of atoms by successive gentle collisions. The He projectile is repelled by the surface electronic density so that GIFAD can be seen as a helium tip AFM operated in the reciprocal space. Atomic diffraction spots have two component, one is point-like corresponding to elastic scattering, the other one, the inelastic component, is broader and consist here in here in vertical stripes pointing upward or downward.

Language:

English

Lunch & Posters session / 57

Accurate determination of infrared spectroscopy in hydrogen-rich materials

Auteurs: Tommaso Morresi[1]; Michele Casula[1]; Rodolphe Vuilleumier[2]

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[2] *Ecole Normale Supérieure*

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The aim of this work is the calculation of vibrational properties of hydrogen-rich materials where Nuclear Quantum Effects play an important role. The computational methods are based on Molecular Dynamics simulations combined with Quantum Monte Carlo (QMC) for the electronic part and a Langevin thermostat correlated according to the covariance matrix of QMC nuclear forces. In particular, we want to assess the influence of the Langevin thermostats over dynamical properties such as vibrational spectra.

Field:

Condensed Matter Physics

Language:

English

Lunch & Posters session / 49

Assembly and cosmic bench test of large area Micromegas Detectors for the ATLAS Muon Spectrometer Upgrade

Auteur: Zhibo Wu[None]

Co-auteurs: Esther Ferrer Ribas [1]; Fabrice Balli [2]

[1] *IRFU/CEA*

[2] *CEA Saclay*

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The steadily increasing luminosity of LHC requires an upgrade to high rate and high-resolution capable detector technology for the inner end cap of the muon spectrometer of the ATLAS experiment. For precision tracking, large area Micromegas quadruplets are produced, in order to provide 8 consecutive active layers with 100 micron spatial resolution per individual plane. As for validation of the detectors, cosmic muons are an extremely powerful tool to scan over their full surface in terms of gain, homogeneity and efficiency. We report on the assembly and overall performance of one of these Micromegas quadruplets.

Language:

English

Lunch & Posters session / 21

Déflectométrie appliquée aux miroirs freeforms et aux larges asphères

Auteur: Hugo Jonquiere[1]

[1] *ONERA*

Auteur correspondant hugo.jonquiere@safrangroup.com

La complexité des optiques spatiales va croissante (Projet ELT : 981 segments de 1.5 m de diamètre, de formes différentes, Miroirs free-form, etc…) tandis que dans le même temps, les cadences de production s'accélèrent (Exemple : Projet ELT : 3 ans pour produire 981 segments).
Les gammes d'instruments métrologiques doivent s'adapter et requièrent des solutions industrielles performantes et polyvalentes et la déflectométrie est une des technologies explorées par SAFRAN REOSC pour répondre à ces problématiques.

La déflectométrie, contrairement à l'interférométrie, constitue une mesure absolue de forme et non un null test. La mesure est par conséquent entachée sur toute sa dynamique de nombreux biais, qu'il est nécessaire d'éliminer afin d'accéder à la mesure de forme du miroir.

La thèse porte sur le développement d'algorithmes de traitement de données et de procédures d'étalonnage afin d'améliorer les performances d'un banc déflectométrique, notamment en basse fréquence.

Language:

English

Lunch & Posters session / 34

A photon traveling 6000 km in two directions at the same time

Auteurs: Igor Dotsenko[1]; Jean-Michel Raimond[1]; Michel Brune [1]; Pierre Rouchon[2]; Stefan Gerlich[3]; Valentin Métillon[1]

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[2] *Inria - Mines Paritech*

[3] *University of Vienna*

Cavity quantum electrodynamics (CQED) is a field where the emission properties of atomes are modified by coupling with modes of cavities. Using Rydberg atoms coupled with ultra high finesse microwave cavities, the CQED team of LKB achieved a strong coupling regime, where the interaction of atoms with light is much stronger than decoherence. The very long life-time of the cavities made it possible to realize numerous experiments exploring the foudations of quantum mechanics of the last decade. In this work, we have built a set-up with two microwave cavities. We have then prepared entangled states of this two cavities, where a photon is spread on the two of them. This states show a lifetime of about 20 milliseconds, corresponding to an effective length of 6000 km in this single photon interferometer.

