

EVALUATION REPORT OF THE UNIT

LPTHE - Laboratoire de Physique Théorique et
Hautes Energies

UNDER THE SUPERVISION OF THE FOLLOWING ESTABLISHMENTS AND ORGANISMS:

Sorbonne Université

Centre national de la recherche scientifique -
CNRS

EVALUATION CAMPAIGN 2023-2024 GROUP D

Report published on April, 10 2024



In the name of the expert committee :

Barend Van Tiggelen , chairman of the committee

For the Hcéres :

Stéphane Le Bouler, acting president

In accordance with articles R. 114-15 and R. 114-10 of the Research Code, the evaluation reports drawn up by the expert committees are signed by the chairmen of these committees and countersigned by the president of Hcéres.

To make the document easier to read, the names used in this report to designate functions, professions or responsibilities (expert, researcher, teacher-researcher, professor, lecturer, engineer, technician, director, doctoral student, etc.) are used in a generic sense and have a neutral value.

This report is the result of the unit's evaluation by the expert committee, the composition of which is specified below. The appreciations it contains are the expression of the independent and collegial deliberation of this committee. The numbers in this report are the certified exact data extracted from the deposited files by the supervising body on behalf of the unit.

MEMBERS OF THE EXPERT COMMITTEE

Chairperson: Mr Barend Van Tiggelen, CNRS, Grenoble

Experts: Ms Asmaa Abada, Université Paris Saclay (representative of CNU)
Mr Matthias Gaberdiel, ETH Zurich, Suisse
Mr Malte Henkel, Université de Lorraine
Ms Claudine Le Vaou, CNRS, Orsay (supporting personnel)
Mr Filippo Vernizzi, CEA, Gif-sur-Yvette (representative of CoNRS)

HCÉRES REPRESENTATIVE

Mr Guy Chanfray

REPRESENTATIVES OF SUPERVISING INSTITUTIONS AND BODIES

Mr Philippe Agard, Sorbonne Université
Mr Bertrand Georgeot, CNRS/INP
Ms Marjolaine Robillard, CNRS/DR2

CHARACTERISATION OF THE UNIT

- Laboratoire de Physique Théorique et Hautes Energies
- LPTHE
- UMR 7589
- Composition of the executive team: Ms Michela Petrini (director) and Mr Marco Picco (deputy director)

SCIENTIFIC PANELS OF THE UNIT

ST Sciences et technologies

ST2 Physique

THEMES OF THE UNIT

The unit studies particle physics & cosmology, string theory, mathematical physics, statistical physics & condensed matter physics at the theoretical level. Inside these four axes the activity splits up into a rich fine-structure involving (non-exhaustively) topological field theories and holography, dark matter and dark energy, development of codes that simulate events in the Standard Model and beyond, machine-learning techniques to analyse collider data, calculation of couplings and mass of the Higgs boson, holographic correspondence that recasts strongly coupled field theories to weakly coupled gravitational theory in higher dimension, compact internal spaces in high-dimensional string theory, classical and quantum integrable systems, random geometries, random matrices, random walks, entanglement entropy, frustrated magnetism, Dirac-like systems such as graphene, decoherence-protected qubits.

HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

The LPTHE was created in 1967 by Maurice Lévy and others, on the newly built Jussieu campus. It was originally focussed to high-energy physics, today the unit studies many different subjects in theoretical physics. It is situated on two floors between towers 13 and 14 on the Campus of Sorbonne University. Except for the major renovations at the Jussieu Campus, the unit did not suffer from recent renovation works.

