Department of Research Evaluation

RESEARCH UNIT SELF-ASSESSMENT DOCUMENT

2024-2025 EVALUATION CAMPAIGN
GROUP E

September 2023

1-GENERAL INFORMATION FOR THE CURRENT CONTRACT

1- Unit Identification

Unit name: **Laboratoire de Physique Théorique et Modèles Statistiques**

Acronym: **LPTMS**

Label and number: **UMR 8626**

Main scientific field:

ST: Science and Technology

Scientific panels (in the Hcéres classification) by descending order of importance:

Panel 1
ST2: Physics

Panel 2
ST2: Physics

Panel 3
ST2: Physics

Panel 4
ST2: Physics

Executive team:

Director: Alberto ROSSO (DR CNRS)

Administrator: Claudine LE VAOU (IE CNRS)

List of the research unit's supervisory institutions and bodies:

- Université Paris-Saclay
- CNRS

Doctoral schools of affiliation:

ED564, Physique en Île de-France

2- Presentation of the unit

History, location of the unit

The Laboratory of Theoretical Physics and Statistical Models UMR 8626 CNRS Université Paris-Saclay was created on January 1st, 1998, with the aim of developing new research themes in statistical physics and condensed matter theory. After A. Comtet's tenure from 1998 to 2002, S. Ouvry served as director from 2002 to 2009, followed by M. Mézard from January 2010 to April 2012. E. Trizac then took over from April 2012 until December 2021. A. Rosso has been the director since January 1st, 2022.

Initially, the LPTMS focused primarily on quantum chaos, quantum fluids and low dimensional systems. However, the composition of the laboratory and its areas of activity have expanded significantly over time. Today, the research themes of the laboratory span from integrability to biology. The laboratory is currently organised into three teams: "Quantum Systems," "Statistical Physics, Field Theory, and Integrable Systems," and "Disordered Systems, Soft Matter, and Interface Physics." While this division does not have administrative or financial implications, it offers a convenient framework for presenting our activities.

At the beginning of the evaluation period, the LPTMS was still located on the second floor of building 100 in the valley of the campus. Since 2019, we have moved to the plateau in the new building 530, alongside FAST and IPa. The details of this move will be presented below. The new location offers ample space and comfort, although connectivity with Paris remains a weak point that we hope will improve soon.

Structure of the unit

The LPTMS is a joint research unit (UMR) affiliated with both the CNRS and the University Paris-Saclay. We are supervised by the CNRS Physics and the Faculté des Sciences d'Orsay. All of our PhD students are registered with the Doctoral School ED564 "Physique en Ile de France".

The management team of LPTMS comprises the director, Alberto Rosso, and the administrator, Claudine Le Vaou. Additionally, the administrative team consists of Claudine Le Vaou as administrator and Delphine Hannoy as administrative assistant. Zhiqiang Qin plays a crucial role in providing technical support, overseeing the management of informatics and computational resources.

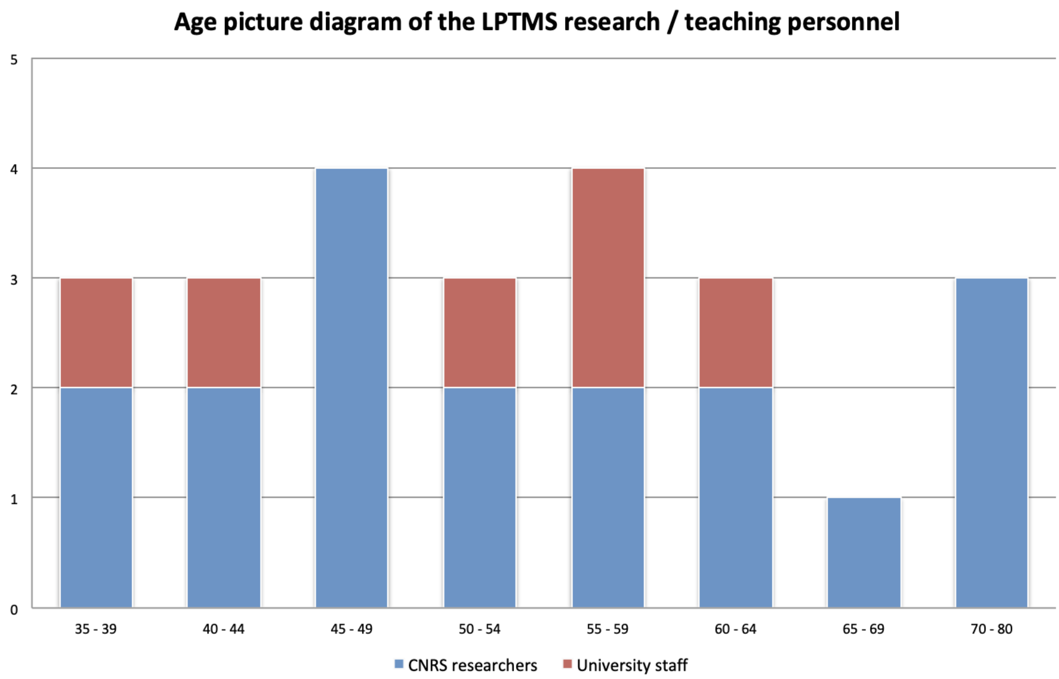
In preparation for the forthcoming HCERES evaluation, the members of LPTMS have endorsed the continuation of A. Rosso as director for the first part of the upcoming contract period spanning from 2026 to 2030.

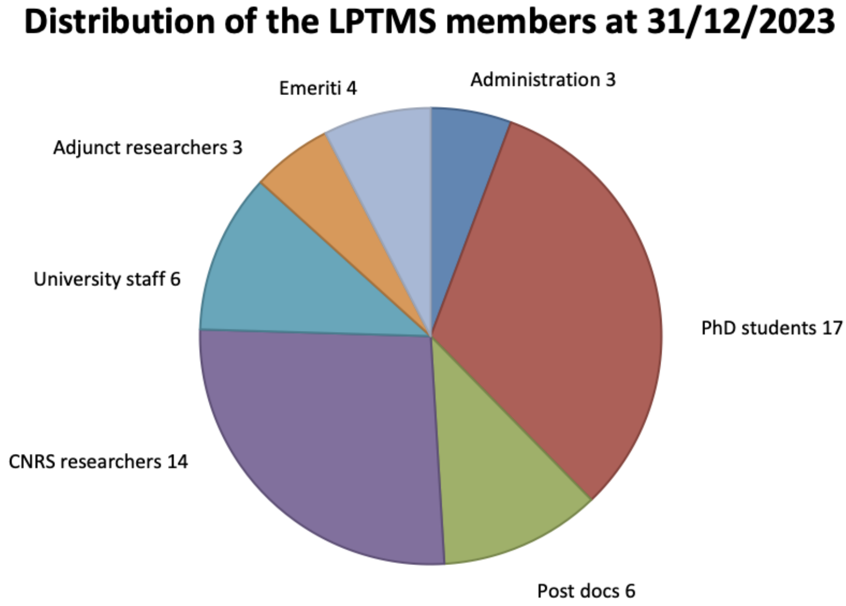
We typically organise the research conducted at LPTMS into three teams corresponding to distinct fields within low-energy physics:

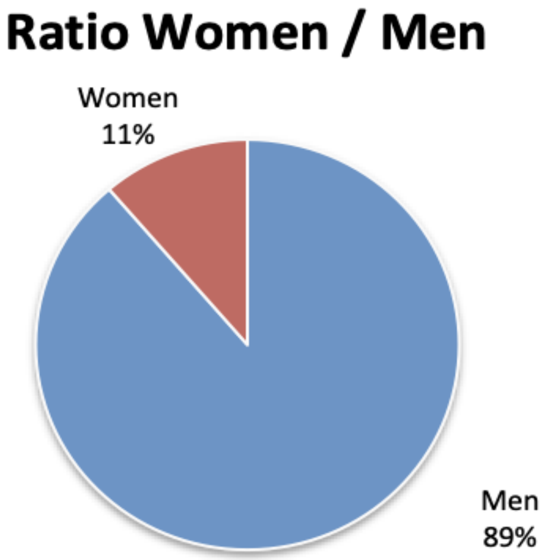
1. Quantum Systems (team leader: N. Pavloff)
2. Statistical Physics, field theory and integrable systems (team leader: Ch. Texier)
3. Disordered systems, soft matter and physics at the interfaces (team leader: S. Franz)

It's important to note that this division isn't strictly delineated into separate groups, as there is significant collaboration among members across different topics.

The management team receives support from a laboratory board, which includes elected members (V. Ros, R. Santachiara, V. Terras, M. Biroli), the three team leaders (S. Franz, N. Pavloff, and Ch. Texier), and a nominated member (S.N. Majumdar). This board meets around three times a year. Important decisions like hiring, research plans, and overall lab activities are discussed in the general assembly (AG), which also meets about three times a year.

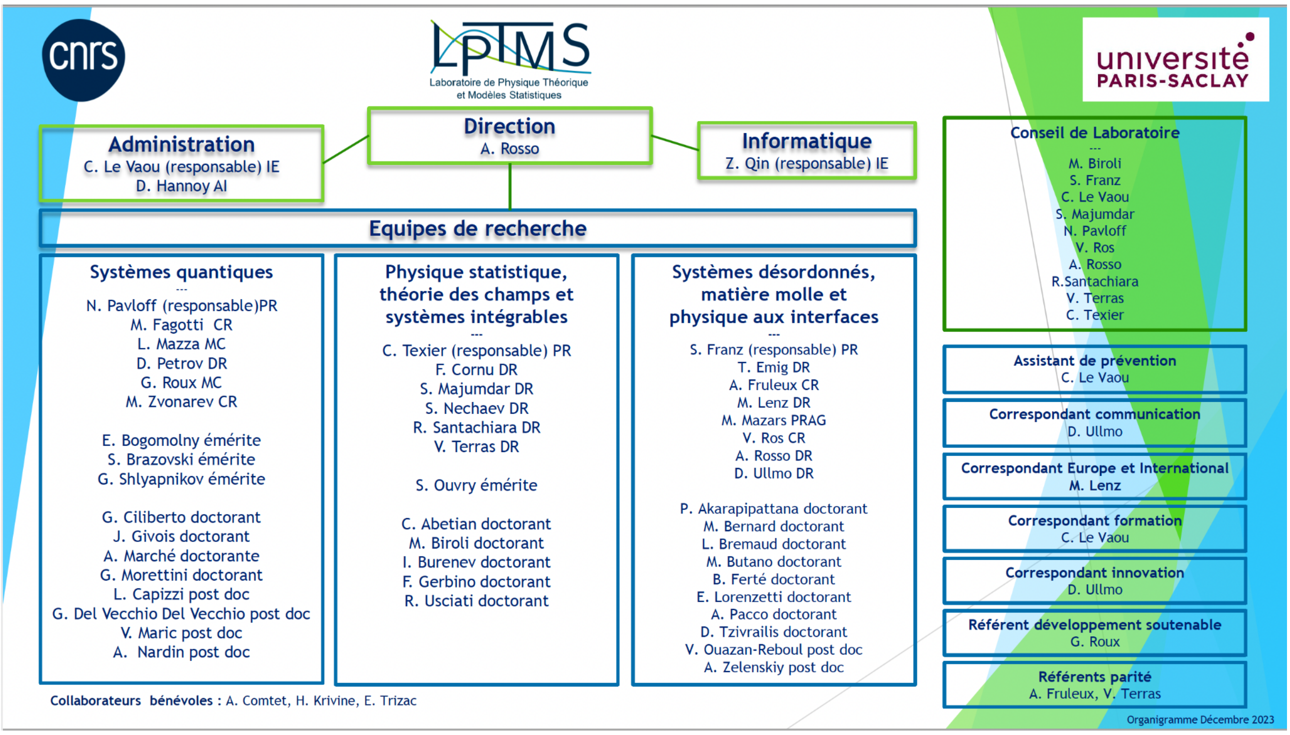






Size and composition of the laboratory at 12/31/2023

At the end of 2023, LPTMS had a total of 23 permanent members, including 2 in administrative roles, 1 in the IT service, and 20 in research positions. The administrative and IT services consist entirely of CNRS employees: two at the IE level and one at the AI level. The researchers are distributed as follows: 14 CNRS permanent researchers (4 CR and 10 DR), 6 teaching-research positions from Paris-Saclay (1 PRAG, 2 MDC, and 3 Prof), 4 emeritus researchers from CNRS, and 3 volunteers from Paris-Saclay. Additionally, O. Giraud (CNRS, DR), temporarily affiliated with Majulab in Singapore, is expected to join the lab in 2025. More than half of our members are non permanents. As of the end of 2023, we had 6 post-docs and 17 PhD students (3 of them in co-supervision with other labs in the Paris area).



