CEMPI REPORT 2019–2021.

Table of contents

1 A brief presentation **2**

2 CEMPI within the context of ULille and of I-SITE ULNE **2**

3 Research **3**

3.1 Awards and distinctions 3

3.2 Publication record 4

3.3 Interdisciplinarity 4

3.4 Research highlights 8

3.4.1 Dynamics 8

3.4.2 Topology and applications 11

3.4.3 Biology/Modelisation stochastic/Data science 12

4 Training **13**

5 Valorization **16**

6 CEMPI budget. Leverage effect **17**

1 A brief presentation

The "Laboratoire d'Excellence" Centre Européen pour les Mathématiques, la Physique et leurs interactions (CEMPI) is a project of the Laboratoire de Mathématiques Paul Painlevé (LPP) and the Laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM) in Lille. It was created in February 2012 in the context of the "Programme d'Investissements d'Avenir" (the French excellence initiative), for the 2012-2019 period.

It has been renewed in 2019 and extended to 2024, on the basis of a new project, with high praise from the international committee. The same year, CEMPI was distinguished as the Labex project of the year (« projet phare ») by the Agence Nationale de la Recherche (the organization that runs governmental research programs in France), jointly with its partner projet, Equipex FLUX (supporting the Fibertech optical fibre manufacturing platform).

The collaboration Painlevé-PhLAM federates forces for fundamental and applied research, for training, and for technological development in a wide spectrum of knowledge that stretches from pure and applied mathematics to experimental and applied physics. A distinctive asset of CEMPI is the FiberTech optical fiber manufacturing platform, the most technologically complete of the three French academic optical fiber platforms.

In this report, we will focus on some recent successes within the period of 2019–2021 concerning research, training and valorization.

2 CEMPI within the context of ULille and of I-SITE ULNE

In 2017, the University of Lille succeeded in obtaining the I-SITE label from the IDEX PIA call under the « Université de Lille Nord Europe » (ULNE) name, with a probatory period going to april 2021. On the basis of the report submitted in july 2021, and of the hearing by the international committee in january 2022, the I-SITE label is to be confirmed anytime soon.

From 2017 onwards, Labex CEMPI has been a pillar of the ULNE I-SITE project, and has been committed not only to its own development but also to the global success of the I-SITE project.

When time for Labex renewal application came in 2018, and as the funding scheme of Labex call only allowed two-thirds (2/3) of the budget to be carried over to the new project, this motivated the ULNE I-SITE to commit to support the renewed CEMPI Labex, as well as other Labex in Lille for the remaining third (1/3) of its budget. In return, CEMPI promised to allocate the I-SITE funding to high-priority I-SITE actions such as student attractivity programs through scholarships, PhD grant funding,...

However, the contribution of Labex CEMPI to ULNE success goes even beyond this, as it is currently intensifying its interactions with researchers outside its historical perimeter, as will be discussed in the section on interdisciplinarity (Sec. 3.3, p. 4). Here, let us emphasize that CEMPI is currently playing a key role to federate two distinct but closely related ULille research communities that extend beyond CEMPI realm but rely on a strong mathematics-physics collaboration.

First, CEMPI launched a working group on « topological matter », capitalizing on the arrival in Lille of a internationally renowned researcher in this topic, Dr. Alberto Amo, a two-times ERC

laureate (outside and within Lille). Topological matter concepts, brought to the front scene by the 2016 Nobel prize in physics, are paving the way towards revolutionary wave guiding, allowing for example unidirectional lossless wave propagation in nanostructured materials. This is of high interest in all domains involving waves, be it in optics or in THz radio waves used in future mobile network-to-antenna links or in acoustics. Currently, an ecosystem of about 30-40 researchers are participating, in PhLAM, Painlevé and IEMN. One highlight of this new ecosystem is that the THz group at IEMN, led by Pr. G. Ducournau, has equalled its world record of wireless data transmission at 100 Gbit/s on a single THz radio link, using a topological waveguide. The same rate had been achieved three years ago with atmospheric transmission, but with much higher energy requirements.

Moreover, CEMPI is providing scientific but also financial support to the Disruptive DYnamics for Communications and Connectivity (DYDICO) project, one of the 12 research clusters launched by I-SITE ULNE, and one the three clusters of the « Digital world for humans » hub of ULNE I-SITE.

Last, a second local ecosystem is rapidly emerging in the field of quantum information and quantum cryptography, a theme that relies heavily on mathematics and physics but which is of much wider application and interest, in particular in computer science and information theory. This ecosystem involves about 40 researchers from PhLAM, Painlevé, IEMN and CRIStAL, and CEMPI plays an important role in it, both through its mathematics branch and the cold atom physics group. Notably, one of the leading organizers is a researcher from the CaPPA Labex, demonstrating a high synergy between different centres of excellence within ULille.

3 Research

The new project is organized in three new focus areas combining expertise from all disciplines involved, replacing the previous structure in terms of disciplines and their interactions : (i) dynamics ; (ii) topology and applications ; (iii) Biology, stochastic modelisation, Data Science.

Every year, CEMPI welcomes a number of scholars to contribute to its scientific activities through their participation in the conferences, workshops and seminars organized in Lille (in particular in the framework of the thematic semester that we organize each year), and the development of common research with the CEMPI permanent researchers.

3.1 Awards and distinctions

- A. Amo (PhLAM) was awarded in 2019 the **ERC** Consolidator Grant **Emergent topology in photon fluids** (2M€) to experimentally unveil novel topological phases in photonic lattices emerging from photon-photon interactions and to implement novel topological phases in photonic lattices subject to periodic temporal modulations, and to explore their behaviour in the presence of interactions.
- In 2021, C. Cancès (LPP) was awarded the prize **Blaise Pascal of the Académie des Sciences** for his work in modelization and numerical analysis of thermodynamical systems coming from physics.
- In 2020, D. Tanré (LPP), with his co-authors U. Bujis (Univ. de Malaga) and U. Felix (Univ. catholique de Louvain) was awarded the **Ferran Sunyer i Balaguer Prize** for

their book *Lie models in topology*. This prize is awarded for a mathematical monograph of an expository nature presenting the latest developments in an active area of research in mathematics, in which the applicant has made important contributions.

- Najib Idrissi was awarded the **Cours Peccot** 2019-2020 of Collège de France for his work during his PhD programm at LPP.
- In 2023, Mylène Maida (LPP) is invited to give a talk at the **séminaire Bourbaki** on the paper of Bordenave and Collins "Eigenvalues of random lifts and polynomials of random permutation matrices" (Ann. Math 2019).
- Catalin Badea (LPP), Vincent Devinck (a former PhD student in LPP), and Sophie Grivaux (LPP) are the recipients of the 2021 **G. de B. Robinson Award of the Canadian Mathematical Society** for their work on Jamison sequences which makes significant connections between many fields of analysis and algebra [21].
- Arnaud Mussot (PhLAM) created and was the first director of the GDR (Groupement de Recherche) ELIOS, federating the French community working on nonlinear effects in optical fibers and integrated optics.
- Marc Lefranc (PhLAM) created and was the first director of the GDR (Groupement de Recherche) « Approches Quantitatives du Vivant » (AQV), federating the French community working at the interface between physics and biology, with around 1000 researchers affiliated.

3.2 Publication record

CEMPI has published 531 articles in international refereed journals over the 2019-2021 period, with indications of a high research quality :

- Of the 175 publications issued by PhLAM/CEMPI researchers over 2019-2021, 29 (16 %) appeared in top-tier journals (3 Nature photonics, 2 Nature physics, 1 Nature materials, 1 Reviews of modern physics, 12 Physical Review Letters, 3 Physical Review X, 2 PNAS, 1 LSA,...). This is to be compared to the fact that over the 2013-2018 period (CEMPI renewal application), 10% of CEMPI physics publications appearing in the top 10% of physics journals. CEMPI physics publications in 2019-2021 received 2340 citations, of which 1216 were attracted by 3 review papers, showing the influence played by PhLAM in the scientific papers.
- **7% of CEMPI mathematics publications** (25 in 2019–2021 compared to 41 in 2013-2018 and 34 over 2008-2013) have appeared in the top 5% of mathematics journals (according to MathSciNet, corresponding to a MCQ around 2).
- **80% of the CEMPI scientific production** is the result of an international collaboration between one or more CEMPI researchers and a colleague from a foreign university.