RESEARCH ENVIRONMENT OF THE UNIT

The LPTHE is supervised by national CNRS and local Sorbonne University which is also the owner of the premises. The unit plays a major role in the local research Federation FRIF (Fédération de Recherche sur les Interactions Fondamentales) together with several other teams or units at LPENS, LPNHE, IAP, APC and LERMA. Until 2019, a labex (Laboratory of Excellence, an ANR structuring project) Lagrange existed involving some of these units. This labex was replaced recently by the Initiative Physique des Infinis created by Sorbonne University covering nine units working on the physics of high-energy, space and plasma. Most PhD students are associated with the Doctoral School EDPIF (École Doctorale en Île-de-France), and less to the Doctoral School STEP'UP ("Earth and Environment Science and Physics of the Universe in Paris"). The LPTHE shared computer facilities with nearby units but today runs its own network. In 2020 an International Research Network (IRN) "Quantum Field and Strings" was created by the CNRS, and is directed by a member of LPTHE. At almost the same spot of the LPTHE at the Jussieu Campus, another theoretical physics unit exists - LPTMC (Laboratoire de Physique Théorique de la Matière Condensée), also supervised by SU and CNRS and with similar work force - that is more dedicated to "low energies" though with an activity on several similar topics, close to the 4th axis of LPTHE.

UNIT WORKFORCE: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	5
Maitres de conférences et assimilés	3
Directeurs de recherche et assimilés	9
Chargés de recherche et assimilés	6
Personnels d'appui à la recherche	2
Sous-total personnels permanents en activité	25
Enseignants-chercheurs et chercheurs non permanents et assimilés	7
Personnels d'appui non permanents	0
Post-doctorants	7
Doctorants	29

Sous-total personnels non permanents en activité	43
Total personnels	68

DISTRIBUTION OF THE UNIT'S PERMANENTS BY EMPLOYER: in physical persons at 31/12/2022. Non-tutorship employers are grouped under the heading "others".

Nom de l'employeur	EC	C	PAR
CNRS	0	15	2
Sorbonne Université	7	0	0
Autres	1	0	0
Total personnels	8	15	2

GLOBAL ASSESSMENT

The LPTHE is a research unit working on theoretical and numerical physics. It has an excellent record of scientific output, both in quantity, quality and topical diversity, and benefits from a worldwide visibility. Its staff members take large responsibilities in various instances in- and outside the perimeters of the two authorities Sorbonne University and CNRS. The committee wants to insist on the excellent and visionary governance of the unit during turbulent times characterized by the Covid pandemic and by many arrivals and departures.

Four research axes exist that cover a broad continuum of topics and methods in theoretical physics. Officially, staff members are not assigned to axes, but in practice (that is, in self-assessment document and during interview) one gets nonetheless the impression that axes represent teams. All four axes produce excellent science and show engagement. Nevertheless, the axis on mathematical physics exhibits an unbalanced age profile and has insufficient work force. The committee supports a reorganisation of this axis such as the one envisaged by the unit director. In view of the upcoming opening of a position of "Maitre de Conférences" at Sorbonne University in 2024 this is an urgent matter that requires immediate proactive action.

Research highlights of the Particle Physics and Cosmology theme include the automation of the calculation of the next-to-leading order electroweak corrections, the derivation of a set of benchmark scenarios for the Minimal Supersymmetric Standard Model and new bounds on primordial black holes. Research highlights of the string theory theme include the analysis of flux backgrounds and non-geometrical compactifications, as well as precision tests concerning the counting of black hole microstates. Research highlights of the mathematical physics theme include the study of finite-size corrections to the entropy equipartition of symmetry-resolved entanglement entropies, as well as new exact results for the density matrix of the XXX spin chain. Among the highlights in statistical and condensed matter physics one can identify the study of the dynamics and motility-induced phase separation of two-dimensional many-body models for assemblies of living or synthetic self-propelled constituents ("active matter"). A second highlight reports the discovery of predicted supersymmetry in the 5-dimensional Random Field Ising Model of interacting spins, work done in collaboration with Nobel-laureate G. Parisi.

The Committee strongly supports the endeavour undertaken by Sorbonne University to foster the promotion of "Maitre de Conférences" with theoretical profile to "Professeur" level (PR2) and is convinced that several staff members at LPTHE are eligible. The Committee also applauds the attribution of a Junior Professor Chaire (CPJ) by Sorbonne University to LPTHE in 2024 and the strong engagement of CNRS to secure the fragile administrative support. This testifies the strong and essential support provided by the two authorities to LPTHE.