Between 2018 and 2023, the total number of permanent members at LPTMS increased by two members. However, during the same time, we saw significant changes and reorganisation in our laboratory.

On the administrative side, K. Kolodziej, who split her time evenly between LPTMS and the Institute Pascal in 2018, transitioned to full-time work at LPTMS in 2020, and later moved to DR4 in April 2023. In October 2023, D. Hannoy relocated from DR4 to LPTMS.

On the research side the LPTMS underwent four hirings:

1. Maurizio Fagotti (2018, CNRS)
2. Leonardo Mazza (2018, MdC)
3. Valentina Ros (2020, CNRS)
4. Antoine Fruleux (2021, CNRS)

Additionally, there were four departures :

1. Thierry Jolicoeur moved to IPhT in 2019.
2. Stephane Ouvry retired in 2023 and now holds the status of emeritus.
3. Grégory Schehr transferred to LPTHE in 2021. He currently holds the status of a permanent visitor and attends once a week.
4. Emmanuel Trizac assumed the presidency of ENS Lyon in 2023. Currently, he volunteers at LPTMS and attends once every two weeks.

In addition to these changes, two new members joined LPTMS from IJCLab:

1. F. Cornu (2019), who holds a DR position from CNRS.
2. M. Mazars (2020), who is a PRAG from Université Paris-Saclay.

Furthermore, S. Nechaev, who was on mobility to the Poncelet, returned to LPTMS in 2022. Additionally, O. Giraud is formally a member of the Majulab in Singapore until 2025.

The situation presents a mixed picture. While LPTMS successfully attracted and retained young and talented researchers, there's also been a loss of some of our leading researchers. It's crucial for us to address this loss and strive to fill the gap in our research team in the near future.

3- Scientific subjects and their implications

In this section, we outline the research themes pursued by LPTMS. To enhance clarity, the presentation of themes is organized team by team, with a focus on inter-team and intra-team collaboration. A synthetic table lists:

1. Members of the team: Permanent members as of 31/12/23 followed by non-permanent members during the evaluation period.
2. LPTMS alumni recruited in academia during the evaluation period, starting with our PhD laureates followed by our postdocs.
3. Number of publications within the team and multiteam publications.
4. List of grants obtained.

Quantum Systems

Members	Alumni in Academics	Publications	Grants
3 CNRS (2 CR, 1DR) 3 UPSaclay (2 MdC,1 PR) 3 Emeriti 14 Post Docs 12 PhD Students 10 Master Students	R. Dubertrand (Northumbria 2019) T. Congy (Northumbria 2020) P.E. Larré (CNRS 2021) A. Biella (CNR Italy 2022) G. Martone (CNR Italy 2023)	157 Publications 5 multi team 22 Phys Rev Lett. 9 high impact	2293 Keuro 2 ERC 6 ANR 1 PEPR 3 SIRTEQ 2 Quantip 1 Joint PhD program 1 IUF 1 IRP 1 LIA 1 PICS 7 PIA projects

This team is composed of the researchers Maurizio Fagotti (CR-CNRS), Leonardo Mazza (MdC-Paris Saclay), Nicolas Pavloff (Prof-Paris Saclay), Dmitry Petrov (DR2-CNRS), Guillaume Roux (MdC-Paris Saclay), and Mikhail Zvonarev (CR-CNRS) and the three emeriti Eugène Bogomolny, Serguei Brazovskii and Georgy Shlyapnikov. M. Fagotti and L. Mazza joined the lab in 2018. Since 2023, O. Giraud (DR2-CNRS) has been at the Majulab in Singapore, and he will return in 2025.

The team members are interested in a wide array of topics in quantum many-body physics, spanning from quantum chaos to localization, quantum information to topological systems, and quantum dynamics in closed and open systems. While our methods encompass both advanced analytical and numerical approaches, we actively collaborate with various experimental teams in France and abroad. Below, we spotlight several results achieved by the team members.

Cold Atoms, optical systems and quantum simulators

In the recent past, D. Petrov proposed to study weakly-interacting Bose gases in which the dominant mean-field interactions are tuned close to zero and new physical effects such as the appearance of a liquid phase appear. This triggered an important experimental activity. In the period of evaluation he further characterised the nature of liquid droplets and got interested also in the phenomenon of self binding in very diluted cold atoms. G. Shlyapnikov collaborates with Chinese experimentalists to realise condensates of ultra cold molecules. They created and described a novel route to coherently bind two atoms.

Cold atoms are employed as quantum simulators to replicate properties of many-body systems. O. Giraud and D. Ullmo collaborated with a group of experimentalists in Toulouse to investigate the transport properties in the intermediate regime where integrable regions of phase space coexist with chaotic ones. In these studies, they demonstrated that the tunnelling rate can be enhanced by chaos. In the field of quantum simulators, G. Roux collaborated with the team of M. Brune and J.-M. Raimond on the study of a new type of simulator which employs circular Rydberg atoms. With this system it is possible to study the thermodynamics and the out of equilibrium dynamics of many body systems such as the XXZ chain.

G. Roux has collaborated with an experimental team at Laboratoire Leon Brillouin on the study of a frustrated spin 3/2 chain. They have been able to demonstrate that, at variance of the case of a spin 1/2 Heisenberg chain, multimagnon processes play a determining role in this system.

Nicolas Pavloff studied acoustic analogues of black holes realised in the flow of a Bose-Einstein condensate. He theoretically reproduced and re-interpreted experimental results demonstrating Hawking radiation in this system. Together with O. Giraud and their students they characterised tripartite entanglement of the quantum modes of the analogue black hole. N. Pavloff also collaborated with the experimental group of A. Bramati at LKB to produce and precisely analyse dispersive shock waves released during the propagation of a laser in a nonlinear medium.

Quantum Dynamics

M. Fagotti is one of the pioneers of Generalized Hydrodynamics (GHD), a theoretical framework aimed at describing the non-equilibrium dynamics of integrable quantum systems in the presence of inhomogeneities. During the evaluation period, he secured an ERC grant and expanded upon these concepts to encompass various non-equilibrium integrable quantum systems, including models with semilocal conservation laws and kinetic constraints, and explored different non-equilibrium protocols. More recently, these studies have revealed that a specific limit of the tripartite information, which is generally zero both in equilibrium and often also out of it, can in fact become nonzero in nonequilibrium settings. Remarkably, Fagotti and collaborators have claimed that such a limit is universal and attains only discrete values even in the presence of interactions. They are now planning to investigate to which extent these phenomena are quantum.

M. Zvonarev and his postdocs computed the dynamical correlation function of the 1D Hubbard model. They observed that in this model, collective excitations, constrained to have no doubly occupied sites, can be viewed as particles carrying anyon statistics. This observation made it possible to decompose dynamical correlation functions into charge and spin parts, with the former represented by impenetrable anyons and the latter by a conventional spin chain. The exact Hubbard dynamics has been compared with predictions of a modern phenomenological approach known as Generalized Hydrodynamics.

On the other hand, Leonardo Mazza focuses on open systems, particularly cold gases in the presence of lossy terms. The main achievement is probably the exact solution of the dynamics of a 1D Bose gas under the effect of strong losses. In these systems and in the presence of harmonic traps Leonardo Mazza revealed the existence of collective modes solely induced by losses, which can be experimentally observed. The ongoing collaboration with Bruno Laburthe-Tolra (Villetaneuse) will hopefully reveal the presence of such modes.

Quantum Chaos and localization

Former LPTMS members proposed a well-known conjecture suggesting that quantum chaos and Gaussian random matrix spectral statistics are common features of quantum many-body systems. However, recent research efforts have focused on exploring alternative phases, including the disorder-induced many-body localised (MBL) phase, the potential existence of an intermediate phase, and quantum scars, which are isolated non-ergodic eigenstates.

In this context, several LPTMS researchers have made significant contributions. O. Giraud, in collaboration with the Toulouse group, conducted studies on multifractality in disordered systems. Notably, they achieved remarkable results for the Anderson model on a random graph. Additionally, together with E. Bogomolny, they identified a broad class of random matrices exhibiting intermediate statistics. G. Shlyapnikov, together with B. Altshuler, investigated the possibility of disorder-induced transitions in two-component Fermi gases with dipolar interactions, as well as in the one-dimensional case with repulsive interactions. Outside of this team, A. Rosso, along with L. Foini and collaborators studied the potential for dissipative localised phases induced by the presence of a bath.

L. Mazza and E. Bogomolny made contributions on quantum scars. The first explored many body models where quantum scars manifest at intermediate scales, leading to states that thermalize over time scales diverging polynomially with system size. The second showed the construction of localised wave functions known as super-scars in pseudo-integrable polygonal billiards.

Topological effects

Together with collaborators in Europe (E. Ardonne from Stockholm) and the US (A. Polychronakos from CUNY) L. Mazza has worked on the definition of the spin characterising fractional quasiparticles of the quantum Hall effect. They have shown that this quantity satisfies a spin-statistics relation, and hence that the fractional statistics is a direct consequence of the fractional spin. They are currently working on the generalisation of this notion to lattices, in view of experiments performed with ultra-cold atoms or photons.

S. Brazovskii has been working on topological defects in electronic crystals, such as charge- and spin density waves (CDW,SDW) or Wigner crystals. In particular, he considered the simulations of formation networks and globules of charged domain walls, which also allowed to contribute to a joint experimental work on detecting the intertwined chiral charge orders and topological stabilisation of the light-induced state. Another type of numerical works have been pursued together with N. Kirova (LPS Paris-Saclay) which were based on solutions of partial differential equations generated by a kind of time-dependent Ginzburg-Landau approach, where the order parameter was complicated by addition of electric forces and the account for the amorphous component. In this way, spatial and space-time vortices have been studied.

A series of work has been devoted to pairing and topology in spinless fermion chains. After demonstration the formation Majorana fermions along a critical line in a model with first and second neighbor interaction, G. Roux, L. Mazza and collaborators studied a model proposed by Ruhman and Altman and showed that, remarkably, it displayed a phase where pairs co-existed with unpaired fermions.

Statistical physics, field theory and integrable systems

Members	Alumni in Academics	Publications	Grants
5 CNRS (DR) 1 UPSaclay (PR) 1 Emeritus 2 volunteers 4 Post Docs 16 PhD Students 9 Master Students	A. Grabsch (CNRS 2022) J. Grela (Krakow 2020) U. Basu (SN Bose Center 2020) N. Smith (Ben Gurion 2021)	183 Publications 16 multi team 15 Phys Rev Lett. 1 high impact	432 Keuro 2 ANR 1 CFM PhD 1 FNR Luxembourg PhD 1 CSC PhD 2 CNRS 80 prime PhD 3 PIA Projects 1 CEFIPRA 1 IRP 1 Alembert program

The permanent members of the team are Françoise Cornu (DR), Satya N. Majumdar (DR), Sergei Nechaev (DR), Stéphane Ouvry (DR, emeritus), Raoul Santachiara (DR), Véronique Terras (DR), and Christophe Texier (Prof-Paris Saclay). Finally, Alain Comtet and Hubert Krivine are volunteers.
Gregory Schehr (DR) was an active member of the team until December 31, 2020, after which he left to join the LPTHE at Sorbonne Université. Sergei Nechaev was in charge of the CNRS IRL "Interdisciplinary Scientific Center Poncelet" in Moscow (IRL 2615) from 2016 to 2022. The program was renewed for the next period (2022-2027); however, due to the situation in Ukraine, the activity of the Center was halted in 2022. Françoise Cornu joined the LPTMS in 2019 from the IJClab.