You will find in the Appendix of this document a list of selected publications.

3.3 Interdisciplinarity

The collaborations between Painlevé and PhLAM have intensified in recent years. In particular, researchers from Painlevé (S. De Bièvre, A. Hertz) and PhLAM (D. Horoshko, M. Kolobov, and

G. Patera) have worked on topics at the intersection of quantum optics and quantum information theory. In [52] a new optical nonclassicality measure was proposed, the properties of which were further analyzed in [61] and [38]. In [37] (in collaboration with N. Cerf, ULB-Brussels) the link between optical nonclassicality and entanglement was explored through bounds between various optical classicality and entanglement witnesses and measures.

In another domain, researchers from Painlevé (S. De Bièvre and G. Dujardin) and from PhLAM (A. Armaroli, M. Conforti, A. Kudlinski, A. Mussot), together S. Trillo (Ferrara) have achieved an analysis of modulational instability in optical fibers with randomly kicked normal dispersion [13] as well as with a normal dispersion perturbed with a coloured noise. They analyzed the modulational instability generated in such fibers through the associated gain, both theoretically and numerically. The effect of coloured noise on the modulational instability was investigated in order to assess whether it can produce a larger modulational instability. They found that generally this is not the case. This opens promising perspectives not only from a mathematical point of view but also for building innovative light sources.

In [42] researchers from Painlevé (S. De Bièvre) and PhLAM (J.C. Garreau, S. Lellouch, and A. Rançon), together with D. Delande (Lab. KB, Paris) studied the dynamics of the many-body atomic kicked rotor with interactions at the mean-field level, governed by the Gross–Pitaevskii equation. It is shown that dynamical localization is destroyed by the interaction, and replaced by a subdiffusive behavior. In contrast to results previously obtained from a simplified version of the Gross–Pitaevskii equation, the subdiffusive exponent does not appear to be universal. A new approximation is proposed that describes correctly the dynamics at experimentally relevant times close to the start of subdiffusion, while preserving the reduced computational cost of the former approximation.

At the interface mathematics and physics, P. Henrich and N. Wicker (Painlevé) and Laurent Héliot (PhLAM) have just submitted an ANR project CAMoMill (Computer Assisted Multimodal Microscopy for Quantifying Molecular Diffusion in Cells) with partners from Laboratoire Interdisciplinaire Carnot de Bourgogne (Dijon, France), IRIMAS laboratory (Mulhouse, France) and NUS (Singapore). This ANR projet deals with the major challenge of measuring molecular transport, interactions, and complex formations in living cells, that are necessary for cell structure, maintenance or functional adaptation. More precisely, the objective of this project is to develop an acquisition chain based on multimodal instrumentation, simultaneous fluorescence correlation spectroscopy (FCS) and single particle tracking (SPT) acquisition and its interactive coupling with fast and model-free analysis methods connecting with acquisition in order to follow and interpret molecular movements in living cells at different spatiotemporal scales.

New collaborations between PhLAM and Painlevé are currently emerging on two important subjects :

1. The dynamics of annular Bose-Einstein condensates, with fascinating applications to quantum N-body problems. The cold atom group at PhLAM (R. Chicireanu, P. Szriftgiser) has recently demonstrated the experimental realisation of a Bose-Einstein condensate. A project with G. Dujardin (CR Inria, Painlevé) around the experimental development of an annular Bose-Einstein potassium condensate for the study of superfluidity and quantum turbulence recently emerged and we are currently trying to recruit a new post-doctoral student in this direction.

2. Kinetic equations governing the dynamics of electron bunches in particle accelerators, with applications to the generation of unconventional radiation in synchrotron facilities. The PhLAM accelerator group (C. Evain, S. Bielawski, C. Szwaj, E. Roussel) has recently demonstrated the stabilisation of the output intensity of the SOLEIL synchrotron at high power, a world premiere. Painlevé researchers (M. Herda, T. Rey) have obtained remarkable results on the mathematics of kinetic equations.

A significant fact to be considered in the context of the ULNE I-SITE project is that besides interdisciplinary research in its historical perimeter, CEMPI is currently actively promoting local interactions outside its own research hub, with computer science, nano-technology (IEMN laboratory, one of the 5 major nanotechnology centres in France) and health in particular.

- Members of the **LPP** (David Dereudre and Emeline Schmisser) and of **IEMN, Institut d'Electronique, de Microélectronique et de Nanotechnologie, ULille** (Eric Lheurette and Yan Pennec) are members of the ANR Project RANDOM (2019–2023) which proposes to set a mathematically controlled disorder in a system of dual electromagnetic and acoustic resonators on a surface. See `https://anr.fr/Projet-ANR-19-CE24-0014` for more details. There is one common publication [54] and a post-doc on the project should be hired.
- Members of the **LPP** (Group of probability) and of **CRIStAL, Centre de Recherche en Informatique, Signal et Automatique de Lille, ULille**, (group of Rémi Bardenet, CNRS junior researcher, PI of the ERC starting grant Blackjack and holder of national artificial intelligence chair Baccarat) participate to the weekly workshop on *Random Point Processes*. A. Rançon (PhLAM) also participates regularly. Mylène Maida (LPP) plans to co-supervises with R. Bardenet a PhD thesis, and several papers between LPP members and R. Bardenet already appeared [3, 22, 45].
- Members of the **LPP** (Barbara Tumpach and Juan Carlos Alvarez Paiva, group of geometry) also collaborate with some members of **CRIStAL and IMT Lille Douai** (Mohamed Daoudi and Emery Pierson) on the project of analyzing human poses and motion by use of geometry technics. In particular, they propose a novel framework for comparing 3D human shapes under the change of shape and pose. This problem is challenging since 3D human shapes vary significantly across subjects and body postures. They solve this problem by using a Riemannian approach. They are already several publications [9, 28, 65].

- Members of the three laboratories of ULille, **the PhLAM, the LPP and the IEMN** have a strong and common interest in topology. A workshop has been launched between the LPP and the PhLAM in 2020 on the theme of Topology and Matter. The CPER Wavetech (2021-2027), conducted by Pascal Szriftgiser (a member of the CEMPI executive committee) and which gathers the LPP, the PhLAM, the IEMN, the IRCICA (Institut de Recherche sur les Composants logiciels et matériels pour l'Information et la Communication Avancée) and the UCCS (Unité de Catalyse et Chimie du Solide) aims to conduct research on the photonics, Térahertz (THz) and quantum mechanics, with a particular focus on the topology.
- Together with colleagues from **PhLAM** (V. Vallet and André Severo Pereira Gomes, both from the **Labex CAPPA**) and **CRIStAL** (N. Melab), and in collaboration with the "**Maison de la Simulation**" (Université de Lille), S. De Bièvre (**Painlevé**-CEMPI) has taken

the initiative to launch a series of seminars on "Quantum Information." The purpose of this working group (WG) is to bring together all the actors of the University of Lille interested in the subjects of quantum computing and quantum technologies. The WG meets every six weeks, on a Friday afternoon. Each meeting consists of two 40 minute guest seminars, followed by a 15 minute discussion and question session. These seminars are intended for a large interdisciplinary audience of researchers, whether they are students, doctoral students, postdocs or more experienced colleagues ; their first goal is to allow all participants to familiarize themselves with the subject. In a second stage, which will start in the spring of 2022, more specialized sessions will be organized, depending on the interests of the participants. Launched in September 2021, the WG has already met three times, bringing each time together around 35 people. These 6 first seminars have been given by researchers from 4 different laboratories : CRIStAL, IEMN, Paul Painlevé and PhLAM. The presentation of the WG as well as the program of seminars and their content are available here : https ://wikis.univ-lille.fr/informationquantique/. These seminars will continue in 2022, with also speakers from outside the University of Lille.