The training through research of young scientists provided by LPTHE is impressive, both at Master and PhD level. Some staff members are successful in outreach, and the Committee agrees with the self-assessment of LPTHE that room exists for improvement.

DETAILED EVALUATION OF THE UNIT

A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

Concerning the scientific production, the recommendations were: "Recent and impending departures are resulting in serious challenges for the Mathematical Physics and String, Branes and Fields Themes. It is urgent that these outstanding groups be reinforced without delay. "; "Research support, especially through labex ILP and idex, is vital for maintaining the high level of scientific activity in the lab."

Among five fresh recruitments (three in first axis on Particle Physics/Cosmology, two in second axis of String theory) three left LPTHE immediately for various reasons, among which a former postdoc of the Particle Physics/Cosmology team of the first axis who preferred to take a position in Bologna. One senior CNRS researcher arrived in third axis on Condensed Matter after a change of affiliation. One more CNRS researcher in String theory left LPTHE after ten years to return to Australia. Two members of this team retired, only one asked for CNRS emeritus. One member of the third axes Mathematical physics retired and left LPTHE. A recent recruitment at CNRS took place in 2023, at the interface of String Theory and Mathematical Physics. The labex Lagrange came to an end in 2019 and was replaced by an "Initiative Physique des Infinis" that also includes space and plasma physics and is considered by the LPTHE to be less adapted to their needs.

Concerning the organization and Life: "Promises were made to open a professorship for an outstanding female member of the lab. For many reasons this promise must be kept." A professorship was created for an outstanding female of the lab (on dark matter physics) at Sorbonne University but the laureate decided to move to LPENS in 2022.

"The administrative staff is functioning extraordinarily well but needs reinforcement after the departure of one of the staff. This is a very high priority. Likewise professional Information Technology support, which is currently non-existent, must be provided." The last contract has been turbulent for both administrative and IT support at LPTHE, with large turn-over. On the administrative side, the LPTHE is supported by one administrator and one secretary. However, during this term there has been a strong turnover of three administrators: one left to get a promotion and was appointed in a bigger unit, the second was not adapted for the responsibility, and a third administrator was appointed. On the IT side, the LPTHE benefitted from a support with temporary contract (CDD) and a recruitment on IE level shared with the neighbour laboratory IMPMC (and also appointed to IMPMC). Both left in 2022, the CDD left to the private sector.

The secretary left in June as she retired. A new recruitment for administrative support arrived in January 2022 and a secretary has been hired recently on a temporary contract until the new permanent recruitment arrives in December 2023. The IT service is currently self-supported by three research staff members. This emergency solution has the satisfaction of LPTHE, but is not desired and fragile in turbulent times. The shortage of IT staff highlights a problem encountered in most other units in Paris Centre.

"Alternative arrangements for student offices should be explored." No more space has become available and seven emeritus researchers were kindly requested to liberate space. Peak periods exist when many Master students arrive for internships. The LPTHE can handle them as they arise with the current space available, but is afraid to have space requisitioned by SU to be used for other purposes.

"The committee strongly endorses the incoming director's proposals for streamlining the governance structure of the lab". Nothing to report.

The ideas presented about developing outreach programs should be implemented. The LPTHE is active in outreach but agrees that "room for improvement exists".

"The committee encourages the development of a long-term policy concerning university appointments."

This recommendation is clearly shared by the unit as well as by both present and former assessment committees but such long-term strategy entirely depends on Sorbonne University that has many constraints to deal with "repyramidage", ERC promotions, promotions of "Maitres de Conférences" ...).

"The promotion of many outstanding assistant professors should be a very high priority. Until this occurs, they should be encouraged to apply for CNRS delegations and IUF positions. The lab should support these applications as strongly as possible".