The team members have shown a keen interest in a diverse range of subjects within statistical physics and mathematical physics. These include equilibrium statistical physics problems such as Coulomb gases, interfaces in random media, quantum statistics, percolation, and conformal field theory. They have also delved into out-of-equilibrium statistical physics and stochastic processes like resetting, last passage time, and active particles. Additionally, integrable systems such as spin chains, combinatorial problems, and random matrices have been areas of focus. These investigations have employed both analytical and numerical methods. Below, we highlight some key results achieved by the team members:

Equilibrium Statistical Physics

Long-range gases: long-range interactions can induce intriguing phase transitions in low dimensions. This topic has been explored by several members, including S. N. Majumdar, G. Schehr, and C. Texier, motivated by various problems in random matrix theory. Specifically, studying the distribution of linear statistics of eigenvalues has prompted consideration of such gases under certain constraints, which can drive phase transitions of various orders (e.g., second order, third order, or "infinite" order). Several properties of a Coulomb gas in one dimension (and its generalisation to Riesz gas) in the presence of a harmonic potential were investigated, yielding numerous exact results by S. N. Majumdar and G. Schehr. Notably, they derived exact distributions of several linear statistics for the first time, along with their large deviation tails.

Quantum Gas and Quantum Statistics: S. N. Majumdar and G. Schehr, along with their collaborators, delved into the statistical properties of fermions confined in an external potential. One notable achievement was establishing an exact correspondence between non interacting fermions in a one-dimensional harmonic trap and the eigenvalues of a Gaussian Unitary Ensemble (GUE) random matrix. This breakthrough facilitated the derivation of numerous exact results, including the quantum fluctuations of the rightmost fermion's position in a zero-temperature trap, which are governed by the renowned Tracy-Widom distribution in random matrix theory. Collaborating with Ch. Texier, they also investigated the fluctuations of these observables, highlighting the differences between statistical ensembles (grand canonical versus canonical). This investigation inspired further research, where Ch. Texier, O. Giraud and a student characterised the occupation numbers of individual stationary states and their correlations for the 1D Bose gas in a harmonic trap, driven by the constraint of particle number conservation.

In the context of intermediate statistics, Haldane introduced the concept of exclusion statistics, extending beyond the standard Fermi-Dirac statistics and leading to fractional occupation filling factors. Recently, Ouvry and Polychronakos extended Bose-Einstein statistics to an "inclusive statistics" that promotes condensation. In this scenario, they demonstrated that free particles can condense even in two dimensions.

Disordered Systems

Localization and product of random matrices: The study of the product of random matrices is fundamental in the physics of 1D disordered systems. Specifically, the average of its logarithm yields the Lyapunov exponent, which governs the free energy of a random Ising chain or the localization length of the 1D Anderson model. Ch. Texier, in collaboration with A. Comtet, J.M. Luck and Y. Tourigny, has classified the various expressions of the Lyapunov exponent for all continuous models. However, much less is known about the fluctuations around this average. In the evaluation period, A. Comtet and Ch. Texier, along with Y. Tourigny, have delved into this question and investigated the generalised Lyapunov exponent (GLE), which is the cumulant generating function for the logarithm of the random matrix product. They have demonstrated that the Generalised Lyapunov Exponent (GLE) can be identified as the largest eigenvalue of a certain non-Hermitian linear operator with non-standard boundary conditions. Additionally, they have investigated specific models where the spectral problem can be solved. Notably, Ch. Texier derived a general formula for the variance of the logarithm of the random matrix product associated with the 1D Schrödinger equation with an arbitrary disordered potential. Other results for the GLE were obtained for power law disorder.

Directed Polymer in random media: The directed polymer problem is a classical problem in disordered systems with connection with KPZ universality class, glassy physics and experimental applications. While most research focuses on the model's ground state, Ch. Texier and A. Rosso, with collaborators Y. Fyodorov and P. Le Doussal explored a different aspect: counting equilibria of the polymer. Using the Kac-Rice formula, they computed the average number of equilibria. This parallels V. Ros's work on disordered mean-field models. Interestingly, this problem can be mapped to the average of the product of random matrices: the analysis of the average number of equilibria was shown to be controlled by the GLE of the 1D disordered model

Interestingly, a Kardar-Parisi-Zhang (KPZ)-like scaling also emerges in a polymer problem without disorder. In a recent Physical Review Letters publication, Nechaev and collaborators studied the stretching of a fractal polymer wound around a disk or cylinder. The typical size of the excursion from the disk boundary exhibits KPZ scaling as a function of the disk radius.

Out-of-equilibrium Statistical Physics and Stochastic Processes

Resetting: Introduced by S. N. Majumdar and collaborators, has emerged as a significant area of study in statistical physics. It involves interrupting the natural dynamics of a process at random intervals and resetting it, leading to a nonequilibrium stationary state. This mechanism has found applications in search algorithms, enhancing their efficiency. Collaborations with the group of S. Ciliberto (ENS, Lyon) have facilitated experimental verification of theoretical results and the discovery of new phenomena. Stochastic resetting has also been extended to classical and quantum many-body systems, uncovering intriguing collective behaviours.

Last passage times: A. Comtet, F. Cornu, and G. Schehr obtained exact results for the statistics of the last time taken to reach a target point during a finite observation period. Various scenarios were examined, including cases where the target differs from the initial position or the presence of asymmetric forces in the case where the target coincides with the initial position. Additionally, the statistics of the last emptying time of a box were explored for a system of independent Brownian particles under a uniform force, particularly in the limit of an infinite observation time.

Active particles: The dynamics of individual active particles were analytically studied in several models by S. N. Majumdar, A. Rosso, and G. Schehr. Activity signatures were identified in the position distribution at both short and long times through analysis of their large deviation tails. Furthermore, universal features of first-passage properties for active particles were unveiled for the first time.

Field theory and integrable systems

Statistical and Conformal Field theory: R. Santachiara has made some pioneering contributions, among the others (i) An RG study on the 2D Ising and Potts models with long-range correlated disorder (in collaboration with M. Picco) (ii)They characterise the geometric properties of critical models by examining the universal effects of toric periodic conditions on percolation clusters. These findings enable the investigation of conformal symmetries of the level set of random surfaces. In the case of the Gaussian free field, where the level set forms a logarithmic fractal, a novel percolation transition has been identified (in collaboration with X. Cao). (iii) R. Santachiara successfully demonstrated the consistency of a new and non compact CFT. This family of theories has recently been applied in string theory to prove significant dualities in the context of quantum gravity and ADS/CFT correspondence. This work offers new insights into the long-standing problem of the analytical continuation of quantum Liouville field theories.

Spin chain with open boundary conditions: V. Terras explored the effects of non-periodic boundary conditions on the resolution of fundamental quantum integrable models such as the XXX or XXZ spin chains, employing non-conventional methods. The simplest case occurs at zero temperature with longitudinal boundary fields, where, employing Algebraic Bethe Ansatz alongside S. Grijalva and J. de Nardis, they compute correlation functions in the open XXZ chain. A new approach based on Separation of Variables was initially developed by V. Terras with G. Niccoli and H. Pei for correlation functions within the anti-periodic XXX case. This method was then applied with G. Niccoli to the open XXZ spin chain with non-longitudinal boundary fields constrained by a constraint. Work is underway to generalise this approach to the XYZ case. Additionally, with K.K. Kozlowski, she has commenced the study of the temperature correlation functions of the open XXZ spin chain using the Quantum Transfer Matrix approach.

Combinatorics: Combinatorics and integrable models share profound connections. An important problem is the enumeration of lattice random walks with a specified algebraic area, which holds deep ties to the spectral properties of a quantum particle moving in a lattice under a magnetic field (known Hofstadter problem). S. Ouvry and A. Polychronakos successfully derived exact enumeration formulas for this problem on different lattices, uncovering an unexpected relationship with exclusion statistics.

Disordered systems, soft matter, and interface physics

Members	Alumni in Academics	Publications	Grants
6 CNRS (2 CR, 4 DR) 2 UPSaclay (1PRAG, 1 PR) 1 volunteer 20 Post Docs 24 PhD Students 17 Master Students	F. Landes (UPSaclay 2018) C. De Bacco (MPI 2018) X. Cao (CNRS 2020) A. Altieri (Univ. Paris Cité 2020) M. Barbier (CIRAD 2021) S. Grigolon (CNRS 2021) P. Ronceray (CNRS 2021) A. Nicolas (CNRS 2019) A. De Luca (CNRS 2019) G. Gradenigo (GSSI Italy 2019) M. Bouzid (CNRS 2020) A. Maitra (CNRS 2022) Mayarani M (IIT Palakkad 2023) M. Baldovin (CNR Italy 2023)	171 Publications 19 multi team 21 Phys. Rev. Lett. 29 high impact	3870 Keuro 1 ERC 1 Fond. Bettencourt 1 Simons Found. 2 ITN 7 ANR 1 joint PhD program 2 CNRS 80 Prime PhD 1 FRM 1 ANR Tremplin-ERC 1 NTNU PhD 7 PIA projects 1 MITI 1 IUF 2 IDéES 1 Q-life Inst.

The permanent members of the team are Thorsten Emig (DR), Silvio Franz (Prof-Paris Saclay), Antoine Fruleux (CR), Martin Lenz (DR), Martial Mazars (PRAG), Valentina Ros (CR), Alberto Rosso (DR), and Denis Ullmo (DR). Emmanuel Trizac now has the status of a volunteer.
Valentina Ros and Antoine Fruleux joined the lab as permanent CNRS researchers in 2020 and 2021, respectively. Martial Mazars joined the LPTMS in 2020 from the IJClab, while Emmanuel Trizac assumed the role of President of ENS Lyon in 2023.

Initially, the team focused on disordered systems. Today, S. Franz, V. Ros, and A. Rosso continue studying models in mean field and finite dimensions where the presence of disorder is critical. However, three new overarching themes have emerged. M. Mazars and E. Trizac are more interested in soft matter problems. M. Lenz and A. Fruleux are biophysicists, while T. Emig and D. Ullmo are exploring the intersection of physics with other disciplines. All of them utilised tools from statistical physics and complex systems to comprehend physical problems relevant to experiments and applications. Below, we present their work categorised into four broad themes.

Disordered Systems

S. Franz works on the physics of glasses, and applications of disordered systems theory in interdisciplinary topics such as inference, machine learning and ecosystems. During the evaluation period has been a co-PI in the Simons research collaboration on "Cracking the Glass Problem". His main achievements concern: (i) *Universality of Jamming critical points*: Drawing an analogy between jamming of spheres and Constrained Satisfaction Problems (CSP) in Computer Science, he investigated the problem of universality of jamming, finding super-universal behavior, common to disordered sphere systems, non-convex neural networks and models of ecological niches. He studied a generalized jammed critical states for CSP and spheres with rectified linear interaction. (ii) *Linear and Nonlinear Excitations in Glasses:* He used simplified disordered models with continuous degrees of freedom to study excitations in glasses. (iii) *Dynamics of Glasses, Optimization and Neural Networks:* Gradient descent (GD) and its finite temperature generalizations are fundamental interest in physics optimization, machine learning etc. He reexamined the GD dynamics of disordered models (p-spin glasses) finding an unexpected dependence of the dynamic basins of attraction from the initial conditions.

V. Ros is one of the most promising junior researchers in the field of disordered systems. Her work on topics like many-body localization and high-dimensional landscapes is gaining recognition across a broad scientific community. At the LPTMS she focused on three problems: (1) *Characterize random high-dimensional landscapes, to understand how they are explored dynamically.*(2) *Classify equilibria of high-dimensional* *systems of equations associated with non-conservative dynamics*. Models of ecosystems, neural networks or socio-economical systems naturally include interactions that are non-reciprocal, rendering the system non-conservative. She worked on characterizing their multiple equilibria phases, focusing on how non-reciprocity in the interactions affects the stability of the equilibria, and consequently the system's dynamics. (3) *Study the interplay between localization and glassiness in quantum systems*. While glassiness and localization are rather distinct phenomena, in general systems with quenched randomness in the localized phase exhibit features of glassiness. Valentina Ros explored a model with coexisting static and fluctuating disorder, and revealed the occurrence of a new phase in this framework, that is localized but not glassy.