In addition, Radu Chicireanu (PhLAM-CEMPI) is currently responsible for the response to an AMI on quantum technologies, which is piloted by F. Balestra in Grenoble and in which the Université de Lille will be a partner.

- Thomas Rey (**LPP**) develops a recent collaboration with S. Billiard (**Laboratoire Evo-Eco-Paléo**, ULille) around the interface between mathematics and biology. More precisely, in a recent preprint (see arXiv :1911.05482), with two other co–authors, M. Derex (Institute for Advanced Study in Toulouse), and L. Maisoneuve (Institut de Systématique, Évolution, Biodiversité, UMR 7205, MNHM), they proposed a new mathematical model intended to described dynamically the evolution of knowledge in structured societies of interacting individuals. This process, termed cumulative culture, has been extensively studied by evolutionary anthropologists, both theoretically and experimentally. Some of the mathematical properties of the new model are analyzed, and exponential convergence towards a global equilibrium is shown for a simplified model. A numerical method is finally proposed to simulate the complete model. Also in another preprint (see arXiv :2201.05219), S. Billiard, Sylvain Billiard, Hélène Leman, Thomas Rey and Viet Chi Tran study a stochastic individual-based model of interacting plant and pollinator species through a bipartite graph : each species is a node of the graph, an edge representing interactions between a pair of species. The dynamics of the system depends on the between- and within-species interactions : pollination by insects increases plant reproduction rate but has a cost which can increase plant death rate, depending on pollinators density. Pollinators reproduction is increased by the resources harvested on plants. Each species is characterized by a trait corresponding to its degree of generalism. This trait determines the structure of the interactions graph and the quantity of resources exchanged between species. Our model includes in particular nested or modular networks. Deterministic approximations of the stochastic measure-valued process by systems of ordinary differential equations or integro-differential equations are established and studied, when the population is large or when the graph is dense and can be replaced with a graphon. The long-time behaviors of these limits are studied and central limit theorems are established to quantify the difference between the discrete stochastic individual-based model and the deterministic approximations. Finally, studying the continuous limits of the interaction network and the resulting PDEs, we show

that nested plant-pollinator communities are expected to collapse towards a coexistence between a single pair of species of plants and pollinators.

- Sophie Dabo (**LPP**) is well involved in the projet ONCOLille. The objective of the institute is to develop interdisciplinary research linking biology, physics, chemistry, mathematics, bioinformatics, economics, technologies for health, humanities and social sciences by developing fundamental research and strong translational/pre-clinical research (development of alternative and original study models) in order to move towards transfer to the clinic (clinical trials, new molecules). ONCOLille is supported by the University of Lille, Inserm, the CNRS, the Lille University Hospital, the Oscar Lambret Center CRCC, the Pasteur Institute of Lille (IPL), and the Lille Cancer Research Institute (IRCL), as well as strong support from the State, the Hauts-de-France region, the MEL (Lille European Metropolis) and the ERDF (European Regional Development Fund). ONCOLille researchers come from 7 laboratories (**CANTHER, PHYCELL, ONCOTHAI, LIMMS, SCALab, LPP, LEM**) covering all the disciplines of the institute. Note 2 laboratories associated with ONCOLille (**PRISM and UGSF**). The central research theme for all the ONCOLille teams is resistance to treatment and tumor dormancy. Note that Sophie Dabo is in charge of ONCOLille's mathematics team and is a member of the Institute's steering committee.
- A long-standing collaboration between PhLAM (M. Lefranc, L. Héliot) and Institut Pasteur de Lille (H. Duez, P. Lefevbre, B. Staels) studies how the liver biological clock synchronises to metabolic signals and to feeding-fasting cycles. The goal is to understanding how dysregulated food timing induces clock disruption and leads to metabolic diseases such obesity or type2-diabetes. First focused on modeling, this collaboration has extended to experiments on clock resetting in hepatocytes carried out at PhLAM with guidance from IPL.

3.4 Research highlights

3.4.1 Dynamics

This focus area is concerned with key problems of a mathematical and/or physical nature in which dynamics plays a key role. These problems may come from the development of innovative optical fibers for telecommunication links and high-power lasers, from the complex behaviour in cold atoms physics and non-linear optics, from statistical mecanics, from geometrical group theory, or from functional and complex analysis.

In [33] S. Keraani (Painlevé), V.D. Dinh (a CEMPI post-doc) and M. Majdoub study the focusing nonlinear Schrödinger equation with exponential nonlinearities. By using variational arguments, they derive invariant sets where the global existence and finite time blow-up occur. In particular, they obtain sharp thresholds for global existence and finite time blow-up.

In [32], J. Danciger, F. Guéritaud (LPP) and F. Kassel study right-angled Coxeter group Γ on k generators. They construct proper actions of Γ on $\mathcal{O}(p, q+1)$ by right-and-left multiplication and on the Lie algebra $\mathfrak{o}(p, q+1)$ by affine transformations, for some naturals p, q with $p+q+1 = k$. As a consequence, any virtually special group admits proper affine actions on some $\mathbb{R}^n$: this includes in particular surface groups, hyperbolic 3-manifold groups, and examples of word hyperbolic groups

of arbitrarily large virtual cohomological dimension. The geometrical group of LPP made also an important progress concerning a generalization of a classical inequality of A. Ancona to random walks on finitely generated groups. More precisely, in [14], L. Potyagailo (LPP), with I. Gekhtman, V. Gerasimov (invited professor by the CEMPI and ULille) and W. Yang proves an inequality that relates the Green metric with any Floyd function. This provides new results for Martin compactifications of relatively hyperbolic groups.

The main research activity of the group of complex geometry concerns the study of holomorphic dynamics in several complex variables. In the last years, Fabrizio Bianchi obtained major foundational results in two different main directions, bifurcation theory and thermodynamical formalism. In the first direction, he is among the founders of a general theory of stability and bifurcation valid in any dimension. The description of bifurcation phenomena occupies a prominent position in the world-level research in the field, and his research in particular exhibited striking differences with respect to the one-dimensional setting. In the second direction, he recently made a breakthrough in the theory by constructing a new, invariant functional space on which the transfer operator associated to Holder continuous (and even less regular) weights acts as a contraction, leading to a statistical understanding of equilibrium states well beyond the results of 30 years of previous research.

In [15], an important breakthrough has been made by S. Grivaux (LPP) and her co-authors in the famous *Invariant subspace problem*. In particular, given a Polish topology τ on $\mathcal{B}_1(X)$, the set of all contraction operators on $X = \ell_p$, $1 \leq p < \infty$ or $X = c_0$, they prove several results related to the following question : does a typical $T \in \mathcal{B}_1(X)$ in the Baire Category sense has a non-trivial invariant subspace ? In other words, is there a dense G_δ set $\mathcal{G} \subset (\mathcal{B}_1(X), \tau)$ such that every $T \in \mathcal{G}$ has a non–trivial invariant subspace. The group of functional analysis is also interested in classes of sequences of integers arising naturally in the study of problems relevant to harmonic analysis, geometry group theory, dynamical systems and number theory. More precisely, in [1], S. Grivaux, C. Badea (LPP) and E. Matheron (Université d'Artois) answered several open questions on three different classes of sequences of integers, namely rigidity sequences, Kazhdan sequences and nullpotent sequences.

Integrable turbulence arising in the Nonlinear Schrödinger Equation (NLSE) offers numerous outstanding challenges. In the strongly nonlinear regime, the decomposition of the dynamics in monochromatic waves (Fourier analysis) breaks, and new approaches are needed. The « Integrable Turbulence » group at PhLAM has contributed seminal advances to the soliton gas approach, where the turbulent signal is represented as a superposition of soliton waves that propagate without deformation, using the Inverse Scattering Transform. In the context of the ANR SOGOOD project gathering 4 experimental groups, they achieved the first controlled generation of a soliton gas in a one-dimensional water tank [43], using very recent tools from nonlinear spectral analysis. The experiments have in particular offered the possibility to measure for the first time the so-called density of states of the generated soliton gas. This quantity plays a central role in the kinetic theory of soliton gases and the results obtained pave the way to a validation of this theory. In [58], the same group showed with Russian colaborators how the so-called modulational instability of the NLSE can be captured in terms of soliton gases, providing additional support to the theory of soliton gases. Notably, this publication was co-signed by Vladimir Zhakharov, a world class mathematician and physicist, laureate of the Dirac medal for its outstanding contributions to the theory of turbulence.