The LPTHE agrees and supports where it can but, again, promotions are decided elsewhere. To avoid this problem in the future, the LPTHE director proposes to recruit more directly on "Professeur" (PR2 level). Sorbonne University fosters the promotion of "Maitres de Conférences" with theoretical profile.

B - EVALUATION AREAS

EVALUATION AREA 1: PROFILE, RESOURCES AND ORGANISATION OF THE UNIT

Assessment on the scientific objectives of the unit

The main scientific objective of the LPTHE is to provide a broad spectrum of fundamental research in theoretical physics, classified in four main axes, and to establish a "continuum" between them as much as possible. This is an admirable and ambitious challenge that has been quite successful for a while, though also risky especially because the huge and growing diversity may dilute the focus. This objective is also fragile against departures and arguably not compatible with today's funding policy that tends to favour individuality and research "useful to society" rather than shared unit action and fundamental research.

Assessment on the unit's resources

The recurrent funding from CNRS and Sorbonne University remained stable between 2017 and 2021 at around 120 k€ and has increased by nearly 20% in 2022 to 144 k€. A part of the recurrent funding is used to cover the stipendia of the Master interns. External funding by grants remained stable from 2017 to 2021 and increased in 2022 due to the acquisition of external funding by the Particle Physics and Cosmology team. The grants are primarily funded by the National Research Agency (11 ANR) and the European Union (3 ERC). In 2022, own resources became almost 10 times larger than recurrent funding from the authorities. This is a very favorite situation, although it brings along extra administration that is fragile and precarious at LPTHE. It also poses the question of sustainability. Own resources differ a lot between the four axes: from 0 over the last two years for the Mathematical Physics to almost 1 M€ in 2022 for the axis on Particle Physics & Cosmology. No official policy exists to take overheads on external grants and share, but punctual actions do exist if needed.

Assessment on the functioning of the unit

The management team of LPTHE, composed of a director, a deputy director, and an administrative manager, is assisted by a laboratory council that meets approximately four times a year. The laboratory council is composed of five elected members (2 CNRS researchers, 2 research professors from Sorbonne University, and one PhD student) and more or less acts as an executive management team that supports the governance in dealing with practical matters. General Assemblies are organized every two months to discuss and decide recruitments and research strategies. Seminars are also jointly organized with other laboratories in the Paris region, but no regular LPTHE seminar exists, only a shared Tea break.

The functioning of the administrative desk is good but fragile. With two administrative supports from CNRS - with however large turn-over - and with no Information Technology (IT) support at all for 21 permanent researchers (compared to the above Table 2 CNRS researchers are actually on leave) this implies a ratio 11:1, not even counting seven emeritus members. Hence, support can be said to be as critical as it was five years ago. The current administrator is member of section 07 of the National Committee of Research (CoNRS, category C).

1/ The unit has set itself relevant scientific objectives.

Strengths and possibilities linked to the context

The extremely broad spectrum of themes and the increasing share of theoretical tools in theoretical physics are positive points. Many themes are conducted on a high scientific level and supported by many collaborations outside LPTHE. The unit succeeds to keep them attractive for young researchers. An opportunity exists to highlight more attractive and contemporary topics, such as decoherence, quantum information, quantum gravity, dark matter, active matter and supersymmetry, that are now too much hidden behind scientific axes that display "business as usual".

Weaknesses and risks linked to the context

The unit suffered from many departures - retirements, mobilities, on-leaves, which makes it difficult to maintain a broad spectrum of activities. The number of emeritus researchers (7 for 21 active researchers) is large. This may eventually hamper scientific innovation, and make it more difficult to create precious space for students and new recruitments.

2/ The unit has resources that are suited to its activity profile and research environment and mobilises them.

Strengths and possibilities linked to the context

Throughout the period, the LPTHE secured external funding beyond its institutional support, mainly through calls for projects from Europe and ANR. An internal support program for the development of European projects was established and proved successful, as it led to the funding of an ERC Consolidator Grant in 2020 and an ERC Starting Grant in 2021 thereby increasing the unit's own resources budget.