A. Rosso's research focuses on the dynamic response of disordered materials, a collaborative effort involving colleagues such as S. N. Majumdar and R. Santachiara. This research explores the competition between impurities and elasticity, leading to phenomena like pinning, plasticity, and intermittent motion (avalanches). The group's expertise lies in proposing and solving dynamical models developing avalanches using techniques from disordered systems. Additionally, they collaborate with experimental teams to analyse data from earthquake catalogues, Barkhausen noise in magnets, and images of crack propagation. Key achievements include: (i) Determining the threshold between fragile and ductile behaviour in amorphous materials.(ii) Identifying the existence of aftershocks in creep experiments, which were previously predicted by them. (iii) Understanding the spatial distribution of avalanches with long-range interactions, which were observed in crack propagation experiments, but not understood. Related research areas in disordered systems involve: the study of their complex energy landscape, in collaboration with Ch. Texier and, more recently, V. Ros. The Darcy law for non-Newtonian fluids, in collaboration with the FAST and S. Franz.

Soft Matter

The main focus of the research on E. Trizac was the physics of cement cohesion. Cement is the most produced material on Earth, and is at the origin of nearly 10% of anthropic CO_2 emissions. Yet, the physical origin of cohesion forces in this material is elusive, and standard theories severely underestimate their order of magnitude. One of the main results was to show that under nano-confinement, water cannot structure itself as in bulk conditions, and consequently loses its ability to screen Coulombic interactions. This dramatically enhances ionic correlations, yielding an attractive (cohesion) force 100 times larger than previously thought. Besides, it was obtained the first accurate and fully analytical equation of state (no fitting parameter) for this system, which completely captures the phenomenon as measured in molecular simulations. In a side work with S.N. Majumdar, E.Trizac studied a family of integrals that caught the attention of mathematicians in the last 20 years : the Borwein integrals, where a seemingly intuitive pattern in a series breaks down at a surprisingly high order. It was shown that a random walk reformulation illuminates the problem, and allows for a number of fruitful generalisations.

M. Mazars's research concerns numerical simulation of systems with long ranged interaction (Coulomb, dipolar, etc.). In the context of an international collaboration with Austria and Slovakia, he has pushed a research line on the ordered ground states of the asymmetric Wigner bilayer. By using machine learning based tools he re-analyzed the huge set of numerical data and found a complex and precise phase diagram. M. Mazars and collaborators have also studied the influence of topological defects in two dimensional melting, resolving the disagreement between the KTHNY theory and the observation of a first order phase transition between the hexatic and fluid phases. They have shown with Monte Carlo simulations and multi-histograms methods that the occurrence of topological defects of small size as predicted in KTHNY theory is precisely observed at the solid/hexatic and hexatic/fluid phase transitions, but simultaneously, the occurrence of topological defects of large size and complex structure drive this transition to be first order.

Biophysics

In the group M. Lenz, most of the period has been covered by an ERC Starting Grant project aimed at elucidating the emergence of macroscopic active processes in the cytoskeleton. They have developed statistical and mechanical models for the self-assembly and mechanics of the cytoskeleton, which has led to a new understanding of actin-generated forces, branched actin rigidity and the structure of crosslinked networks. In a second effort, covered by the Impulscience grant from Fondation Bettencourt-Schueller, they investigate the self-assembly of geometrically frustrated objects as an inspiration for the emergence of deleterious aggregates in protein aggregation diseases. This effort combines elastic models of irregular particles that highlight the protein's flexibility, and lattice models of particles with complex interactions meant to account for their highly anisotropic physicochemical properties. The hope of this effort is to uncover collective effects in self-assembly that robustly emerge in the limit of very complex interactions. Both research themes are conducted in close collaboration with experimentalists, from experimental biophysicists to protein crystallographers, neurodegenerative disease experts and DNA origami specialists.

Living organisms grow and organize in a very reproducible manner despite stochasticity arising from the environment or being intrinsic to biology. The aim of A. Fruleux. 's research is to study this robustness and the biological mechanisms that support it. He notably investigated the cells' response to mechanical perturbations. In particular he used reaction-diffusion models and statistical inference techniques to study the dynamics of proteins involved in the response of Yeast cells to mechanical stimuli. He also studies how cellular responses impact the organization of tissues, and in the frame of collaboration with R. Levayer at Institut Pasteur, how it leads to cell competition between “normal” (wild-type) and mutant cells. He also investigates the impact of cell variability on upper-scales using stochastic models and multi-scale data analysis. He predicted and showed experimental evidence for a mechanism stretching the variation space scale of time persistent fluctuations in growing tissues. This mechanism could have a strong impact on organ shapes heterogeneity. He recently started a collaboration with A. Lerouzic at IDEEV (Paris-Saclay) with the goal of describing how natural selection structures gene regulatory networks and lead to developmental robustness.

Physics at the interface

T. Emig studies the interplay between quantum and thermal fluctuations and geometry (Casimir Effect), both in equilibrium and out of equilibrium, to a wide range of different systems including disordered systems, superconductors, quantum magnets, and non-linear dynamics of granular systems. He also explores new directions of research. His recent topics of interest are *urban climate physics* and the description of *medical and physiological effects in sports*, combining physics driven models, statistical analysis and harvesting information from big data collected by wearable devices. In many of these fields, he has introduced new methodologies that advanced the field and intensified research activities in the field. In particular, a new approach in physiology was introduced by studying real world data from wearable devices. Real world data, such as that collected routinely in hospitals and point-of-care institutions, but also those now available from wearable devices, is projected to change healthcare dramatically. In his work he linked smartwatch-collected running data from approximately 14,000 runners to their individual physiological parameters, via a mathematical model of human running performance.

D. Ullmo initiated an activity on *Mean-Field Games* (MFG) at the LPTMS. In a first period, extending from 2018 to 2021, the goal was mainly to understand the generic properties of Mean-Field games on simple examples. This resulted in the publication of a review article in Physics Report, where the connection between mean-field games and the nonlinear Schrödinger equation is highlighted, and provides a nice entry point to the subject for physicists. This connection was later used to analyse the integrable regime of MFG, their weak-noise limit and properties of Mean-Field Games with negative coordination. In a second period, from 2021 till present, this work was pursued in more applied directions. A first one is the modelling crowd dynamics, and corresponds to the Ph.D. thesis of M. Butano. In this context, it was shown that MFG gives an excellent account of experimental data obtained of crowd's dynamics. A second direction is the application of Mean-Field Games to the description of epidemics dynamics, also addressed in the context of a thesis, by L. Bremaud (in co-supervision with Olivier Giraud), and for which an epidemic model including social structure is being analysed, and analytical results on epidemic models on homogeneous networks have been obtained.

4- Activity profile

Activities (Distribute 100 points on these 7 items)	
Contribution to innovative teaching based on research (University Research Schools - EUR, structuring training through research - SFRI, etc.)	10
Research administration (responsibility for steering research (VP, Institute Management, Scientific Director, etc.), participation in evaluation systems (CNU, CoNRS, CSS, etc.), responsibility for IdEx, project management (ANR, Horizon Europe, ERC, CPER State-Region contract, France 2030, etc.), editorial responsibilities in national or international journals or collections.	25
Research dissemination (sharing knowledge with the general public, scientific outreach, interface between science/society)	10
Research and research supervision (involvement in supervision at doctoral level and post-doctoral level)	55
Technical expertise (for national and regional public authorities, businesses, international bodies (UN, FAO, WHO, etc.)	0
Valorisation, transfer, innovation	0
Other activities.	0

5- Research environment

Since relocating to the plateau of the University Paris-Saclay in 2019, LPTMS has fostered robust connections with our neighbouring institutions. Specifically, we have developed strong collaborations and partnerships with:

- **The Institut Pascal (IPa).** Created on 1st January 2018 and located within our building,The IPa plays a key role in arranging scientific meetings and forming international collaboration across various fields covered by Paris-Saclay University. Since the beginning, LPTMS has strongly supported the institute, with Denis Ullmo leading as its first director from 2018 to 2022. Additionally, members of LPTMS have helped organise 6 extended programs and 1 conference hosted by IPa to date.

- **The Federation Friedel Jacquinot (FFJ).** Our relocation spurred the federation of the 6 physics laboratories of the plateau: FAST, ISMO, LAC, LPS, LPTMS, LuMIn. This structure fosters collaboration and engagement within our physics community through initiatives such as the FFJ colloquium or the FFJ days. The directors of the 6 laboratories also hold regular meetings for scientific and operational coordination. LPTMS plays an active role within the federation, driven by the initiatives of R. Santachiara and, since January 2023, by D. Hannoy, the deputy administrator of the federation.

- **Labex Palm and Graduate School of Physics.** LPTMS played a pivotal role in the creation of Labex PALM (Laboratoire d'excellence Physique Atomes Lumière et matière), aimed at fostering scientific collaborations within the Campus Paris-Saclay. Although terminated in 2022, this structure has been succeeded by the Graduate School of Physics of the University Paris-Saclay, notably through its component PHOM (Physique Ondes et Matières). PHOM actively supports our scientific projects in Quantum matter and Complex systems. Additionally, LPTMS is involved in two Interdisciplinary Objects: QUANTUM and Living Machine at Work.

- **The Physics Department and the Faculté des Sciences.** The 3 professors and 3 associate professors from LPTMS actively participate in teaching courses for the Physics Department, contributing significantly to both bachelor's and master's programs. Additionally, E. Trizac has served as vice dean of the Faculty, while N. Pavloff, Ch. Texier, and G. Roux have been members of the Department Board. Furthermore, G. Roux oversees the organisation of the Department's Bachelor's program.

- LPTMS maintains a close relationship with the **IPhT**, the other theoretical physics laboratory located on the plateau. Our collaboration with them involves ongoing exchanges and fruitful interactions for joint initiatives. Recently, we organised a two-day meeting together at the conclusion of the COVID pandemic, further strengthening our ties and fostering collaboration between our institutions.

LPTMS is a leading unit in statistical and quantum physics, with strong involvement in the physics community of the Paris area and at the national level. We would like to mention:

- **the Permanent Visitors program.** LPTMS has a program of permanent visitors from other laboratories, including X. Cao (LPENS), A. De Luca (Cergy), N. Kitanine (Univ. Bourgogne), P. Le Doussal (LPENS), and G. Schehr (LPTHE), who are actively engaged in official co-supervision of PhD students.

- **Master and doctoral programs**. The members of LPTMS are involved in teaching in the two Parisian Masters: ICFP and Physics of Complex Systems. Moreover, E. Trizac (2018-2021) and Ch. Texier (2021-today) is deputy director of the master Physics of Complex Systems. Concerning the doctoral program, V. Terras is deputy director of the parisian doctoral school EDPIF (2019-today). E. Trizac (2018-2023) was part of the board of the annual meeting *Les journees de la physique statistique*.

- Several members of LPTMS are actively involved in national Research Groups (GdR), including APQ (Approches Quantitatives du Vivant), IDE (Interaction, Désordre, Elasticité), and Branchement. Additionally, they participate in the management of the SFP (M. Lenz and E. Trizac) and serve on the Scientific Board of the Ecole de Physique des Houches (A. Rosso).

On the international scale, the LPTMS has well established scientific exchanges :

- **International Thesis:** Seven, among our doctoral students conduct a joint doctoral thesis with abroad universities (3 from Univ. La Sapienza in Rome, 1 from Univ Tubingen, 1 from Univ. Freiburg, 1 from NTNU, 1 from Univ. Los Andes). We had 2 Joint PhD CNRS programs with Imperial College (D. Ullmo), Univ. Tokyo (L. Mazza) and an international thesis (S.N. Majumdar and S. Nechaev). Furthermore, as a testament to our attractiveness, the majority of our PhD students come from abroad.