Language:

English

Lunch & Posters session / 37

The connector theory: New approximations for the exchange-correlation potential

Auteur: Ayoub Aouina[1]

Co-auteurs: Matteo Gatti [1]; Lucia Reining [1]

[1] *LSI*

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In material science we often use model systems to describe real materials. In this talk we are interested in the question of how to import, in principle exactly, a quantity of interest from a model into a real system. The prescription how to do that is what we call "connector theory" [1]. An enormous advantage of this strategy is that model results can be obtained once forever and tabulated. After introducing the theory we will focus on approximating the exchange-correlation (xc) potential of density-functional theory (DFT) [2] including the time-dependent (TD) case, and we use the homogeneous electron gas (HEG) as the model system. Then we discuss the features of the connector theory and explain why it constitutes a better scheme for approximations than an approach that would directly approximate the xc potential. By making use of advanced calculations for the TDDFT xc kernel of the HEG [3], we derive xc potentials that have a non-local density dependence and are non-adiabatic. We consider some examples to discuss qualitative and quantitative differences between the results of our approach and those of the local-density approximation (LDA) and we show why our theory goes beyond the LDA. Finally a generalisation for the efficient calculation of observables will also be discussed.

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[3] M. Panholzer, M. Gatti, and L. Reining, Phys. Rev. Lett. 120, 166402 (2018)

Language:

English

Lunch & Posters session / **42**

The performance of a critical review of heat transfer characteristic using nanofluid flow

Auteur: Soufiya MIZANI[1]

Co-auteurs: Hicham ZERRADI [1]; Aouatif DEZAIRI [1]

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the Experimental and theoretical research related to improving the transfer of A number of authors have carried out heat using nanoparticles and their results showed that the heat transfer of nanofluids is very important in this context our work presents a critical model for improved heat transfer This work is done on the basis of a 2D numerical dimension of heat transport models, which can be used to develop a better coupled geometry for a better cooling system This work includes the results of a numerical simulation performed to study the nanofluid flow . Two types of nanofluids involving Al2O3 and CuO nano-particles dispersed separately in base fluids of water and ethylene glycol , those nanofluids were taken to evaluate their effect on the flow around different arrangement of cylinders. The continuity and the momentum equations have been numerically solved by using a special technic. Besides the thermo-physical parameters of nanofluids have been evaluated using the theory of one fluid phase, thus, con-temporary correlations of thermal conductivity and viscosity of nanofluids have been used in this paper as well as our previous work. The correlations are functions of particle volumetric concentration as well as temperature. The results of heat transfer characteristics of nanofluid flow of this critical review rev-eled clear improvement comparing with the base fluids. This enhancement is very interesting in engineering of flows with different situation characteristics, while the gap ratios (G/D) of our review and incidence angle exert an enhancement efficiency influence on the heat transfer characteristics. In this study the results obtained can be a fruitful source for developing and validating of new codes both in scientific and commercial manner.

Key words: Nanofluid, Fluid flow, Heat transfer, 2D simulation, critical review

Language:

English

Lunch & Posters session / 47

Time Between the Maximum and the Minimum of a Stochastic Process

Auteurs: Francesco Mori[1]; Satya Majumdar[1]; Grégory Schehr[1]

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The properties of extremes of a stochastic process/time series of a given duration T are of fundamental importance in describing a plethora of natural phenomena. For example, this time series may represent the amplitude of earthquakes in a specific seismic region, the amount of yearly rainfall in a given area, the temperature records in a given weather station, etc. The study of extremes in such natural time series have gained particular relevance in the recent context of global warming in climate science. In many applications it is important to estimate when the extremal values will be reached. For instance, in finance one wants to predict the time at which the price of a stock will reach its maximal value. In this work we consider the time-difference τ between the global minimum and the global maximum for a variety of stochastic processes. We present an exact solution for the probability density function of τ in the cases of one-dimensional Brownian motion and Brownian bridge (a periodic Brownian motion of period T). We demonstrate that these results can be directly applied to study the position-difference between the minimal and the maximal height of a fluctuating $(1+1)-$dimensional Kardar-Parisi-Zhang interface on a substrate of size L, in its stationary state. Numerical simulations are in excellent agreement with our theoretical findings.

Language:

English

Lunch & Posters session / 20

Efficient algorithm to estimate the parameters of gravitational waves sources

Auteur: Marc Arène[1]

Co-auteur: Edward Porter [2]

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Gravitational waves are ripples of space time typically produced by inspiraling pairs of neutron stars and/or black holes, our *sources*. Once detected by the ground-based LIGO and Virgo interferometers, the next step is to **estimate the parameters** of these sources such as their distance, localization in the sky, masses of each component etc.