Occasional scientific collaborations exist with the direct neighbour LPTMC (Laboratoire de Physique Théorique et de la Matière Condensée), which constitutes an opportunity, especially for Axis 4 on statistical physics.

Weaknesses and risks linked to the context

Not all four axes are equally wealthy in own resources, and external resources are often difficult to share: three ERC grants concern the first axis on particle Physics & Cosmology (2 on dark matter, 1 on QCD). Among eleven ANR projects funded, five are in this same axis, two in the axis on strings, and four in the axis of statistical & condensed matter physics.

The administrative team is currently composed of two people (an administrator and a secretary employed by CNRS). The team also supports the activities of the Federation FRIF. The separate roles of secretary (day-to-day management) and administrator (contracts and human resources) were very well defined but after the turbulent turn-over in 2023 this slightly faded away. The initial administrator, unable to secure a promotion, chose to leave the laboratory to join the neighbour unit-IRCP (Institut de Recherche de Chimie de Paris). She was replaced in January 2019 by someone who did not meet expectations of LPTHE and left for LPNHE. A third administrator was hired in January 2022. The secretary, who had been around for 10 years, retired in 2023 and was replaced by a temporary contract employee who did not stay either, and a new person with temporary contract has been appointed by CNRS. The administrative service's situation can be said to be fragile and precarious.

In 2019, CNRS allocated two permanent IT positions to create an Information Technology (IT) team shared with another laboratory (IMPMC) on the Jussieu Campus. However, one of the two positions remained unfilled, and a temporary contract employee was recruited in 2021. Unfortunately, the permanent IT staff member faced difficulties and the contract employee obtained a permanent position elsewhere; both left LPTHE in 2022. Since then, the management of the LPTHE's network has been taken up voluntarily by three permanent researchers, which seems to suit the LPTHE. The absence of an IT engineer poses a real risk to the unit's cybersecurity and constitutes a significant extra work load for the research staff.

3/ The unit's practices comply with the rules and directives laid down by its supervisory bodies in terms of human resources management, safety, environment, ethical protocols and protection of data and scientific heritage.

Strengths and possibilities linked to the context

The LPTHE takes the values of gender equality and non-discrimination during recruitments seriously. The present director of the unit is gender equality officer for the entire Sorbonne University and her global view at Sorbonne University is a real asset.

The administrator has been appointed as the prevention assistant for the unit after the necessary training. She works in collaboration with the supervising authorities to inform staff about the instructions to follow and about evacuation schemes during exercises.

The unit is ready to analyse and to reduce its carbon footprint and to establish rules to reduce traveling, but no concrete plan exists for the moment.

Weaknesses and risks linked to the context

A huge struggle exists to get promotions for Assistant Professors and to attract IT staff.

The absence of an IT engineer poses a significant risk in terms of system development and updates, and could have negative consequences on data security. Gender parity (13% female) is lower than physics on average (20%), but is hardly different in other units on theoretical physics.

EVALUATION AREA 2: ATTRACTIVENESS

Assessment on the attractiveness of the unit

The unit continues to be remarkably attractive scientifically despite the increasing cost of life in Paris.

- 1/ The unit has an attractive scientific reputation and is part of the European research area.*
- 2/ The unit is attractive because for the quality of its staff support policy.*
- 3/ The unit is attractive through its success in competitive calls for projects.*
- 4/ The unit is attractive for the quality of its major equipment and technical skills.*

Strengths and possibilities linked to the context for the four references above

Explicit indicators for scientific attractivity are the large number of (international) visitors (150) during the period 2018-2022, the large number of PhD students (53) and postdocs (28) that have worked at LPTHE. Many members of LPTHE have international collaborations. During the evaluation period two ERC grants have been obtained and eleven ANR grants (and one ERC Starting Grant finished in 2018), several international PICS programs started and /or finished, showing a large success rate in competitive calls. Two SU faculty members obtained IUF support. Many members of LPTHE are active in the organisation of conferences and workshops (around 70 during the period of assessment) and contribute to the peer assessment of science either in editorial boards of journals (25, such as EPJC, JHEP, Scipost, J.Phys.A...) or in panels of funding agencies and assessment instances (roughly 70, such as ERC, Marie-Curie, Region IdF, several research councils in Europe, Comité National de la Recherche, Hcéres etc.). More than 300 invited lectures have been delivered during the assessment period.