The accelerator physics group at PhLAM has developed unique expertise in the nonlinear dynamics of electron bunches in synchrotron light sources, a difficult subject given the relativistic motion of the electrons. In particular they showed some years ago how powerful coherent THz radiation can be generated by an instability creating a spatial structure in the electron bunch. More recently, they developed a revolutionary ultrafast optical measurement technique allowing them to explore different phenomena in electron bunch dynamics and opther optical phenomena.

One outstanding achievement of the accelerator group in the 2019-2021 period has been to utilize tools and concepts from chaos control theory to demonstrate a clever feedback allowing them to overcome the nonlinear instability affecting the output intensity of the SOLEIL synchrotron facility and to widely extend the usable operating range of this very large instrument (building budget 277 M€) [55]. They also contributed to show that X-ray radiation with a wavelength as short as 6 nm can be generated from a free electron laser by operating it in the echo-enabled harmonic generation configuration [64].

The photonics group at PhLAM benefits from the FiberTech optical fiber manufacturing platform, a notable equipment in Europe, which allows them to design innovative optical fibers on demand. Its activity is developed in several areas : nonlinear photonics, optical fibers for telecommunications with spectral or spatial multiplexing, nonlinear endoscopes. In addition to interdisciplinary publications mentioned above (Sec. 3.3), one key achievement has been the observation of an « extraordinary » modulation instability in optics and. hydrodynamics [17]. In this work, they showed that nonlinear effects leads to a wider band of unstable frequencies than predicted from linear stability analysis. Interestingly, both this work and [43] involved both optics and hydrodynamics, an indication of the strong interdisciplinary character of CEMPI research.

Another notable fact regarding the photonics team is the renewal of the joint laboratory with Prysmian/Draka, the world leader in telecommunication cables and the obtention of a ANR contract on multimode photonics for telecommunication applications.

The Cold Atom Physics group at PhLAM has made significant progress towards the observation of novel quantum many-body effects in lattices of ultracold atoms. In particular, it reported in 2019 the engineering of a Floquet Hamiltonian simulator with well-controlled disorder [60], allowing them to explore new physical effects. In parallel, the group has developed in the last four years a new and complex experimental system aimed at creating atomic quantum gases with tunable interactions, in the goal of probing the interplay between many-body physics and disorder/topology effects. In 2021, the group has obtained the very first atomic Bose-Einstein condensate in Lille. The new experiment is innovative because it is one of the first entirely based on telecom fiber laser sources, a mature technology now applicable for fundamental scientific research.

The goal in the long run is to implement the concept of Quantum Simulators, namely to realize in the laboratory model quantum systems with highly controllable Hamiltonians, which will allow to a better understanding the behavior of other quantum systems, stemming in various fields of physics. The Quantum Simulators represent one of the pillars in the recent developments in the quantum technologies, which were put in the foreground of the national (“Plan Quantique Français”) and international (“European Quantum Flagship”) science agencies.

3.4.2 Topology and applications

This focus area is concerned with topological questions naturally arising in physics and in the application of homotopical methods in arithmetic and representation theory.

The experimental groups of PhLAM have made significant progress towards the observation of novel topological effects in lattices of ultracold atoms and photonic resonators.

The Floquet Hamiltonian simulator designed by the Cold Atoms group features [59] paves the way for studying robust topological phases in the time domain, thanks to its well controlled disorder. The recently obtained Bose-Einstein condensate with tunable interactions between Potassium atoms is a new playground for the study of nonlinear topological phases in the upcoming years.

Among the most important results of the topological photonics group at PhLAM, we can mention the measurement, for the first time, of the wave function of the lowest Landau level in a lattice of coupled photonic resonators subject to an artificial magnetic field, and the observation of associated topological edge states by A. Amo et al [40]. The group has also reported the direct measurement topological invariants in a photonic honeycomb lattice. Those results were obtained in lattices of polariton micropillars, whose properties are static. The group has now implemented a new set-up based on coupled fiber rings which simulate Hamiltonians whose properties change in time, opening the door to the exploration of Floquet topological phases. In the period 2019-2021, the topological photonics group at PhLAM has co-authored several reviews on different aspects of topological photonics [63, 44], and has co-organised one international conference on topological photonics and chaired two programs at CLEO/EQEC Europe on this topic. Their members have actively participated in the CEMPI work group on topology. A collaboration with Patrick Popescu-Pampu from the Paul Painlevé Laboratory has been initiated in 2021 on the study of topological invariants in physical systems.

The Geometry and Topology Group of the Painlevé Laboratory has been a place for sustained research thanks to the synergy created between the CEMPI and the ANR PRCI OCHoTop between the France and the Switzerland. Benoit Fresse has studied the spaces of embeddings of manifolds in a Euclidean space. The main result of this work is a combinatorial description of the rational homotopy of the connected components of these embedding spaces in terms of spaces of Maurer-Cartan elements in certain L-infinity algebras of graphs. Parallely with Lorenzo Guerra (postdoc of the OCHoTop ANR project in Lille) they have defined a model on cochain algebras of the p-complete homotopy type of operads in spaces. Alexis Virelizier has compared the 3-dimensional homotopic quantum field theories (HQFT) with aspherical target constructed via state sum and surgical methods : they are related via the center of monoidal categories graded by a group. Parallely with Kursat Sozer (postdoc of the OCHoTop ANR project in Lille) they have introduced the notion of a monoidal category graded by a crossed module and used such categories to construct 3-dimensional HQFTs with target a 2-type.

Others members of the group have been very active as well. Anoine Touzé and Aurélien Djament have made progress in the understanding in positive characteristic of the cohomology between representations of classical groups, by using classical homotopic results (such as Hurewicz theorems)

in the framework of functor categories. For instance, they compared the algebraic cohomology and the discrete cohomology of polynomial representations (generalizing to infinite perfect fields several fundamental results established for finite fields in the 1970s). Ivo Dell'Ambrogio has introduced the notion of a Mackey 2-functor (inspired by Grothendieck's derivation theory and the classical theory of Mackey functors). These 2-functors provide a general framework for studying equivariant phenomena in topology and geometry as well as in linear representation theory. One of the most striking application of this theory is a broad generalization of Green's correspondence.

Finally, the Arithmetic and Algebraic geometry Group has been in the spotlight during the thematic semester in 2019 and is currently leading the ANR PRCI projects GALF and SMAGP connecting France–Luxembourg–Canada and France–Russia, respectively. The topology of locally symmetric spaces play a pivotal role in Mladen Dimitrov's work on the p-adic aspects in the theory of automorphic forms, where the Betti cohomology of these real manifolds interacts with the totally disconnected aspects of the theory. A wide range of arithmetic applications include the description of the geometry of the p-adic eigencurve at classical weight one points [24] , the construction of p-adic L-functions for automorphic forms on GL_{2n} and study of their trivial zeros [4, 41]. Ralf Cluckers makes important breakthrough in the direction of 40-year-old Igusa's conjecture on exponential sums. In particular, he proves an upper bound on the log canonical threshold of a hypersurface that satisfies a certain power condition and use it to prove several generalizations of Igusa's conjecture, with the log canonical threshold in the exponent of the estimates. He shows that this covers optimally all situations of the conjectures for non-rational singularities by comparing the log canonical threshold with a local notion of the motivic oscillation index. Pierre Dèbes has been studying the arithmetic of covers of the line in connection with the Inverse Galois Problem and proved a polynomial analog for rings such as $\mathbb{Z}[X]$ or $\mathbb{F}_p[X, Y]$ of the famous Schinzel Hypothesis on prime numbers [25].