- LPTMS visitors represent a diverse range of nationalities, totaling 31 countries as outlined in the portfolio Item 2. Specifically, we maintain special relationships with five specific countries:

  Argentina: We participate in different exchange programs. In particular, with Centro Atomico Bariloche we have the LIA LPM involving A. Rosso and G. Schehr; with the University Mar Del Plata we had the LIA LICOQ, followed by the IRP COQSYS involving O. Giraud and R. Santachiara.
  Germany: We have two joint thesis programs with Tubingen involving O. Giraud, and with Freiburg involving N. Pavloff. Additionally, M. Lenz and S.N. Majumdar received an award from the Humboldt Foundation.
  India: We maintain a longstanding tradition of exchanges with India, particularly with institutions such as TIFR (Mumbai, Bangalore, Hyderabad), RRI (Bangalore), and IIS (Bangalore). Among all our Indian post docs, 7 have secured permanent positions. Specifically 3 during the period of 2018-2022: Urna Basu and M. Mayarani obtained professor positions in India following their postdoc with us, while A. Maitra secured a CNRS position in Cergy. Moreover, S.N. Majumdar is part of the scientific Board of ICTS. **Italy:** We have established longstanding collaborations with several Italian universities, particularly with institutions in Trieste (ICTP and SISSA) and Rome (La Sapienza). A notable example of our collaboration with Trieste is the Master in Physics of Complex Systems, a highly successful program conducted across Trieste, Turin, and Paris. This program was initiated from the French side through the efforts of S. Franz and E. Trizac. Additionally, our laboratory's partnership with the group of Nobel laureate G. Parisi stands as a significant achievement. In this context, LPTMS recently played a central role as one of the hubs for the Simons collaboration focused on Cracking the Glass Problem.
  Russia: Many members of our laboratory have received training in Russia, and we have a longstanding tradition of exchanges with both Russia and Ukraine. In 2016, S. Nechaev was appointed director of the Interdisciplinary Scientific Center Poncelet in Moscow. Unfortunately, due to the war, the Center closed in 2022. S. Nechaev returned to LPTMS, and the remaining funding from Poncelet was partially utilised to host Ukrainian scientists and their families at LPTMS.

6- Consideration of the recommendations in the previous report

A - Recommandations concernant les produits et activités de la recherche

Le maintien du niveau actuel de la recherche effectuée au sein de l'unité ainsi que la qualité de l'encadrement des doctorants doivent rester des priorités.

The scientific production of LPTMS is presented in the self-assessment document (part 3), which includes a list of more than 530 publications, among which we count 60 PRL and 39 on journals with higher impact factor (Nature, PNAS,..). Some of these papers have already attracted a large audience. Between 2019 and 2023, LPTMS trained 52 PhD students and 38 postdocs. Moreover, in the evaluation period, among all our PhD graduates, 11 now hold a permanent position in academia, with 8 of them in France. Similarly, among all our postdocs, 12 have secured a permanent position in academia, with 4 of them in France. We believe we have successfully implemented this recommendation.

B - Recommandations concernant l'organisation et la vie de l'unité

Le comité recommande à l'unité de maintenir l'atmosphère qui y règne et sa cohérence global pour garder sa dynamique collective. Une augmentation des collaborations internes dans l'unité devrait renforcer encore plus son impact sans que son rayonnement international n'en pâtisse

The collaborative and friendly atmosphere at LPTMS is ensured by several key factors. Firstly, the excellent work of our administrative and IT staff ensures that we have excellent working conditions. Secondly, our collective dynamics promote peaceful coexistence between different styles of interpreting research work. Internal collaboration has been actively promoted, with 22 of our publications being joint inter-team publications. In most cases, the collaboration is between the teams of Statistical Physics, Field Theory, and Disordered Systems, and Soft Matter. We hope to trigger more inter-team collaborations with the Quantum team in the future as well.

C - Recommandations concernant les perspectives scientifiques à cinq ans et la faisabilité du projet

L'unité doit continuer à être créative et innovante dans ses travaux de recherche, en s'appuyant sur ses multiples expertises tout en recherchant de nouveaux projets ou applications. Le laboratoire devrait profiter de son attractivité par le biais de mutations de jeunes chercheurs ou de chercheurs plus confirmés.

The arrival of M. Fagotti and L. Mazza has led to the exploration of new research directions. Specifically, their presence has facilitated the investigation of the exciting domain of Quantum dynamics of integrable or open systems. V. Ros has made significant contributions with her work on complex landscapes, which extends beyond the original realm of disordered systems. Her research has applications in diverse areas such as ecological systems and machine learning. Finally, A. Fruleux is dedicated to studying the mechanisms that govern biological robustness in cell or organism development, a project in collaboration with biologists.

We are delighted with their arrival. They are already perfectly integrated into the laboratory. However, we believe it is crucial for us to continue attracting new young profiles in these challenging fields.

2- PORTFOLIO INTRODUCTION

The portfolio is organised in seven Items to highlight strengths and peculiarities of the LPTMS.

- **Items 1, Team presentation.** We show all the LPTMS members in the period 2018-2023.
- **Item 2, Visitors, long stays and event organizations.** We provide the full list of our visitors from 31 different countries, of our long stay (> 7 days), as well as the scientific events we organized.
- **Item 3, Lab's Life, seminars.** It is dedicated to the scientific life of LPTMS and describes the organization of seminars both within and outside the laboratory.
- **Item 4, Carbon footprint**. It includes discussions regarding the carbon footprint of the laboratory and strategies to reduce it. We summarise the study conducted by G. Roux on our carbon production in 2019 and outline the actions that we have decided to take in response.
- **Item 5, Teaching and outreach.** The first section of this item is devoted to teaching and management responsibilities undertaken by our full and associate professors. The second part is devoted to our outreach activities.
- **Item 6, Research Training**. Here, we focus on the training of our PhD students, which, alongside research, constitutes the core of our activity. Lastly, we provide a comprehensive list of all students who have undertaken long internships during the period from 2018 to 2023.
- **Item 7, Scientific productions.** We decided to include three publications from A. Fruleux, L. Mazza, and V. Ros, who are among the latest additions to the laboratory. Additionally, for Statistical Physics, Field Theory, and Integrable Systems we included a successful paper authored by a talented PhD laureate from the team.

3 - SELF-ASSESSMENT DOCUMENT

3-1 Self-evaluation of the unit

Evaluation area 1: Profile, Resources and Organisation of the Unit

Standard 1. The unit has set itself relevant scientific objectives.

The three relevant scientific objectives of the LPTMS are:

1. Advancing scientific knowledge: The LPTMS conducts cutting-edge research in theoretical and statistical physics, aiming to deepen our understanding of fundamental principles across various scales, from the atomic level to living matter.
2. Training: The laboratory is committed to providing high-quality training to PhD students and postdoctoral researchers, with the goal of preparing them for successful careers in academia and industry.
3. Teaching: The LPTMS actively participates in teaching physics at the Université Paris-Saclay, in the greater Paris area, and abroad. By offering courses, supervising student projects, and engaging in educational initiatives, the laboratory contributes to the dissemination of scientific knowledge.

The LPTMS is committed to excellence by ensuring total independence for our researchers. Our administrative and IT staff ensures the best working conditions, freeing researchers and students from administrative procedures and IT issues. Additionally, the LPTMS actively seeks young researchers who demonstrate potential for significant contributions to our domain of research.

Our impact is primarily scientific, as we advance scientific knowledge and prepare the next generation of physicists. However, our training also has a non-negligible economic impact, as the importance of quantitative and statistical methods is increasingly recognized. In the period 2018-2023, more than 25% of our graduates found positions in the private sector.

Standard 2. The unit has resources adapted to its activity profile and research environment and mobilizes them.

LPTMS receives an annual grant from both the CNRS and the University Paris-Saclay. The university grant is primarily allocated for current supplies and computer equipment, while the CNRS grant funds various missions and internships. Additionally, most members of LPTMS have their own financial support, as outlined in Evaluation Area 2, Standard 3. Thanks to the overheads generated from these funding sources, LPTMS is able to support a variety of actions. The principal ones are:

1. LPTMS provides support for research activities during lean periods, enabling members to maintain their competitiveness and attract funding. For example, in 2022, when many ANR grants expired and only one team secured new funding, LPTMS funded the remaining teams for one year. In 2023, LPTMS teams received four new ANR grants.
2. LPTMS supports the provision of laptops, attendance at summer schools, and participation in conferences for all non-permanent members, ensuring equal opportunities for all students.
3. LPTMS sponsors the organisation of the laboratory's "days," which occur every three years, fostering scientific collaboration and a sense of belonging. Additionally, smaller social events are supported each year to further encourage collaboration and camaraderie among members.
4. LPTMS provides support for the missions of its emeritus members, who remain scientifically active but may not be eligible to apply for funding.
5. Occasionaly, LPTMS offers contract extensions of a few months to non-permanent members who need extra time to complete their projects.

In the table below, we provide the grants received from our supervisory authorities, including the annual grant as well as specific funding. On the second line, we present the funding received from national and international contracts. The exceptional amounts in 2019 and 2023 correspond to the ERC LOCOMACRO and Impulscience (Fondation Bettencourt), respectively.

	2018	2019	2020	2021	2022	2023
CNRS + Univ. Paris-Saclay	113 K€	103 K€	94 K€	110 K€	111 K€	94 K€
Grants	408 K€	1802 K€	475 K€	343 K€	698 K€	2869 K€

Standard 3. The unit's functioning complies with the rules and directives defined by its supervisors on human resources management, safety, environment, ethical protocols and data as well as scientific heritage protection.

Human resources

Hiring: We don't directly influence the hiring process, but we're dedicated to attracting talented scientists to LPTMS. We devote a significant portion of our weekly seminars to young researchers, giving them opportunities to present their work, engage in scientific discussions, and receive valuable feedback. Additionally, we guide them through the French hiring procedure. We believe this effort is valuable and will yield positive results in the near future.

Carriers administrative and IT staff: During the evaluation period, K. Kolodziej was initially recruited with a fixed-term contract (CDD) from 2017 to 2018. She transitioned to a permanent position as an AI (Assistant Ingénieur) in December 2018, with a shared position between IPa and LPTMS. In January 2020, she fully joined LPTMS until March 2023, when she moved to the DR4. Delphine Hannoy is an AI and joined the lab in October 2023, through a CNRS mobility campaign, transitioning from the DR4 to LPTMS. Claudine Le Vaou, our administrative manager, was promoted to IE (Ingénieur d'Études) in 2021. Zhiqiang Qin has been our IT service manager since 2016, holding the position of IE (Ingénieur d'Études). The administrative and IT staff play a crucial role in shaping the atmosphere within the laboratory. All researchers, both permanent and non-permanent, are aware that we work in privileged conditions thanks to them. We feel that CNRS is very attentive to the management issues of our laboratory, and we hope that it will recognize the excellence of our staff's work.

Carriers CNRS researchers: During the period 2018-2023, LPTMS saw significant advancements in career positions among its CNRS researchers. This included the addition of three new DR2 (Directeur de Recherche de 2ème classe) positions filled by M. Lenz (2018), O. Giraud (2021) and R. Santachiara (2022), as well as the promotion of three researchers from DR2 to DR1 (Directeur de Recherche de 1ère classe): D.Ullmo (2019), V.Terras (2021), and A. Rosso (2021). Additionally, S.N. Majumdar advanced to the position DRCE 1 (Directeur de Recherche de Classe Exceptionnelle)(2021) and finally DRCE 2 (2023). While LPTMS refrains from commenting on individual decisions made by the National Committee, the overall trajectory of career progression demonstrates dynamism and motivates excellence among our CNRS researchers. LPTMS management strongly encourages its CR (Chargé de Recherche) members to pursue HDR (Habilitation à Diriger des Recherches).

Carriers Enseignant chercheurs: During the period 2018-2023, L. Mazza was recruited as a Maitre de Conference, and M. Mazars joined the lab in 2020. Regarding career advancements, there is asymmetry. Many professors saw significant advancements, such as N. Pavloff (PRCE 1, 2020), E. Trizac (PRCE 2, 2020), and Ch. Texier (PR1, 2021). However, for Maitres de Conference, the situation is stagnant since the last competition in 2016, which led to the promotion of Ch. Texier. G. Roux, who was recruited in 2008, never had an opportunity for advancement; he could only apply and receive the promotion to Hors Classe in 2021. This lack of progression is a common issue in the physics department and affects Maitres de Conference across the campus. LPTMS stands in solidarity with them and with our own Maitres de Conference members.