This task is currently carried out by MCMC typed sampling algorithms, taking between days and several weeks to converge to the full posterior distributions of our parameters.

Thanks to improved sensitivities of the interferometers, the third run of observation -aka O3 which started on April 1st 2019- has a detection rate of ~1 event / week. This brings an obvious tension with respect to the time needed by our methods to converge.

The main purpose of my PhD is to develop an efficient sampler, the **Hamiltonian Monte Carlo** (HMC), to estimate the parameters about 10 times faster than currently used algorithms.

After a brief review of gravitational waves and sampling methods I will explain why the HMC is a promising tool in the context of gravitational waves.

Field:

GW/MCMC analysis

Language:

English

Lunch & Posters session / 40

Is supersymmetry a real symmetry of Nature ? Aspects of supersymmetry breaking.

Auteur: Osmin Lacombe[None]

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Supersymmetry (SUSY) was first introduced to address unanswered aspects of the Standard Model of particle physics such as the unification of gauge couplings at high energies. It then proved useful in broader theoretical contexts, from string theory to dark-matter models. SUSY assumes the existence of N symmetries relating fermionic and bosonic fields. When N>1, it is referred to as « extended » SUSY. Supersymmetry predicts additional particles, called superpartners, for each particle of the Standard Model (electrons, muons, quarks⋯). Superpartners are not observed at our energy scales, therefore SUSY might exist at higher energy but « break » at a certain scale: this phenomenon is called spontaneous symmetry breaking. In analogy to the famous Brout-Englert-Higgs (BEH) mechanism for electroweak symmetry breaking, SUSY breaking models predict the existence of a massless fermion, called Goldstino, for each broken SUSY generator. In this talk, I will discuss models making use of Fayet-Iliopoulos (FI) terms [1] to implement spontaneous breaking. Depending on the context, Goldstini are viewed as superpartners of various bosonic fields (standard model fields, inflation field⋯) and the SUSY breaking scale is related to the corresponding energy scales (electroweak scale, inflation scale⋯). Hence, the study of SUSY breaking contributes to the understanding of the hierarchy between the dark energy, electroweak, inflation or Planck scales. Goldstino dynamics can be described through non-linear formulations of SUSY [2] in which SUSY operators act non-linearly on fields. Recent progress [3] has lead to systematic descriptions of the connection between SUSY breaking models and the low energy dynamics of Goldstini fields. in extended SUSY, « partial » breaking [4] can occur when at least one combination of SUSY generators remains unbroken. Partial SUSY breaking plays an important role in the understanding of D-branes, fundamental string theory objects. In this talk I will first give an overview of SUSY in particle physics, its spontaneous breaking and non-linear realisations. I will then present my work on partial SUSY breaking with a new FI term induced by the « deformation » of N=2 SUSY [5], and its physical consequences [6] in the non-linear SUSY context.

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[4] Antoniadis, I., Partouche, H. and Taylor, T., Phys.Lett. B372 (1996) 83-87
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[6] Antoniadis, I., Jiang, H. and Lacombe, O., in preparation.

Field:

Particle physics/SUSY

Language:

English

Lunch & Posters session / 17

Generative Adversarial Networks for Fast Simulation in ATLAS

Auteur: Aishik Ghosh[1]

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Accurate simulations of a showers from particles from the Large Hadron Collider in the ATLAS calorimeter are incredibly resource intensive, consuming the largest fraction of CPU time on the CERN computing grid. Generative Adversarial Networks are investigated as a scalable solution for modelling the response of the electromagnetic calorimeter for photons over a range of energies. Steps have been taken to inject detailed knowledge about the detector geometry as well as physics metrics of importance into the training procedure of the network. The synthesised showers show good agreement to showers from a computationally expensive full detector simulation using Geant4. They also show good agreement on several new complex physics variable distributions that are only possible to study after integrating the trained generative model into the ATLAS software. Timing studies indicate at least three orders of magnitude improvement in speed when showers are generated in serial on a CPU. The integration into the ATLAS software also allows for fair and detailed comparisons with more traditional fast simulation techniques developed over the past years in ATLAS. This study demonstrates the potential of using such deep learning algorithms as a scalable solution for fast detector simulation in the future.