More than 300 invited lectures have been delivered during the assessment period.

Weaknesses and risks linked to the context for the four references above

The administrative support provided by two CNRS full-time staff members has been difficult and turbulent since the departure of the long-serving administrator in 2019. Even though a new administrator was finally appointed in 2022, the experienced secretary ("gestionnaire") retired in 2023. During the interview, the administrative support at LPTHE was clearly insufficient and precarious, and needs urgent consideration. A temporary support is currently provided by the Délégation Paris Centre to validate travels missions supported by CNRS resources.

This problem is not specific for LPTHE and is a manifestation of the general difficulty in recruiting research support staff ("PAR"), due to the cost of living in the Paris area. The LPTHE did not benefit from the newly created "Initiative Physique des Infinis" as the successor of the former labex structure Lagrange that was much more adapted to the (postdoc) demands of the LPTHE. This is regrettable in view of the high quality of LPTHE.

EVALUATION AREA 3: SCIENTIFIC PRODUCTION

Assessment on the scientific production of the unit

The LPTHE has produced 549 publications in peer-reviewed journals between 2017 and 2022 with a large diversity in themes. For 21 active ETPR ("équivalent temps plein recherche", counting university staff as 0.5 ignoring 2 IUF members with reduced teaching load, and CNRS staff as 1) and seven still active emeritus (estimated as ETPR = 0.5), this comes down to 3.2/year/ETPR, which is large compared to the national average of roughly 2. Among these publications 140 can be found in high impact journals such as Nature, Phys. Rev X, Phys. Rev Lett., and many JHEP and JCAP. There were 21 PhD graduations, that is roughly 1 per habilitated researcher (24 HDR, including emeritus). At the time of evaluation, 36 postdocs and PhD were present, that is 1.7 per research staff member. The LPTHE produced fourteen publicly available codes (among which is worth mentioning the highly cited and continuously updated "Poor Particle Physicist Cookbook for Dark Matter Indirect Detection") and seven textbooks. These numbers indicate a healthy scientific output.

- 1/ *The scientific production of the unit meets quality criteria.*
- 2/ *The unit's scientific production is proportionate to its research potential and properly shared out between its personnel.*
- 3/ *The scientific production of the unit complies with the principles of research integrity, ethics and open science. It complies with the directives applicable in this field.*

Strengths and possibilities linked to the context for the three references above

All publications are published in high quality peer-reviewed journals, 25% in journals with high visibility. They are all available in full text in the HAL repository (and for the papers in High Energy Physics, displayed by INSPIRE). Roughly 30 publications appeared in Diamond Open Access journal such as CRAS and SciPost (two staff members of LPTHE are part of the editorial board of Scipost). Codes developed in particle physics and Cosmology are publicly available. Many data are openly available at GitHub.

No inactive researchers have been identified and also the seven retired scientists with emeritus status are active.

Weaknesses and risks linked to the context for the three references above

Some but few inter-axis publications exist, despite the eagerness of LPTHE to define scientific axes to fill a continuum of topics. The large number of different subjects constitutes a risk of dilution.

EVALUATION AREA 4: CONTRIBUTION OF RESEARCH ACTIVITIES TO SOCIETY

Assessment on the inclusion of the unit's research in society

No official policy exists to define and execute the role of the LPTHE in society. Actions in popularization of physics do exist on a more individual basis, such as the participation in the annual "Fête de la Science" on the Jussieu Campus. As a theoretical research unit with activity centred on fundamental physics, the interaction with the economic world is not developed.