Gender parity and discrimination: At LPTMS, we are an international laboratory and we welcome diversity. Despite our best efforts, achieving gender parity among our permanent researchers remains a challenge, a common issue within the field of theoretical physics. Recently, V. Ros was unanimously invited to join LPTMS solely based on her merit as an excellent physicist. Hopefully, her inclusion also contributes to improving gender parity.

The relocation in 2019 and the new offices

In 2019, LPTMS relocated from its historical location in the valley of the campus to the plateau. The main motivations for this move were:

1. Moving to a new building with more comfortable offices and increased space for visitors and students.
2. Transitioning to an area closer to the laboratories focused on quantum and complex systems physics.
3. Accompanying the establishment of the Institute Pascal (IPa) and taking advantage of its exciting scientific programming.

Relocating to the new building 530 with FAST and IPa has provided LPTMS with spacious and comfortable offices. Each permanent member now has their own office, while students share offices with no more than two individuals. The abundance of space encourages discussions and accommodates visitors, and we also have a pleasant terrace for communal lunches and social events. Additionally, the move presented an opportunity to acquire modern and ergonomic furniture.

The previous management, alongside the administrative and IT staff, deserve recognition for their outstanding work during the relocation process. Thanks to their efforts, researchers and students experienced a smooth and efficient transition, which was completed in just one week. Despite facing challenges such as flooding and temperature control issues in the new building, significant improvements have been made over time. However, some offices still encounter heating problems during winter or become too hot in summer. Efforts continue to address these remaining issues and ensure a comfortable working environment for everyone at LPTMS.

Being in the new building offers the opportunity to be side by side with the IPa and closer to laboratories working in our domain. Despite the adverse effects of the pandemic, interactions are growing, as evidenced by the six programs already held at the IPa and the creation of the FFJ federation. The downside of the relocation is that we are far from public transportation, which poses challenges for part of our permanent staff and for the students. We hope that the construction of the new metro line will be completed as soon as possible so that we can once again be well connected to downtown Paris.

Safety and Security

A document about risk and safety is drafted each year with the agreement of supervising institutions and is accessible online. Additionally, we register all accidents in our "health and safety register." C. Le Vaou serves as the referent for Safety and Security for the lab. More recently, D. Hannoy has received training as a Safety and Security Assistant, and a few members have been trained in handling fire extinguishers. The Safety and Security Assistant collaborates with the university and the CNRS to maintain a safe working environment. Depending on the circumstances, specific instructions may be provided, such as during exercises on the evacuation.

For the LPTMS, the two main sources of risk are office work and psychosocial risks. To mitigate the first, we strive to ensure ergonomic workstations for all lab members, providing quality screens and chairs. We are also very concerned about the second risk, as more than half of our members are students, many of whom are far from their families. Both researchers and administrative staff actively try to detect potential problems. During the pandemic, we faced a critical situation, and during the second confinement, the lab was the only social space allowed for them, leading to a special affection for the LPTMS, stronger than what we were used to.

Data security

The servers and the clusters are centralised in the data centre of Paris-Saclay university while the workstations are located in the offices of the laboratory and are connected to 1Gb VLAN. The entire system is protected by a firewall. The user data on the file server are backed up every day on the different sites and are restorable. The system on the laptop of the laboratory is encrypted to guarantee the security of user data.

Only two machines are accessible from the outside: one machine is used as an access gateway(ssh) and the second gives access to the web service(http and https). Both machines operate with recent operating systems which are maintained regularly. Connection to the internal network is only possible via the wired network with a MAC-address filtering and a nominative registration of users.

Environment Protocol

The discussion about the LPTMS carbon footprint began in June 2019. In 2020, G. Roux was appointed as the LPTMS sustainable development referent and prepared the laboratory's carbon accounting, with assistance from C. Le Vaou, K. Kolodziej, and O. Giraud. An individual carbon emission of 6 tonnes has been estimated for the year 2019.
In 2022, the results were presented in an animated session during the lab’s days, leading to the creation of a committee tasked with proposing a reduction plan. The composition of the committee reflected the diverse perspectives within the lab on this subject. It included members from various positions within the laboratory, namely: L. Brémaud (PhD student), O. Giraud (DR), K. Kolodziej (ITA), S. Ouvry (DR), and G. Roux (MCF).
On March 29, 2023, several actions were proposed at the general assembly of the laboratory and voted upon. In the spirit of a collective approach as much as possible, the adopted actions were voted on by an absolute majority of permanent members and an absolute majority of non-permanent members. In the Portfolio the Item 4 is fully dedicated to the Environment Protocol.

Synthetic self-evaluation

The unit offers excellent working conditions to both its permanent and non-permanent researchers. This is made possible by the outstanding performance of the administrative and IT staff, the favourable economic situation, and the recent relocation to a beautiful new building.

LPTMS is dedicated to capitalising on this opportunity to attract new and talented scientists, as well as to welcome colleagues from other laboratories. Additionally, LPTMS prioritises the career advancement of its members and is concerned about the stagnant situation of career development opportunities in the university. The lack of growth opportunities is not a reflection of individual performance but rather stem from the limited number of retirements in the University.

Evaluation area 2. Attractiveness

Standard 1. The unit has an attractive scientific reputation and contributes to the construction of the European research area.

LPTMS is globally renowned for its contributions to statistical physics and the theory of quantum systems.

- We have a dense network of international collaborations worldwide. We also visit them, and we count more than 50 long stays at prestigious research centres such as MIT, Weizmann, ICTP Trieste, University La Sapienza, and the Tata Institutes.
- LPTMS members are also invited to present their work at international conferences and workshops. While we have not listed all of them, as there are hundreds, we provide a list of the 32 participations in long programs (more than 7 days) to which we have been invited.
- LPTMS members have also organized 44 international conferences and workshops. Following the pandemic, we were particularly active in restarting scientific activities, organizing 6 summer schools or long scientific programs.
- Our members serve on the Scientific boards of significant French and international organisations such as the French Physical Society (SFP), the École de Physique des Houches, Statphys, Fundamental Problems in Statistical Physics (FPSP), and the scientific board of the Institut de Recherche en Mathématique et Physique of the Catholic University in Leuven. G. Roux is a member of the National Committee of section 02, while Texier and L. Mazza are members of the CNU. During the evaluation period, we actively participated in numerous thesis defences, HDR evaluations, HCERES as well as recruitment committees.

- We regularly review papers from all scientific journals in our domain, including prestigious ones such as Nature and PNAS. Some of our members have served as guest editors for special collections. For instance, S.N. Majumdar is part of the editorial team for the Journal of Statistical Physics, Journal of Physics A, and JSTAT. Additionally, we act as referees for major grant agencies.

In the Portfolio Item 2, we provide the list of our visitors, our long stay as well as the conferences that we organized. During the evaluation period, several of our members received significant distinction and prizes:

1. Martin Lenz was honoured with the Friedrich Bessel Research Award from the Humboldt Foundation in 2020.
2. Satya N. Majumdar was awarded the Silver Medal of CNRS in 2019, along with the EPS Prize for Statistical and Nonlinear Physics in the same year. He also received the Gay-Lussac Humboldt Prize from the Humboldt Foundation in 2019, as well as the Vajra Fellowship from the Indian Ministry of Science and Technology in 2018.
3. Valentina Ros was the recipient of the EPS Early Career Prize for Statistical and Nonlinear Physics in 2019, and she also received the Early Career Best Paper Award in 2022 from the Journal of Physics A.
4. Members of the IUF: Silvio Franz (2017-2022), Nicolas Pavloff (2022-2027) and Emmanuel Trizac (honorary member).

Another indicator of recognition is the significant responsibilities undertaken by some of our members:

1. Sergey Nechaev served as the director of the Interdisciplinary Scientific Center Poncelet from 2016 to 2022.
2. Emmanuel Trizac held the position of vice dean of the Faculty of Sciences from 2021 to 2023, and since 2023, he has been serving as the President of ENS Lyon.
3. Denis Ullmo served as the director of the IPa from 2018 to 2023.

Standard 2. The unit is attractive for the quality of its staff hosting policy.

PhD and postdoc at LPTMS: More than half of the members of the lab are students (see Portfolio Item 1 and Item 6). We are a core location for PhD students of the Ecole Doctorale Paris Ile de France (EDPIF). To ensure the social and scientific integration of all new students, we employ the following strategies:

1. We host a Welcome Day in January, during which all new members are formally introduced. A buffet is organised to commemorate the occasion.
2. We facilitate the monthly student seminar and encourage small events such as barbecues and social gatherings organised by students. After the pandemic, we initiated special activities to revive scientific discussions.
3. We assign senior students the responsibility of integrating new members into the community.
4. We monitor the presence of any practical or psychological issues and provide support as needed.

To ensure equal opportunities for all our students, regardless of their supervisor's financial support, we implement the following strategies:

1. All PhD and postdoc students are provided with a new laptop.
2. All PhD and postdoc students have the opportunity to participate in a summer school, and the LPTMS offers support for conferences where our junior researchers can present their results.
3. Occasionally, we extend their contracts by a few months to allow them to complete their research projects.
4. Additionally, the administrative staff is very attentive to their needs and provides special assistance to non-European students in administrative procedures to obtain visas.

New permanent members: LPTMS, along with our supervisory authorities, place great importance on the integration of new permanent members into the lab:

1. Both CNRS and Université Paris-Saclay provide initial financial support to new members.
2. Université Paris-Saclay reduces teaching duties for the first year after recruitment.

3. LPTMS supports the initial financial applications of our new members. For example, all our four new members received the Chair Excellence Junior from the Labex PALM.
4. LPTMS provides them with a dedicated office equipped with new furniture and computers.
5. Senior members mentor them and assist in finding their first students, as well as presenting their work at scientific meetings organised in the area.

Visitors: The full list of our Visitors is provided in the Portfolio Item 2. We have a lot of visitors coming from 31 countries. Some of them are recurrent. We provide them administrative and logistic support.

Scientific integrity and open science: The LPTMS respects the strategy of CNRS and Paris-Saclay University in the domain of open science and scientific integrity.

Standard 3. The unit is attractive because of the recognition gained through its success in competitive calls for projects.