Field:

Machine learning/ATLAS

Language:

English

Lunch & Posters session / 50

Quantum walks under magnetic field

Auteur: Hugo Perrin[None]

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Quantum walks can be seen as the quantum counterpart of the classical random walk on lattice. They lead to a dynamic which is very different from the tight binding hamiltonian framework and its schrodinger equation. Other features from both systems can be compared and I mainly focus on the effect of a transverse magnetic field to the lattice. In the hamiltonian case, when we plot the energy of the system with respect to the magnetic flux, we obtain a fractal like pattern known as the "Hofstadter butterfly". This figure is the phase diagram of a topological insulator i.e systems where their physical properties are guided by number (invariant) insensitive to perturbation.
A quantum walk counterpart of these butterflies can be plotted but another topological invariant needs to be defined.
Eventually, I have reproduced in a recent paper an Arahanov-Bohm cage like effect for quantum walks, an unusual phenomenon of extreme localisation of the electron wavefunction when the magnetic flux is tuned to a precise value.

Field:

Language:

English

Lunch & Posters session / 18

New constraints on the nuclear equation of state from the thermal emission of neutron stars in quiescent low-mass X-ray binaries

Auteurs: Nicolas Baillot d'Etivaux[1]; Sebastien Guillot[2]; Jérôme Margueron[3]; Natalie Webb[2]; marcio catelan[4]; Andreas Reiseneger[4]

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In the last decades, nuclear equation of state has been a dealing problem. Measuring neutron stars (NSs) radii can bring a key information on nuclear matter properties at very high densities. We employ an empirical parameterization of the equation of state with a Markov-Chain Monte Carlo approach in a Bayesian framework, to consistently fit the spectra of 7 selected NSs. Despite previous analyses predicting low NS radii, we show that it is possible to reconcile the astrophysical data with nuclear physics knowledge, with or without including a prior on the slope of the symmetry energy Lsym. With this empirical parameterization of the equation of state, we obtain radii of the order of about 12 km without worsening the fit statistic. More importantly, we obtain the following values for the slope of the symmetry energy, its curvature Ksym, and the isoscalar skewness parameter Qsat: Lsym = 37.2(+9.2,−8.9) MeV,
Ksym = −85(+82,−70) MeV, and Qsat = 318(+673,−366) MeV. These are the first measurements of the empirical parameters Ksym and Qsat. Their values are only weakly impacted by our assumptions, such as the distances or the number of free empirical parameters, provided the latter are taken within a reasonable range. We also study the weak sensitivity of our results to the set of sources analyzed, and we identify a group of sources that dominates the constraints. The resulting masses and radii obtained from this empirical parameterization are also compared to other measurements from electromagnetic observations of NSs and gravitational wave signals from the NS-NS merger GW 170817.

Field:

EoS/NS

Language:

English

Lunch & Posters session / 24

Understanding shear bands characteristics and formation in model glasses through the measure of the local yield stress.

Auteur: Armand Barbot[1]

Co-auteurs: Matthias Lerbinger [1]; Anaël Lemaître [2]; Damien Vandembroucq [1]; Sylvain Patinet [1]

[1] *PMMH, CNRS UMR 7636, ESPCI Paris, PSL University, Sorbonne Université, Université de Paris, F-75005 Paris, France*

[2] *Université Paris-Est, Laboratoire Navier (UMR 8205), CNRS, ENPC, IFSTTAR, 2 allée Képler, F-77420 Marne-la-Vallée, France*

Auteur correspondant armand.barbot@espci.fr

Many phenomena remain poorly understood in amorphous materials such as plasticity and shear banding, their brittleness and disordered structure making it difficult to study them experimentally. As a consequence, we use model two-dimensional Lennard-Jones glasses and measure their local yield stress, a measure of the local softness, as presented in [1]. This method is nonperturbative and is applied on a well-controlled length scale. Applying it on well-relaxed glass under simple shear loading showed that the first plastic events create a local yield stress [2] diminution in the material which cause the emergence of a shear band [3]. Furthermore, we find that a single plastic event suffices to bring the local yield stress distribution to a well-defined value, thus essentially erasing the memory of the initial structure.