Finally, Valery Gritsenko constructed the first infinite family of antisymmetric paramodular forms of weight 3 and gave examples of such forms in weight 2 as Borcherds products whose first Fourier-Jacobi coefficient is a theta block [30]. As a corollary, he proved irrationality, i.e. non-negativity of Kodaira dimension, of the moduli spaces of Kummer surfaces associated to (1,t)-polarized abelian surfaces. The problem for the minimal Siegel modular threefolds was open since 1998. The constructed weight 2 paramodular form also supports the Brumer-Kramer conjecture (a 2-dimensional generalization of the Shimura–Taniyama–Weil conjecture on the modularity of elliptic curves).

3.4.3 Biology/Modelisation stochastic/Data science

In the Focus Area III (Biology/Stochastic modeling/Data Science), we mention three major contributions on the mathematical side. In the domain of stochastic modeling, David Dereudre, Adrien Hardy and Mylène Maïda have co-authored a paper [54] in the Communications of Pure and Applied Mathematics on the stochastic behavior of eigenvalues for a large class of Random Matrices. For a certain class of random matrices, the distribution of random eigenvalues follows the so called Sine-beta point process, which is also the universal point process arising as the thermodynamic limit of the microscopic scale behavior in the bulk of one-dimensional log-gases, or beta-ensembles,

at inverse temperature $\beta = 1/T > 0$. In this paper, a new approach has been driven using tools between probability theory and statistical physics. First they obtain a description of the process via the Dobrushin-Lanford-Ruelle (DLR) equations which are equations from statistical physics tuned to describe the classical equilibrium states for particle systems. Precisely they provide the local descriptions of the process in any bounded window given the process outside the window. Based on these DLR equations, they show that the sine-beta process is number-rigid and tolerant : The number, but not the position, of particles lying inside a bounded window is a deterministic function of the exterior configuration. This kind of rigidity for particle system has been recently detected and its investigations are very fashionable at the moment. This new approach developed in the paper is remarkable, recognized by the community as a very interesting new point of view.

In the domain of machine learning and data science, Benjamin Guedj has co-authored a paper [31] on PAC-bayesian theory at NeurIPS 2020 which was selected for an oral presentation (top 3%). Conditional Value at Risk (CVaR) is a family of "coherent risk measures" which generalize the traditional mathematical expectation. Widely used in mathematical finance, it is garnering increasing interest in machine learning, e.g., as an alternate approach to regularization, and as a means for ensuring fairness. In this paper the authors present a generalization bound for learning algorithms that minimize the CVaR of the empirical loss. The bound is of PAC-Bayesian type and is guaranteed to be small when the empirical CVaR is small. They achieve this by reducing the problem of estimating CVaR to that of merely estimating an expectation. As a by-product, they obtain concentration inequalities for CVaR even when the random variable in question is unbounded.

At PhLAM, studies at the interface between physics and biology have focused on how nonlinear dynamical phenomena are used by living cells to process biological information, to orchestrate important biological functions, and to take life-or-death decisions. In particular, a fundamental problem is to understand why death decision is so heterogeneous in response to the same stress. A theoretical study showed extensively how the nonlinear dynamics of signaling pathways implying feedback loops can amplify cellular noise and generate a probabilistic death response satisfying some power laws [39]. Other CEMPI researchers explored the link between fluctuations in protein concentrations within the cell and phenotypic heterogeneity [36]

A biologist colleague joined PhLAM in 2021 after been invited research professor at Ugent for 9 years, attracted by the local expertise in the complex cellular dynamics exploiting nonlinear dynamical effects such as bistability, oscillations and pulsing. He intends to develop a center of expertise in biosensing, harnessing the capacity to produce or engineer a modulation of a specific biochemical signaling dynamics (chemical, optogenetics, microfluidics), and to monitor it in real-time at the same single living cell level (biosensing) and to correlate to other measurements of cell behavior (cell phenotype, gene expression and transcription, protein expression).

4 Training

The training of mathematicians and physicists at the graduate and post-graduate level is also an important aspect of the activities of CEMPI. Four master's degrees are associated to the CEMPI : Master de Mathématiques, Master Mathématiques et Applications, Master de Physique and Mas-

ter Data Science. The CEMPI provides each year a number of fellowships to students enrolling in one of the following master's tracks : Parcours Recherche (Master de Mathématiques), High Performance Computing Simulations HPCS (Master Mathématiques et Applications), Optics, lasers and complex systems SCOL (Master de Physique).

We have already set up a system which foreshadowed the graduate programs of the I-SITE and which now fits well with the Graduate Program Information and Knowledge Society (GP IKS) forming a positive synergy with the CEMPI program. In particular, our CEMPI students participate to the inderdisciplinary activities proposed by the GP IKS and on the other hand, our scholarships complete the ones of the GP. We also propose some specific actions for our Master students : choice of a mentor among the CEMPI members but which does not belong to the pedagogical team of the Master so that the student can freely talk about the possible problems she/he could have ; organization of common activities, incitation to participate to our Painlevé colloquium by organizing a preparatory talk. It should be noted that, this year, several M2 CEMPI students attended to the first three colloquium given by Marie Théret, Gabreil Peyré and Andréas Hôring. Some mobility grants for participation to thematic schools (completing also the one proposed by the GP IKS) could be awarded.

Thanks to the scholarships, we succeed to attract each year between 5 and 8 students from abroad (mainly from foreign university : Lebanon, Morocco, Tunisia, India, Pakistan, China,....) This flow of very good students strengthens our Masters in Mathematics. Here are the flux of our three Master programs during the past fourth years, with the number of fellowships.

Year	Master Math.	CEMPI fellowships		HPCS	CEMPI fellowships		SCOL	CEMPI fellowships
2018–2019	39	2		14	1		34	1
2019-2020	22	4		21	1		36	1
2020–2021	25	4		19	1		27	1
2021–2022	40	11		30	1		39	2

Every year, CEMPI also provides a number of PhD fundings and post-doctoral positions. We would like to mention that the attractiveness of our Labex CEMPI, which contributes to the influence of the University of Lille, can also be measured in particular through the growing success of our Master scholarships and Post-doctoral position call. Over the past two years, we have gone from around thirty applications to around fifty applications for each call. Note that in 2021–2022, we decided to increase the number of Master's scholarships because we had some opportunities, first due to the increase in applications and also due to a release of the budget on the part of organization of conferences and invitation during two years due to the health crisis.

Concerning our doctoral program, each year, the CEMPI provides between two and three PhD grants (50%). These half-grants are completed mainly by funds from Région Hauts de France.

Number of Phd students at LPP and PhLAM

Year	PhD supported by CEMPI (at least 50%)	Number of CEMPI PhD defence
2019	9	6
2020	5	2
2021	6	0

As we can see in the following table, most of our CEMPI PhD students, after their defense, go for a post-doctoral position abroad or in France.

Future of students who have defended their PhD and who were funded by CEMPI

Year	Researcher in private companies	Post-doctoral position	Other
2019	1	4	1
2020	0	2	0

One of our former PhD student, Najib Idrissi, after a post-doc at ETH Zürich (2015–2018), obtained a Maître de conférence position at Institut de Mathématiques de Jussieu-Paris Rive Gauche and was awarded the **Cours Peccot** 2019-2020 of Collège de France for his work during his Phd.

Also, as examples, let us mention three success story (among several others) :

- After a post-doc CEMPI–FEDER position at LPP (with Stephan de Bièvre) in 2013–2015, Simona Rota Nodari obtained in 2015 a Maître de Conférence position (Assistant professor) at Université de Bourgogne (Dijon), and in 2021, she became Professor (Full professor) at Université Côte d'Azur (Nice)
- Nguyen Viet Dang, after a post-doc CEMPI at LPP in 2014–2015 (with Gabriel Rivière), became Maître de Conférence at Université Claude Bernard Lyon 1, before obtaining a position of Professor in 2021 at Sorbonne University (Institut Mathématique de Jussieu).
- Dimitrios Chatzakos had a CEMPI post-doc position at LPP in 2017-2019 and he obtained a position as Assistant Professor at University of Patras (Grece) in 2021.