LPTMS members attract national and international funding. During the evaluation period, we received approximately 6 million euros to fund our research. Among our non-permanent members, 20 PhD students and 37 postdocs were recruited using this funding. Below we list the contracts active in the period 2018-2023:

3 ERC grants

- Nombquant (G. Shlyapnikov)
- MicMactin (M. Lenz)
- LoCoMacro (M. Fagotti)

2 other European grants

- ITN Nanotrans (E. Trizac)
- ITN Nanophlow (E. Trizac)

3 private foundation grants

- Simons Foundation (S. Franz)
- ImpulScience Fondation Bettencourt-Schuller (M. Lenz)
- CFM PhD P. Mergny (S.N. Majumdar)

4 International grants

- CEFIPRA project 5604-2 (G. Schehr)
- FNR Luxembourg - PhD grant B. De Bruyne (G. Schehr)
- NTNU - PhD grant F. Lanza (A. Rosso)
- CSC - PhD grant L. Gan (S. Ouvry)

16 ANR Grants

- Muscactin (M. Lenz)
- Haralab (N. Pavloff)
- Thermoloc (A. Rosso)
- TRYAQS (T. Jolicoeur, G. Roux)
- IDTODQG (M. Zvonarev)
- Ramatraf (G. Schehr)
- COCOA (O. Giraud)
- State (E. Trizac)
- Droplets (D. Petrov)
- CoCynet (M. Lenz)
- FruSa (M. Lenz)
- Discreep (A. Rosso)
- Loqust (L. Mazza)
- Edips (S.N. Majumdar)
- Fennec (E. Trizac)
- FruSa - Tremplin ERC (M. Lenz)

3 other national grants

- FRM BioFib (M. Lenz)
- HQI - HPC Quantum Initiative (L. Mazza)
- Q-Life Institute (M. Lenz)

2 IUF (Institut Universitaire de France)

- Senior (S. Franz)
- Senior (N. Pavloff)

5 regional grants

- SIRTEQ PhD L. Gotta (L. Mazza, G. Roux)
- SIRTEQ HydroLive (N. Pavloff)
- SIRTEQ DLCICQE (M. Zvonarev)
- Quantip Post-doctoral funding J. Despres (L. Mazza)
- Quantip OpenQMBP (L. Mazza)

6 CNRS PhD Funding

- 80 Prime F. Benoist (M. Lenz)
- 80 Prime V. Schimmenti (A. Rosso)
- 80 Prime R. Usciati (R. Santachiara)
- 80 Prime International PhD A. Flack (S.N. Majumdar)
- Joint PhD programme Imperial College M. Butano (D. Ullmo)
- Joint PhD programme Tokyo Univ. A. Marché (L. Mazza)

5 Other CNRS funding

- PICS (M. Zvonarev)
- MITI (M. Lenz)
- LIA LICOQ (O. Giraud)
- IRP COQSYS (O. Giraud)
- IRP PHD2RGF (S.N. Majumdar)

3 Other Univ. Paris-Saclay funding

- Jean d'Alembert grant J. Viti (R. Santachiara)
- IDéES (V. Ros)
- IDéES (A. Fruleux)

17 PIA grants

- IDI PhD L. Barberi (M. Lenz)
- ADI PhD G. Ciliberto (N. Pavloff)
- PALM QuanDynWoTran (M. Fagotti)
- PALM 1DColdAnyons (L. Mazza)
- PALM RESPROREM (G. Schehr)
- PALM FRACSPINQUENCH (S. Ouvry)
- PALM TimeCrystal (L. Mazza)
- PALM PhysBioPSa (M. Lenz)
- PALM OptFlo (A. Rosso)
- PALM QSIM_MBDyn (L. Mazza)
- PALM Relaxed (L. Mazza)
- PALM HighDyn (V. Ros)
- PALM MorphoStat (A. Fruleux)
- PALM TMB (N. Pavloff)
- PALM GlassMan (V. Ros)
- PALM SRWQ (S. Ouvry)
- PALM SemDyn (D. Ullmo)

Standard 4. The unit is attractive for the quality of its major equipment and technological skills.

LPTMS is a theoretical physics unit. Our only equipment our computer system it consists of 46 workstations (43 Linux, 2 Mac OSX and 1 Windows), 37 laptops (21 Mac OSX, 8 Windows and 8 Linux), 12 servers (authentication/ access control, file, web, printing, backup, license, database, etc.), 1 VM cluster (3 nodes with high availability) and 1 computing cluster (22 compute nodes, 2 GPUs and 1378 CPUs).

Synthetic self-evaluation

LPTMS is a highly regarded laboratory with strong international visibility. Its members are frequently invited to speak at international conferences and institutions worldwide, showcasing their expertise and contributions. Many members also actively participate in research management at both national and international levels. Furthermore, several of our members have been honoured with prestigious awards in France and abroad.

The quality of our research also attracts many PhD students, postdocs, and visitors from all over the world, who are central to the scientific life of the laboratory. Several initiatives have been implemented to ensure their seamless integration.LPTMS members have been highly successful in grant applications, with five major grants (and several ANR) active during the evaluation period. Through the overheads of these grants, LPTMS can provide economic support to students or researchers while awaiting new funding.

Evaluation area 3. Scientific production

Standard 1. The scientific production of the unit meets quality criteria.

Over the evaluation period, the members of the laboratory achieved the following publications:

- 533 articles in peer-reviewed journals
- 61 preprints on arXiv
- 18 conference proceedings and posters
- 7 books and 10 book chapters

This important scientific LPTMS production is impressive for impact, variety and quality. Even within such a brief period, we have over a dozen papers that have garnered between 400 and 100 citations each. To have an idea of the variety of our production we listed below the list of the journals where we publish.

Reviews	Number of publications
Physics Reports	2
Nature Physics	2
Nature Communications	7
Science Advances	3
PNAS	8
Physical Review X	7
Physical Review Letters	60
eLife	2
Quantum Science and Technology	3
Quantum	2
Macromolecules	3
Journal of High Energy Physics	7
Scientific Reports	6

SciPost Physics	37
Journal of Chemical Physics	10
Physical Review Research	13
Soft Matter	9
Physical Review B	33
Physica A	2
PLoS ONE	2
New Journal of Physics	4
Nuclear Physics B	8
Annals of Physics	3
Symmetry	3
Journal of Physics: Condensed Matter	2
Physical Review E	75
Physical Review A	44
Journal of Physics A	51
Journal of Statistical Mechanics	49
EPL	9
Journal of Statistical Physics	11
Comptes rendus de la Physique	2
Journal of Mathematical Physics	2
JETP	3
American Journal of Physics	3

List of the reviews with a single publication: **Nature, Science, Reviews of Modern Physics, Nature Methods, Nature Reviews Physics, Nature Machine Intelligence, Annual Review of Condensed Matter Physics,** Nucleic Acid Research, Reports on Progress in Physics, Annual Review of Nuclear and Particle Science, Npj Quantum Materials, Physical Review D, Journal of Cell Science, Physics of Fluids, Physical Review Applied, Journal of Geophysical Research: solid earth, Heredity, Transport in Porous Media, Journal of Physical Chemistry B, Brain Multiphysics, Bulletin of the seismological society of America, Computational & Applied Mathematics, Physical Biology, Universe, Entropy, Physics Letters A, Journal of Physics: complexity, Magnetic Resonance in Chemistry, Communications in Mathematical Physics, Polymer Science, series C selected topics, Molecular Physics, European Physical Journal E, European Physical Journal D, Modern Physics Letters A, Annales de l'Institut Henri Poincaré, European Physical Journal B, Journal of Physics Communications, European Journal of Physics, Collective Dynamics, Markov processes and related fields, Probability and Mathematical Statistics, Il Nuovo cimento della società italiana di fisica C, Physics of Particles and Nuclei Letters, AIP Conference Proceedings, Ecologie & politique: sciences, culture, société, Peer Community Journal.

References for the articles cited in this section

[1] **FAGOTTI M., MARIC V., and ZADNIK L.**, *Nonequilibrium symmetry-protected topological order: Emergence of semilocal Gibbs ensembles,* Phys. Rev. B 109, 115117 (2024)
[2] TYLUTKI M., ASTRAKHARCHIK G. E., MALOMED B. A., **PETROV D. S.,** *Collective excitations of a one-dimensional quantum droplet,* Phys. Rev. A, 101 (5) 051601(R) (2020) [88 citations in GS (17/04/2024)]
[3] NGUYEN T. L., RAIMOND J.-M., and al, *Towards Quantum Simulation with Circular Rydberg Atoms,* Phys. Rev. X, 8 (1) 011032 (2018) [176 citations in GS (17/04/2024)]
[4] EVANS M.R., **MAJUMDAR S.N., and SCHEHR G.**, *Stochastic resetting and applications*, J. Phys. A. : Math. Theor. 53, 193001 (2020) [400 citations in GS (17/04/2024)]
[5] CHIPPARI F., PICCO M., **SANTACHIARA R.**, *Two-dimensional Ising and Potts model with long-range bond disorder: a renormalization group approach,* SciPost Physics, 15 (4), 135 (2023)
[6] NICCOLI G., **PEI H., TERRAS V.,** *Correlation functions by separation of variables: the XXX spin chain,* SciPost Physics, 10 (1), 006 (2021)
[7] **FRANZ S., SCLOCCHI A.**, URBANI P., *Critical jammed phase of the linear perceptron,* Phys. Rev. Lett., 123 (11),115702 (2019)
[8] **SORICHETTI V., LENZ M.**, *Transverse fluctuations control the assembly of semiflexible filaments,* Phys. Rev. Lett., 131, 228401 (2023)
[9] GOYAL A., **PALAIA I.**, IOANNIDOU K., ULM F-J., VAN DAMME H., PELLENQ R., **TRIZAC E.**, DEL GADO E., *The physics of cement cohesion,* Sci. Adv. 7 (32) eabg5882 (2021)

The research output of LPTMS contributes to addressing open problems that are of interest to the international scientific community. The results have relevance across various aspects: some articles tackle long-standing open issues, others introduce new techniques, while some provide valuable insights for experimentalists.

M. Fagotti and his collaborators made a paradigm shift in the characterization of the late time properties of quantum spin chains after global quenches. Specifically, in [1] they have shown that a state in a symmetry sector time evolving under a symmetric Hamiltonian can become locally indistinguishable from an unconventional statistical ensemble with symmetry-protected topological order. That happens when the Hamiltonian exhibits so-called semilocal conservation laws, which give rise to unusual and counterintuitive phenomena.

In [2], D. Petrov and his collaborators investigated the excitation spectrum of one-dimensional quantum droplets. The nonlinear Schroedinger equation governing the droplets, in addition to the usual cubic term, also features a peculiar quadratic nonlinearity which originates from beyond-mean-field effects and which makes quantum droplets different from solitons. This is a topic of strong experimental interest. However, under current experimental conditions the shapes of the droplets and solitons may be difficult to distinguish. The authors note that in this case a clearer manifestation of beyond-mean-field effects is contained in the excitation spectrum. In particular, quantum droplets always have excitations below the particle emission threshold whereas solitons have no such excitations.

In the framework of a new quantum simulator proposal by the group of J.-M. Raimond and M. Brune, G. Roux contributed to study the phase diagram, the adiabatic preparation of targeted ground states and the effect of the motion coupling to its fidelity [3]. This proposal is a new route in the field of Rydberg simulators with the promise of extremely long stability allowing to study long-time dynamics while current platforms are limited to short time scales. In particular, they show that the coupling with the atomic residual motion does not alter the quality of the simulator provided it is kept weak enough, yet in the experimentally accessible range.

S.N. Majumdar and collaborators initiated the field of `stochastic resetting' leading to a new out of equilibrium dynamics with applications ranging from random search algorithms in computer science to the foraging dynamics of animals in ecology. New experiments by S. Ciliberto and group (ENS, Lyon) om diffusion in an optical trap with resetting protocol verified analytical predictions and led to new questions. This subject has seen an explosion of activities, both theoretical and experimental, as reviewed in [4], that has attracted more than 400 citations.

In [5], Raoul Santachiara and collaborators shed new light on the physics of long-range correlated disorder and its impact on the phase diagram of such systems, particularly when the long-range nature of the disorder distribution becomes relevant. Their study focused on a class of two-dimensional systems, providing analytical insights that clarify key aspects of the problem. Notably, they showed that unlike short-range disorder, higher cumulants of the disorder distribution can alter the critical exponent. This finding is significant as previous theoretical works only accounted for Gaussian distributions of disorder, leading to inaccurate conjectures about critical exponent values.

Separation of Variables (SoV) is an alternative approach to Bethe Ansatz for the resolution of Quantum Integrable Systems. It has a wide range of applications, and can in particular be used for solving models which do not admit a Bethe Ansatz solution due to the lack of a simple reference state. However, the problem of computing, within this SoV approach, physical quantities such as correlation functions remained so far open. In [6], V. Terras, her PhD student H. Pei and a collaborator solved this long standing problem on the example of a simple model, the twisted XXX spin chain: they managed to compute correlation functions exclusively within the SoV approach for different boundary twists, hence showing explicitly, as a side result, that the thermodynamic limit of the correlation functions do not depend on the twist. In systems such as jamming of spheres or constraint satisfaction problems, a critical point distinguishes the phase where spheres do not overlap and constraints are satisfied from the jammed phase. In their work [7], S. Franz and collaborators illustrate that criticality can pervade an entire region of the jammed phase by carefully choosing the cost function. Through numerical simulations, they uncover critical power laws in configurations and introduce a scaling theory to compute the emerging critical exponents.

In this study [8], M. Lenz and his postdoctoral researcher have made advancements in understanding the physics behind the self-assembly process of the cell cytoskeleton. Building upon previous findings that indicated its control through a non-equilibrium kinetic trapping transition, the researchers delve into the microscopic mechanisms influencing these kinetics. They discover that thermal fluctuations of the filaments significantly accelerate the self-assembly process by enabling filament ends to locate each other without requiring movement of the entire filament.