[1] A. Barbot et al., Phys. Rev. E, 97, 033001 (2018)
[2] S. Patinet et al., arXiv::cond-mat/1906.09818 (2019)
[3] A. Barbot et al., arXiv::cond-mat/1906.09663 (2019)

Field:

Materials science

Language:

English

Lunch & Posters session / 43

Conception and optimisation of Micro-Pattern Gas Detectors for the future Electron-Ion Collider

Auteur: Maxence Revolle[1]

[1] *CEA Saclay*

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Micro-Pattern Gas Detectors (MPGD) are now commonly used in particle physics experiences (COMPASS,ALICE,ATLAS…), mainly as a particle tracker. For the new Electron Ion Collider (EIC) in the

USA, planned for 2030, a collaboration between CEA-Saclay, Brookhaven National Laboratory and Stony Brooks University have been created with the goal of improving MPGDs based tracking chambers. By using "zigzag" readout pattern instead of the standard straight parallel strips, we are proving that it is possible to reduce the number of strips by at least a factor of 2 and still achieve a spatial resolution better than 100um thus reducing the cost of the instrument.

Three different MPGDs technologies are studied and compared : Micromegas, micro-RWell and GEM. The principle of the Zigzags readout will be presented followed by recent results of the characterisation using a proton beam done earlier this year showing an improvement of the spatial resolution.

Field:

Particle physics/EIC/MPGD

Language:

English

Lunch & Posters session / 35

Searching for clues about the Universe's origins in big data sets

Auteur: Hamza El Bouhargani[1]

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Inflation theories elegantly address a number of problems raised by the standard Hot Big Bang scenario, however one of its major predictions, the existence of a stochastic background of cosmological gravitational waves, is yet to be confirmed. Currently the most promising, if not the only, way to achieving this is through the observation of the Cosmic Microwave Background (CMB) polarization. The primordial gravitational waves generated by inflationary mechanisms leave a specific imprint on the polarization anisotropies of the CMB. Their detection would deeply impact our understanding of cosmology and fundamental physics. The search for this faint signal as well as its precise characterization require unprecedented sensitivities, prompting a rapid growth in the size of the data sets being collected by the experiments. The size of the full raw data sets that we need to process is expected to reach the Petabyte scale in the forthcoming CMB experiments. Processing these data efficiently requires better numerical tools, able to fully capitalize on the computational power of massively parallel supercomputers. In my talk, I will present a brief overview of the scientific context and some of the most exciting experimental efforts planned to hunt these primordial gravitational waves. I will also describe some of the computational challenges posed by their anticipated data sets along with some of the methods we develop to tackle them.

Field:

Cosmology/Computer science

Language:

English

Lunch & Posters session / 31

Study and optimisation of the non-linear and 6D dynamics of an electron beam in an ultra-low emittance storage ring

Auteur: Lina HOUMMI[1]

Co-auteurs: Ryutaro NAGAOKA [2]; Javier RESTA LOPEZ [3]; Carsten P. WELSCH [3]

[1] *University of Liverpool/Synchrotron SOLEIL*

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The SOLEIL synchrotron is the French national third generation light source storage ring, which provides photon beams to 29 beamlines from infrared to hard X-rays. Future synchrotron sources aim at increasing the brilliance by decreasing the electron beam emittance, down to the natural diffraction limit: they are Diffraction Limited Storage Rings (DLSRs). In order to improve its performance and allow access to new experiments, an upgrade of the SOLEIL 2.75GeV storage ring is under study, and aims at decreasing the horizontal electron beam emittance by a factor 40 at least.
After a brief review of the state-of-the-art of the synchrotron light sources and their applications, this contribution presents two new layouts of magnet lattice, optimised by means of multi-objective algorithms. Eventually, the results of such optimisation process will be discussed in details.

Field:

Accelerator physics/Soleil

Language:

English

Lunch & Posters session / 23

The Iris Billiard: Critical Geometries and Global Chaos.

Auteurs: Gregory PAGE[1]; Charles ANTOINE[1]; Julian TALBOT[1]

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A new class of 2D billiards, defined by a unit circle enclosing a geometrically variable, central scattering ellipse is introduced.

The system exhibits mixed dynamics which is explored via Recurrence plots (RPs) and the associated recurrence quantification analysis (RQA), with a focus on long-term motion starting from the unstable period 2 orbit.