Let us mention that we encourage our postdocs to postulate to a MSCA (Marie Skłodowska-Curie Actions) grant upon arrival. Beside boosting their career, this fellowship will allow them to stay for a third year. Both of the CEMPI post-doc arrived this year have submitted an application. Our labs have already some success in this sense since we have one MSCA postdoc, Paolo Aceto, arriving this year in the domain of geometry. His project is to use techniques of four-dimensional topology for studying deformations of complex surface singularities.

To finish this section, let us point out that we had some difficulties with parity in our recruitment of post-doc and Master's students. You will find below the two tables giving the figures.

Proportion of female applications and post-doc recruitments

Year	Number of applications	Number of female applications	Number of Post-doctoral offers	Number of female recruited
2020	37	4	2	1
2021	66	10	3	1
2022	43	5	2	0

Proportion of female Masters applications

Year	Number of applications	Number of female applications	Number of masters scholarships	Number of female granted
2020	32	10	5	2
2021	53	11	13	1
2022	40	7	7	2

We try to make our recruitment committees aware of societal biases and we ask them to be aware of this issue of parity when recruiting, but we probably should do better.

5 Valorization

Besides publications in refereed journals, it is important that knowledge is synthetized in reference monographs and diffused to the general public. In collaboration with Springer, CEMPI launched the CEMPI subseries of Lecture Notes In Mathematics/Physics. Three volumes were already published in 2015, 2017 and 2019. A fourth one "Homotopie réelle des espaces de configurations", based on the above mentioned Cours Peccot of Najib Idrissi, will appear in 2022.

Patrick Popescu-Pampu gave on 17 March 2021 a talk about a ground-breaking paper of the great mathematician and philosopher René Thom at the outreach cycle of conferences "Un texte, un mathématicien" organized at the Bibliothèque Nationale de France in Paris. On 25 February 2020 he gave a talk about the mathematics of the Mercator projection at the outreach cycle of conferences "5 à 7 de l'Académie des sciences" in Paris.

Industrial collaborations with contracts ranging from a few k€ to several 100k€ [1] have been carried out over the period 2019 2021. The valorization proceeds mostly through the funding by Europe, ANR or BPI France of joint projects between academic and industrial partners. A recent example is an agreement with CEA LIST including a collaboration with Safran (the world's second largest aeronautical equipment manufacturer), where research and development of optical fibers and specialty coatings are carried out for sensor applications in harsh environments for integration into aircraft engines : PhLAM receives 35k€/year and two theses are currently funded. Industrial interactions exist in many areas, as photonics is a discipline diffusing in many fields, for example : Prysmian (Telecom), Andra (Nuclear), CEA Cesta (power lasers), Cea List (sensors), Leukos (laser source), Genes Diffusion (biophotonics), Adelis Tech (biohotonics), ONERA (frequency comb for spectroscopy), Saint Gobain (new materials), Lightcore Technologies (endoscopes), IXblue (dosimetry), Cailabs (Telecom), Nokia (telecom), Laserspec (sensors), etc. for a total (including funded theses) over the 2019/2021 period of 1.9 M€.

The Joint LIFT laboratory works on the design of new telecommmunication optical fibers for transmission with Prysmian, world leader in the production of telecommunication cables. Research is done on the design, production, and characterization of optical fibers for transport and amplification, to increase network throughput using a spatial multiplexing approach (multimode/multicore). Two theses are in progress (including 1 co-financed by Prysmian) and 15k€/year are brought by Prysmian. This opens opportunities in industry for doctoral students, as shown by 3 recruitments of doctoral students by our partner over 2 years. This collaborative work increases the visibility of our work in major conferences in the field, makes it possible to direct research on questions of application interest. This joint laboratory is also supported by the Haut de France region (52.5k€/year).

The joint SYLFE laboratory is a partnership with CEA CESTA which operates the MegaJoule laser, one of the two most powerful facilities for laser-ignited fusion in the world. Research is carried out on parametric fibered amplification of high-energy femtosecond pulses using specialty fibers as well as on fully fibered oscillators of the Mamyshev type in the context of the PETAL line of the MegaJoule Laser (four funded theses including two in progress)

Created in July 2019, Lightcore Technologies is a spin-off of Institut Fresnel, XLIM and PhLAM,

1. See https ://fibertech.univ-lille.fr/fr

devoted to cutting-edge nonlinear optical imaging for biomedical and scientific applications. Lightcore Technologies provides photonic-based multimodal imaging and analysis solutions for research, life sciences and medical applications. Technologies developed include multiphoton microscopes and flexible endoscopes for fluorescence and label-free imaging, such as second harmonic generation (SHG) and coherent Raman processes (CARS and SRS). This makes advanced multimodal imaging available in a compact, easy-to-use, and affordable package, without need for an optical table or specially equipped laboratory environment, and without requiring installation or alignment by qualified personnel. A patent from the PhLAM is being exploited. A joint laboratory is being finalized and a research engineer from Lightcore has been put to PhLAM full-time since the end of 2021 [2].

In the context of the Nanobubbles ERC project led by Kevin Braeckmans (professor at UGent and long-term invited professor at ULille), a patent was filed : *Method and device to provide a microfluidic flow*, K. Braeckmans, R. Xiong, M. Layachi, A. Treizebre, F. Anquez, Q. Thommen, E. Courtade, WO/2020/221883 (2021). The overall objective of the Nanobubbles project was to design efficient ways to achieve high-throughput photoporation (i.e., the fact of permeating the cellular membrane by optical means to introduce genetic material or drugs). A spin-off is currently being created at Ugent to develop high-efficiency photoporation platforms utilising this patent, which is to be licensed to the spin-off.

6 CEMPI budget. Leverage effect

CEMPI funding for the period 2020–2024 is 578 704€ each year, without overhead costs (363 036€ from the PIA/ANR and 215 667€ from the I-ISITE ULNE). For the period 2020–2021, the following table gives the repartition of the expenses :

Year	2020	2021	Total
Salaries	140 297€	407 903€	548 200€
Equipment	54 100€	109 247€	163 347€
Operating costs	28 502€	155 495€	183 997€
Total	222 899€	672 645 €	895 544€

As one can see, the cost are distributed as follows : 61,3 % : salaries (invited professors, postdocs, doctoral students) ; 18,2 % : equipment and consumables ; 20,5 % : Master fellowships, organization of and participation in conferences and other operating costs. Another observation is the rise in power which can be explained first by the fact that 2020 was the first year of the new project and also by the fact that 2020 was strongly impacted by the coronavirus crisis which has prevented us from carrying out many actions. Nevertheless, we already used 895 544€ in two years, which represents 34% of the total budget.

The leverage effect of CEMPI funding manifests itself principally in two ways. First, CEMPI supports preliminary work on promising subjects, allowing our researchers to apply successfully

2. Find out more at https ://lightcore.tech/

for more significant grants from ANR, the European H2020 programme (EURAD EUropean joint program on RADioactive waste management), and now the ISITE ULNE project, thus pushing the CEMPI project further. Second, CEMPI is also a quality label that creates trust in our research and excellence, allows us to obtain more PhD grants and facilitates structural investment from institutions such as through the CPER project WaveTech at Hauts-de-France, Ondes et Matières pour le « Deep Tech », funded by Région Hauts-de-France, French government and EU (26,62 M€over 2021-2027), which follows the CPER project P4S Photonics for Society (2015–2021). Additionally, the increased reactivity makes it easier to engage in industrial contracts. The leverage effect is clearly demonstrated by the following tables over the period 2019–2021.

The leverage effect in 2019.

Type of projects	Number of projects	Total budget €
ANR	16	2 005 907
EU	7	120 056
Industry	6	312 173
Region (hors CEPR)	2	256 900
IUF	1	15 000
CNRS (Momentum,...)	3	124 644
CPER	1	874 909

Total : 3 759 591€

The leverage effect in 2020.