In [9] E. Trizac, along with his PhD student and their collaborators, delves into the origins of the significant cohesion forces observed in cement. The main findings reveal that under nano-confinement, water's structuring differs from that in bulk conditions, resulting in a loss of its ability to screen Coulombic interactions. This leads to a substantial increase in ionic correlations, resulting in an attractive (cohesion) force that is 100 times larger than previously estimated.

Standard 2. Scientific production is proportionate to the research potential of the unit and shared out between its personnel.

The productivity of LPTMS is remarkable, with a well-balanced distribution across different teams and fruitful collaborations among team members. Our four junior researchers are outstanding scientists, fully integrated into the laboratory and contributing significantly to the scientific excellence of LPTMS. The administrative and IT staff ensure optimal working conditions and resource utilization.

The collaborative atmosphere among our members provides support to researchers facing periods of low productivity or motivation. LPTMS management regularly engages with them, offering assistance, including financial support, to establish new collaborations or explore new research directions.

Furthermore, LPTMS strongly encourages PhD students and Postdocs to initiate their own research projects, providing support for conference attendance, publication fees, and organizing independent scientific events. During the evaluation period, 14 publications were solely authored by PhD students and 48 by Postdocs.

Standard 3. The scientific production of the unit respects the principles of scientific integrity, ethics and open science. It complies with the applicable guidelines in this field.

The unit's scientific output adheres to all rules and principles ensuring its integrity and scientific rigour. LPTMS publications include research articles published on open-access platforms like arXiv and HAL, as well as in international peer-reviewed journals. Many of these articles are available as open source or "platinum open access" through platforms like SciPost. Additionally, LPTMS produces teaching materials, accessible on our website, along with computer codes and data. Researchers are responsible for disseminating these data and codes, making it openly accessible on platforms like GitHub.

Synthetic self-evaluation

The scientific output of the unit is excellent and ensures that LPTMS maintains an international leadership position in the field of statistical physics. This excellence is the result of various factors, three of great importance:

1. The individual excellence of its researchers.
2. A collaborative and constructive spirit among its researchers.
3. The ideal working conditions ensured by our administrative and IT staff.

Evaluation area 4. Contribution of Research Activities to Society

Standard 1. The unit stands out by the quality and quantity of its non-academic interactions.

While the LPTMS doesn't have extensive collaborations with the private sector, there have been some instances of interaction. For instance, Pierre Mergny completed his PhD under joint supervision of Satya N. Majumdar (LPTMS) and Marc Potters (CFM), with funding provided by the CFM Edge Fund.

Furthermore, since 2022, Martin Lenz has been a laureate of the Fondation L'Oréal Bettencourt's ImpulSciEnce program. His project on self-assembly currently represents the most financially significant project undertaken by the laboratory.

Standard 2. The unit develops products for the cultural, economic and social world.

This standard does not align with the activities of the unit in fundamental science.

Standard 3. The team shares its knowledge with the general public and takes part in debates in society.

LPTMS actively participates in scientific outreach efforts. Each year, we enthusiastically take part in open house events, showcasing six carefully prepared experiments to engage a large audience. Additionally, we welcome secondary school students for discovery internships, providing them with valuable hands-on experiences in the world of science.

Some of our members are very active in outreach activities and participate in public debates or lectures for large audiences. Among them, the volunteer work of Hubert Krivine stands out. From 2018 to 2022, he authored two books entitled "Comprendre sans savoir, savoir sans comprendre" and "L'IA peut-elle penser?" Both books address the growing influence of artificial intelligence and big data in our lives. Our outreach activity is discussed in more detail in the Item 5 of the portfolio.

Synthetic self-evaluation

The primary goal of LPTMS is the advancement of fundamental science, with any direct impacts on society considered secondary. However, we do participate collectively in outreach activities, and some of our members are particularly active in this regard. Notably, the work of Hubert Krivine stands out.

While our students often secure highly qualified positions in high-tech companies and startups, our direct engagement with the private sector remains limited and has room for improvement in the future.

4- UNIT TRAJECTORY

Scientific History and the LPTMS today

The LPTMS was established in 1998. It emerged from a reorganisation of the theoretical physics division of the IPN (URA 62). Initially focused on nuclear physics and particle physics, the URA 62 gradually expanded into new directions: quantum chaos, quantum fluids, and low-dimensional systems. This scientific dynamism was a determining factor in proposing the creation of a new laboratory under the title "Laboratoire de Physique Théorique et Modèles Statistiques." The project, led by young researchers (A. Comtet, P. Leboeuf, O. Martin, S. Ouvry), benefited from the constant support of two former directors of URA 62 (O. Bohigas and X. Campi).

From the start, the project promoters believed it was important to have a location on the Moulon plateau to facilitate scientific exchanges with the LPS and the LAC. This relocation was possible only in 2019, 21 years after the creation of the LPTMS. It was the renovation of the buildings on the "petit plateau" that allowed this project to come to fruition. We are now located in the Pascal building, near the IPa, and part of the Federation Friedel Jacquinot (FFJ), a consortium of the six physics laboratories of the petit plateau.

Over the years, the arrival of new researchers has expanded into new areas such as disordered systems, cold atoms, and condensed matter, while also reinforcing existing themes, particularly in statistical physics. The initial vision of the project's promoters, coupled with the efforts of successive directors (M. Mézard, E. Trizac), has significantly increased LPTMS's presence within the university and its scientific influence. Today, LPTMS covers an impressive array of topics, ranging from integrability to quantitative biology. Alongside IPhT it stands as a major hub for low-energy theoretical physics on the Paris-Saclay campus.

The main objectives in the previous evaluation were:

1. To maintain the standard of scientific excellence and training
2. To encourage scientific interaction among the members
3. To explore new directions and projects, as well as attract new members

LPTMS successfully achieved all the objectives, and below we provide a summary table for the evaluation period, including information on lab members, their publication counts, grants received, and the number of former members who secured permanent positions.

Members	Alumni in Accademia	Publications	Grants
17 CNRS (3 IT, 4 CR, 10 DR) 6 UPSaclay (2 MC, 1 PRAG, 3 PR) 4 Emeriti 3 volunteers 38 Post Docs 52 PhD Students 36 Master Students	12 Post Docs (4 in France) 11 PhD Students (8 in France)	533 Publications (22 multi team) 60 Phys Rev Lett. (2 multi team) 39 high impact	CNRS 455 Keuro UPSaclay 170 Keuro Grants 6595 Keuro

The scientific production of the LPTMS is intense and diverse. We publish in both highly specialized journals and high-impact journals. Some articles have resolved long-standing problems, while others are exploring new directions. A measure of the impact of our work is also reflected in citations. There are at least a dozen articles written after 2018 that already have over 100 citations. Moreover, the working environment fosters collaboration, resulting in numerous papers authored by various members of the laboratory. We have counted 22 interteam publications as evidence of this collaborative effort.

The training capacity of LPTMS has improved. We had 52 PhD students during the evaluation period, bringing the total number of LPTMS PhD graduates to 113 since its inception. New research directions have been pursued across all teams. Significant contributions have come from the four junior researchers, all of whom are highly talented and active.

Unfortunately, during the evaluation period, we also experienced the departure of several longstanding members of LPTMS. Due to this turnover, the number of researchers in the laboratory remained unchanged, but our new location allows for expansion. One of the goal of the LPTMS in the upcoming period will be to attract new researchers.

The scientific project

In the coming years, the research themes identified in this evaluation period will be further developed by the individual teams.

The Quantum Systems team will focus on the following themes:

1. Quantum Chaos: This area is a domain of excellence at LPTMS. Recent developments in quantum scars, intermediate statistics, and multifractality require further understanding.
2. Cold Atoms Physics: This is another classical theme at LPTMS. Research in this field will concentrate on effects beyond mean-field interactions, as well as the physics of black holes in diluted condensates.
3. Topological Effects in Electronic Materials and Condensates: This is a timely subject on which many members will work.

The Statistical Physics, Field Theory, and Integrable systems team will focus on the following themes:

1. Rare Fluctuations and Large Deviations: A significant activity of LPTMS involves and will involve the development of methods to assess the risk of extremely rare events.
2. Polymer Physics: The spatial conformation of polymer chains is a central problem in biology that will be investigated.
3. Conformal Field Theory: The study of the non-local theories will be pursued using conformal bootstrap methods.

The Disordered Systems, Soft Matter, and Interface Physics team will focus on the following themes:

1. Quantitative Biology: An important project involves the self-assembly of geometrically frustrated objects as inspiration for the emergence of deleterious aggregates in protein aggregation diseases. Additionally, the arrival of A. Fruleux is welcomed, as Antoine is working on regulatory factors that make many biological processes well reproducible. Both projects closely collaborate with experimental groups.
2. Interdisciplinary Physics: A project is devote to a description of medical and physiological effects in sports, harnessing information from big data collected by wearable devices. A second project to the use of mean field games strategy to model human behaviour in transportation.
3. Complex Matter: The equilibrium properties of complex materials with amorphous order, long-range interactions, or hard-core interaction remain at the heart of the activity of the group.

The Physics of out-of-equilibrium systems is a cross-cutting theme that will occupy the research activities of many members of LPTMS. On the quantum front, describing dynamics after a quench or transport in a steady state is a challenge of modern physics and will engage all three teams. In particular, in integrable systems, the arrival of M. Fagotti has been a driving force behind significant activity that will continue over the next five years. The evolution of open quantum systems in the presence or absence of drives is another important theme, which has become central thanks to the arrival of L. Mazza. Concerning Statistical physics, Stochastic resetting is a topic developed during the evaluation period in the Statistical Physics, Field Theory, and Integrable systems team. It has already generated significant interest within a broad community as it allows the study of genuinely non-equilibrium stationary states. This theme also has connections with phase transitions induced by quantum measurements, a topic studied in the Quantum Systems team.

In a disordered system, equilibrium properties depend on low-energy configurations. Its dynamics, instead, depends on a complex energy landscape rich in metastable states separated by energy barriers. Describing this landscape is a major challenge that would allow characterising the dynamics of both classical and quantum disordered systems. Similar landscapes, defined in highly-dimensional spaces, are also found in other contexts. In ecology, where species are in continuous evolution, or in machine learning, where learning occurs through the minimization of a function (the loss function) defined in a multidimensional space. V. Ros is an expert in studying these landscapes. Her arrival has given a significant boost to this activity and to the interactions with computer science laboratories such as LISN.

Coherence between resources and research strategy

Regarding our resources, LPTMS is equipped with state-of-the-art computational facilities, and since the relocation, we have ample space and comfortable offices. Our administrative and IT staff ensure the best working conditions for all researchers, students, and visitors. These favourable conditions are one of the key attractions of the laboratory.

The research team is excellent and covers a wide spectrum of low-energy theoretical physics. The overlaps between the various teams and the collaborative environment enable fruitful collaborations and exchanges. A fair career progression is necessary to motivate researchers and maintain the atmosphere of the laboratory. The stagnant situation regarding the promotion of Maîtres de Conférence is critical, and the solutions found by the university are inadequate. LPTMS hopes for a change of course in the near future.

In its new location near the IPa, LPTMS has the potential to grow and become a hub for exchanges between theoretical physics, experimental physics, biology, computer science, and mathematics. Although at the beginning of the evaluation period the laboratory grew from 18 to 22 members, towards the end of the period, we decreased to 20. The return of O. Giraud will not improve the situation as S. Franz will leave the laboratory on January 1st, 2025, to teach at the University of Lecce.

LPTMS is actively seeking to attract junior scientists in all domains covered by the three teams. Particularly, there is a need to strengthen the Quantum Systems team to meet the national effort of the Quantum Plan. Additionally, there is a keen interest in establishing a stronger research line in the direction of machine learning and data science. We have several ongoing projects with computer science laboratories with PhD co-supervision. The fact that three permanent members of the LISN are LPTMS PhD laureates is another sign of our commitment. We hope to attract some junior researchers in this emerging field.