The main result shows the existence of a set of critical ellipse geometries at which the dynamics undergoes a transition to global chaos.

Further results show the existence of counterintuitive, fractal behaviours within a well defined variable space at the moment of dynamical transition at these critical geometries.

The presentation will conclude with possible explanations of these behaviours.

Field:

Maths

Language:

English

Lunch & Posters session / 54

”Cavity” quantum thermodynamics: Autonomous Maxwell’s demon

Auteurs: Baldo Luis Najera-Santos[1]; Valentin Métillon[2]; Alexia Aufféves[3]; Patrice Camati[3]; Michel Brune [2]; Jean-Michel Raimond[2]; Igor Dotsenko[2]

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Quantum thermodynamics follows the approach of classical thermodynamics to study the energy exchange during the interaction of quantum systems. It defines the quantum counterparts of heat, work, and entropy, and it provides equations that constrain the variation of these quantities. The Maxwell’s demon *Gedankenexperiment* portrays a tiny being that uses the information on individual molecules of a gas to rectify thermal fluctuations without work expenditure, thus, violating the Second law of thermodynamics. In the present work, we implemented experimentally an autonomous Maxwell’s demon with a single circular Rydberg atom and a single mode of a superconducting microwave cavity. We treat two levels of the atom as a qubit, which resonantly exchanges energy with the cavity. We prepare the qubit and the cavity in thermal states at different temperatures and we let them exchange a photon by means of an adiabatic passage. Transferring the atoms from the low-energy level to an additional off-resonant level is equivalent to a sneaky demon preventing the low-energy qubits from interacting with the cavity, therefore, extracting heat out of thermal fluctuations. The obtained results can be explained by applying a generalized version of the second law, which takes into account the information exchange between the qubit and the demon.

Field:

Quantum thermodynamics in cavity QED with circular Rydberg atoms

Language:

English

Lunch & Posters session / 55

Programmable linear quantum networks with a multimode fibre

Auteurs: Saroch Leedumrongwatthanakun[1]; Luca Innocenti[None]; Hugo Defienne[None]; Thomas Juffmann[None]; Alessandro Ferraro[None]; Mauro Paternostro[None]; Sylvain Gigan[None]

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High-speed data transfer through optical fibres using spatial multiplexing is practically limited by modal crosstalk. Instead of considering this modal crosstalk as a limitation, we here harness its mode mixing to process quantum optical information. We implement a programmable linear optical network based on the concept of inverse photonic design exploiting the technology of wavefront

shaping. We demonstrate manipulation of two-photon quantum interference on various linear networks across both spatial and polarization degrees of freedom. In particular, we experimentally show the *zero-transmission law* in Fourier and Sylvester interferometers, which are used to certificate the degree of indistinguishability of an input state. Moreover, thanks to the ability to implement a non-unitary network, we observe the photon anti-coalescence effect in all output configurations, as well as the realization of a tunable coherent absorption experiment. Therefore, we demonstrate the reconfigurability, accuracy, and scalability of the implemented linear optical networks for quantum information processing. Furthermore, we study the statistical properties of one- and two-photon speckles generated from various ground-truth states after propagating through a multimode fibre. These statistical properties of speckles can be used to extract information about the dimensionality, purity, and indistinguishability of an unknown input state of light, therefore allowing for state classification. Our results highlight the potential of complex media combined with wavefront shaping for quantum information processing.

Field:

Quantum information, Quantum optics

Language:

English

Lunch & Posters session / 56

Hydraulic fracturing and active coarsening position the lumen of the mouse blastocyst

Auteur: Mathieu LE VERGE SERANDOUR[1]

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We investigate the role of cell contractility and molecular adhesion in the formation of the blastocoel during early mouse embryo development, a fluid-filled lumen that positions the first axis of symmetry of the embryo. We show that hundreds of micron-sized fluid filled cavities appear throughout the entire embryo on basolateral (adhesive) sides of cells, fracking cell-cell contacts. Via a process akin to Ostwald ripening, these microlumens exchange fluid, such that a single dominant lumen emerges. We build a model to study the coarsening of the network of microlumens, reproducing the features of the dynamics and positioning of the blastocoel. Our results suggest that the lumen forms at the Trophectoderm-ICM interface, corresponding to the lowest contractile cell-cell interface.

Field:

Biophysics, Modeling, Morphogenesis, Embryogenesis

Language:

English