Type of projects	Number of projects	Total budget €
ANR	12	723 401
EU	9	1 596 292
Industry	4	638 953
Region (hors CEPR)	1	46 000
IUF	1	11 250
CNRS (Momentum,...)	1	60 000
CPER	1	1 347 708

Total : 4 423 604€

The leverage effect in 2021.

Type of projects	Number of projects	Total budget €
ANR	36	1 465 967
EU	10	845 931
Industry	6	85 083
Region (hors CEPR)	4	96 946
CNRS (Momentum,...)	3	11 400
CPER	2	1 402 476

Total : 3 970 803€

Annexe :

Here is a list of selected CEMPI publications (2019–2021).

Références

[1] Badea C., Grivaux S., Matheron E. *Rigidity sequences, Kazhdan sets and group topologies on the integers*, J. Anal. Math. 143 (2021), no. 1, 313–347.

[2] Balmer, Paul ; Dell'Ambrogio, Ivo. *Green equivalences in equivariant mathematics*. Math. Ann. 379 (2021), no. 3-4, 1315–1342.

[3] Bardenet R. and Hardy A. *Time-frequency transforms of white noises and Gaussian analytic functions*. Appl. Comput. Harmon. Anal. 50 (2021), 73–104.

[4] D. Barrera, M. Dimitrov and A. Jorza, *p-adic L-functions for nearly finite slope Hilbert modular forms and exceptional zero conjectures*, J. Eur. Math. Soc., DOI 10.4171/JEMS/1165 (2021).

[5] Benedetti, Vladimiro ; Manivel, Laurent ; Tanturri, Fabio. *The geometry of the Coble cubic and orbital degeneracy loci*. Math. Ann. 379 (2021), no. 1-2, 415–440.

[6] Cluckers, Raf ; Halupczok, Immanuel. *A p-adic variant of Kontsevich-Zagier integral operation rules and of Hrushovski-Kazhdan style motivic integration*. J. Reine Angew. Math. 779 (2021), 105–121.

[7] Colmez, Pierre ; Dospinescu, Gabriel ; Hauseux, Julien. *Nizioł, Wiesława p-adic étale cohomology of period domains*. Math. Ann. 381 (2021), no. 1-2, 105–180.

[8] Coupier, D., Saha, K., Sarkar, A., Tran, V.C. *The 2d-directed spanning forest converges to the Brownian web.*, Ann. Probab. 49 (2021), no. 1, 435–484.

[9] Daoudi M., Otberdout N., Alvarez Paiva J.C. *Metric Learning on the Manifold of Oriented Ellipses : Application to Facial Expression Recognition*. In book : Pattern Recognition. ICPR International Workshops and Challenges, 2021.

[10] Dang, N.V., Rivière, G. *Pollicott-Ruelle spectrum and Witten Laplacians.*, J. Eur. Math. Soc. (JEMS), 23 (2021), no.6, 1797–1857.

[11] Darné, Jacques. *On the Andreadakis problem for subgroups of IA_n*. Int. Math. Res. Not. IMRN 2021, no. 19, 14720–14742. 20E36 (20E05 20F36).

[12] Dereudre, D., Hardy, A., Leblé, T., Maïda, M., *DLR equations and rigidity for the sine-beta process*, Comm. Pure Appl. Math. 74 (2021), no. 1, 172–222.

[13] Dujardin, G and Armaroli, A and Nodari, Simona Rota and Mussot, A and Kudlinski, A and Trillo, S and Conforti, M and De Bièvre, Stephan. *Modulational instability in optical fibers with randomly-kicked normal dispersion*, Physical Review A., vol. 103, no. 5, 2021.

[14] Gekhtman Ilya, Gerasimov, V., Potyagailo, L., Yang, W., *Martin boundary covers Floyd boundary*, Invent. Math. 223 (2021), no. 2, 759–809.

[15] Grivaux S., Matheron E., Menet Q. *Does a typical ℓ_p-space contraction have a non–trivial invariant subspace ?* Trans. Amer. Math. Soc., 374, no. 10, 7359–7410, 2021.

[16] Grivaux S., Matheron E., Menet Q. *Linear dynamical systems on Hilbert spaces : typical properties and explicit examples*. Mem. Amer. Math. Soc. 269 (2021), no. 1315, v+147pp.

[17] Guillaume Vanderhaegen, Corentin Naveau, Pascal Szriftgiser, Alexandre Kudlinski, Matteo Conforti, Arnaud Mussot, Miguel Onorato, Stefano Trillo, Amin Chabchoub, and Nail Akhmediev, *« Extraordinary » modulation instability in optics and hydrodynamics*, PNAS 118, e2019348118 (2021)

[18] B. Ponsioen et al., *Quantifying single-cell ERK dynamics in colorectal cancer organoids reveals EGFR as an amplifier of oncogenic MAPK pathway signaling*, Nature Cell Biology, 23, 277 (2021).

[19] Touzé, Antoine. *On the structure of graded commutative exponential functors*. Int. Math. Res. Not. IMRN 2021, no. 17, 13305–13415.

[20] Antei, Marco and Emsalem, Michel and Gasbarri, Carlo. *Erratum for « Heights of vector bundles and the fundamental group scheme of a curve*. Duke Math. J. 169 (16), 3221–3222, 2020.

[21] Badea, Catalin ; Grivaux, Sophie ; Devinck, Vincent. *Escaping a neighborhood along a prescribed sequence in Lie groups and Banach algebras*. Canad. Math. Bull. 63 (2020), no. 3, 484–505.

[22] Bardenet R. and Hardy A. *Monte Carlo with determinantal point processes*. Ann. Appl. Probab. 30 (2020), no.1, 368–417.

[23] Benedetti, Vladimiro ; Filippini, Sara Angela ; Manivel, Laurent ; Tanturri, Fabio. *Orbital degeneracy loci II : Gorenstein orbits*. Int. Math. Res. Not. IMRN 2020, no. 24, 9887–9932.

[24] A. Betina, M. Dimitrov and A. Pozzi, *On the failure of Gorensteinness at weight* 1 *Eisenstein points of the eigencurve*, Amer. J. Math., 144 (2022), 227–265.

[25] A. Bodin, P. Dèbes and S. Najib, *The Schinzel hypothesis for polynomials*, Transactions A.M.S., 373/12 (2020), pp. 8339–8364.

[26] Cancès, C. and Gaudeul, B. *A convergent entropy diminishing finite volume scheme for a cross-diffusion system*. SIAM J. Numer. Anal. 58(5), 2684–2710, 2020.

[27] Cancès, C., Chainais-Hillairet, C., Herda, M. and Krell, S. *Large time behavior of nonlinear finite volume schemes for convection-diffusion equations*. SIAM J. Numer. Anal. 58 (5), 2544–2571, 2020.

[28] Daoudi M., Alvarez Paiva J.C. and Kacem A. *The Riemannian and Affine Geometry of Facial Expression and Action Recognition*. In : Handbook of Variational Methods for Nonlinear Geometric Data. Springer 2020.

[29] Desprès, B. and Herda, M. *Computation of sum of squares polynomials from data points*. SIAM J. Numer. Anal. 58(3), 1719–1743. 2020.

[30] V. Gritsenko, C. Poor, D. S. Yuen, *Antisymmetric Paramodular Forms of Weights 2 and 3*, International Mathematics Research Notices 20 (2020), pp. 6926–6946.

[31] Benjamin Guedj, Zakaria Mhammedi, Robert C. Williamson. *P*AC-Bayesian Bound for the Conditional Value at Risk, Neural Information Processing Systems, 2020.

[32] Danciger, J., Guéritaud, F. and Kassel, F. *Proper affine actions for right-angled Coxeter groups*. Duke Math. J. 169(12), 2231–2280, 2020.

[33] Dinh, Van Duong ; Keraani, Sahbi ; Majdoub, Mohamed. *Long time dynamics for the focusing nonlinear Schrödinger equation with exponential nonlinearities*. Dyn. Partial Differ. Equ. 17 (2020), no. 4, 329–360.

[34] Fresse, B. and Willwacher, T. *The intrinsic formality of E_n-operads*. J. Eur. Math. Soc. (JEMS), 22(7), 2047–2133, 2020.

[35] Gritsenko, Valery ; Poor, Cris ; Yuen, David S. *Antisymmetric paramodular forms of weights 2 and 3*. Int. Math. Res. Not. IMRN 2020, no. 20, 6926–6946.

[36] Protein level variability determines phenotypic heterogeneity in proteotoxic stress response, Guilbert, M., Anquez, F., Pruvost, A., Thommen, Q. and Courtade, E., FEBS J. doi :10.1111/febs.15297 (2020).

[37] Hertz, Anaelle and Cerf, Nicolas J. and De Bièvre, Stephan. *Relating the entanglement and optical nonclassicality of multimode states of a bosonic quantum field*. Phys. Rev. A, vol. 102, no. 3, 2020.

[38] Hertz, Anaelle and De Bièvre, Stephan. *Quadrature Coherence Scale Driven Fast Decoherence of Bosonic Quantum Field States*. Phys. Rev. Lett., vol. 124, no. 9, 2020.

[39] Hurbain, J., Labavić, D., Thommen, Q., Pfeuty B. Theoretical study of the impact of adaptation on cell-fate heterogeneity and fractional killing. Sci Rep 10, 17429 (2020).

[40] O. Jamadi, E. Rozas, G. Salerno, M. Milićević, T. Ozawa, I. Sagnes, A. Lemaître, L. Le Gratiet, A. Harouri, I. Carusotto, J. Bloch, and A. Amo, *Direct Observation of Photonic Landau Levels and Helical Edge States in Strained Honeycomb Lattices*, Light : Science & Applications 9, 144 (2020).

[41] F. Januszewski, , M. Dimitrov and A.Raghuram, *L-functions of $GL(2n)$: p-adic properties and nonvanishing of twists*, Compositio Math. 156 (2020), 2437–2468.

[42] Lellouch, Samuel and Rançon, Adam and De Bièvre, Stephan and Delande, Dominique and Garreau, Jean Claude. *Dynamics of the mean-field-interacting quantum kicked rotor*. Phys. Rev. A, vol 101, no. 4, 2020.

[43] Suret P, Tikan A., Bonnefoy, F., Copie F, Ducrozet G, Gelash A., Prabhudesai G., Michel G., Cazaubiel A., Falcon E., El, G. and Randoux S. *Nonlinear Spectral Synthesis of Soliton Gas in Deep-Water Surface Gravity Waves.* Phys. Rev. Lett. 124, 264101 (2020).

[44] Y. Ota, K. Takata, T. Ozawa, A. Amo, Z. Jia, B. Kante, M. Notomi, Y. Arakawa, and S. Iwamoto, *Active Topological Photonics*, Nanophotonics 9, 547 (2020).

[45] Bardenet R., Chainais P., Flamant J. and Hardy A. *A correspondence between zeros of time-frequency transforms and Gaussian analytic functions* . 13th International Conference on Sampling Theory and Applications, SampTA, 2019,

[46] Beltràn, C. and Hardy, A. Energy of the Coulomb gas on the sphere at low temperature. Arch. Ration. Mech. Anal. 231(3), 2007–2017, 2019.

[47] Bianchi, Fabrizio. *Misiurewicz parameters and dynamical stability of polynomial-like maps of large topological degree*. Mathematische Annalen, Springer Verlag, 2019, 373 (3-4), pp.901-928.

[48] Bianchi, Fabrizio. *Parabolic implosion for endomorphisms of $\mathbb{C}^2$*. Journal of the European Mathematical Society, European Mathematical Society, 2019, 21 (12), pp.3709-3737.

[49] Bresch, Didier and Gisclon, Marguerite and Lacroix-Violet, I. *On Navier-Stokes-Korteweg and Euler-Korteweg systems : application to quantum fluids models*. Arch. Ration. Mech. Anal. 233(3), 975–1025, 2019.

[50] Cancès, C. and Matthes, D. and Nabet, F. *A two-phase two-fluxes degenerate Cahn-Hilliard model as constrained Wasserstein gradient flow*. Arch. Ration. Mech. Anal. 233(2), 837–866. 2019.

[51] Cluckers, R., Mustata, M. and Nguyen, K.H. *Igusa's conjecture for exponential sums : optimal estimates for nonrational singularities*. Forum Math. Pi. 7, 3–28, 2019.

[52] De Bièvre, Stephan and Horoshko, Dmitri B. and Patera, Giuseppe and Kolobov, Mikhail I. *Measuring Nonclassicality of Bosonic Field Quantum States via Operator Ordering Sensitivity*. Phys. Rev. Lett., vol. 122, no 8, 2019.

[53] Dereudre, David. *Introduction to the theory of Gibbs point processes. Stochastic geometry*, 181–229, Lecture Notes in Math., 2237, Springer, Cham, 2019.

[54] Fernez N., Burgnies L., Dereudre D., Lippens D. and Lheurette E., *Poisson distributions in disordered metamaterials absorbers*, Journal of Applied Physics 125, 2019.

[55] Evain, C., Szwaj, C., Roussel, E. et al. Stable coherent terahertz synchrotron radiation from controlled relativistic electron bunches. Nature Physics 15, 635–639 (2019).

[56] Alessandro Furlan, Marine Jacquier, Aurore Woller, +3, Laurent Héliot, Hélène Duez, Bart Staels, and Marc Lefranc, Mathematical models converge on PGC1α as the key metabolic integrator of SIRT1 and AMPK regulation of the circadian clock, PNAS 116 13171 (2019).

[57] García Barroso ; Evelia ; González Pérez, Pedro ; Popescu-Pampu, Patrick ; Ruggiero, Matteo. *Ultrametric properties for valuation spaces of normal surface singularities*. Trans. Amer. Math. Soc. 372 No. 12 (2019), 8423–8475.

[58] Andrey Gelash, Dmitry Agafontsev, Vladimir Zakharov, Gennady El, Stéphane Randoux, and Pierre Suret, Bound State Soliton Gas Dynamics Underlying the Spontaneous Modulational Instability, Phys. Rev. Lett. 123, 234102 (2019).

[59] C. Hainaut, A. Rançon, J.-F. Clément, I. Manai, P. Szriftgiser, D. Delande, J. C. Garreau, and R. Chicireanu, *Experimental Realization of an Ideal Floquet Disordered System*, New J. Phys. 21, 035008 (2019).

[60] C. Hainaut, A. Rançon, J.-F. Clément, I. Manai, P. Szriftgiser, D. Delande, J. C. Garreau, and R. Chicireanu, Experimental Realization of an Ideal Floquet Disordered System, New J. Phys. 21, 035008 (2019).

[61] Horoshko, D. B. and De Bièvre, S. and Patera, G. and Kolobov, M. I. *Thermal-difference states of light : Quantum states of heralded photons*, Phys. Rev. A., vol 100., no 5, 2019.

[62] Idrissi, Najib. *The Lambrechts–Stanley model of configuration spaces*, Inventiones mathematicae, 216, 1–68 (2019).

[63] T. Ozawa, H. M. Price, A. Amo, N. Goldman, M. Hafezi, L. Lu, M. C. Rechtsman, D. Schuster, J. Simon, O. Zilberberg, and I. Carusotto, *Topological Photonics*, Reviews of Modern Physics 91, 15006 (2019).

[64] Rebernik Ribič, P., Abrami, A., Badano, L. et al. Coherent soft X-ray pulses from an echo-enabled harmonic generation free-electron laser. Nature Photonics 13, 555–561 (2019).

[65] Szczapa B., Daoudi M., Kacem A., Guerreschi P., Gebert L. and Alvarez Paiva J.C. *2D Landmark-Based Facial Asymmetry Assessment in the Clinical Case of Facial Paralysis*. 14th IEEE International Conference on Automatic Face & Gesture Recognition, 2019.