- 1/ The unit stands out for the quality and the amount of its interactions with the non-academic world.*
- 2/ The unit develops products for the cultural, economic and social world.*
- 3/ The unit shares its knowledge with the general public and takes part in debates in society.*

Strengths and possibilities linked to the context for the three references above

Among the 53 PhD students that have been trained by LPTHE, 40% find jobs in industry mostly as data-scientist. Significant outreach activity happens.

Weaknesses and risks linked to the context for the three references above

Outreach varies a lot from one theme to another and will be discussed separately below.

ANALYSIS OF THE UNIT'S TRAJECTORY

The new term will be characterized by a reorganisation of the axes that is being debated among the staff members with no current consensus. This Committee has made a recommendation for the axis on mathematical physics, for which a new strategy is urgent. At the "Comité National de la Recherche" some changes may take place. Section 01 (particle, nuclear and high energy physics) might split off the activity on nuclear physics and some (CNRS) theoreticians in high energy physics, currently affiliated with section 02 of theoretical physics, might want to move to section 01. This may have some repercussions on the way that LPTHE as a whole interacts with CNRS, but no major strategic changes are expected. All axes have proposed new topics to be studied. Some good yet ambitious plans exist: The LPTHE wants to foster its link with the national "Plan Quantique", reinforce "machine-learning" as a theoretical tool, and be more active in outreach.

RECOMMENDATIONS TO THE UNIT

Recommendations regarding the Evaluation Area 1: Profile, Resources and Organisation of the Unit

The major efforts undertaken during the last term to secure administrative support need to be continued. Even if current Information Technology (IT) support, provided by own staff members, suits all members of LPTHE, a more sustainable solution is desired. The LPTHE is encouraged to formulate a plan to monitor and reduce its carbon footprint.

The LPTHE has chosen to organize their research into four axes with - officially - zero hierarchy and zero assignments of work forces. The Committee does not want to make a formal recommendation on this choice. Nevertheless, an opportunity exists to exploit the four axes to create a more vertical organisation of the unit. This would simplify the identification of needs in staff and financial support per axis by the unit director, without jeopardizing inter-axes activity.

The Committee recommends to continue collaboration with surrounding units such as LPNHE and LPTMC.

Recommendations regarding the Evaluation Area 2: Attractiveness

The promotion of the several excellent "Maitres de Conférences" of the unit is urgent. The LPTHE should continue the strong support for promotion requests.

A new organization of the axes is desirable, for the mathematical physics axis in particular. This issue is urgent since the LPTHE should prepare the recruitment of a "Maitre de Conférences" in 2024.

Another high priority is to address the funding problem for postdocs and students. In the past many of them were hired under the labex ILP, but this has now been replaced by IPI (high energy + plasma physics) and the success rate is significantly lower. The committee encourages the LPTHE to pursue all funding opportunities - including ANR - to improve this situation.

Recommendations regarding Evaluation Area 3: Scientific Production

Continue the excellent work, in all four axes.

Recommendations regarding Evaluation Area 4: Contribution of Research Activities to Society

The committee supports the aspiration of LPTHE to be even more active in outreach.

THEME-BY-THEME ASSESSMENT

Theme 1: Particle physics and cosmology

Name of the coordinator: Mr Pietro Slavich

TOPICS OF THE THEME

The theme focuses on studying the Standard Model of Particle Physics and its extensions, covering a wide range of topics from phenomenology to more formal aspects. This involves precise calculations of collider processes and observables in the Standard Model and beyond for some known extensions with predictions for both the LHC and future colliders, along with the investigation of dark matter and astroparticle phenomenology, including indirect dark matter detection, and the exploration of supersymmetric models.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

From the previous report:

The group's focus on "energy frontier" physics, which is currently one of its strengths, could evolve into a weakness, if progress in particle physics occurs primarily in other areas. There is one permanent member involved in astroparticle physics, and minimal activity in topics related to cosmology or the intensity frontier. We encourage the theme to explore the prospects of diversifying its activities.

The University's commitment to open a professor position in astroparticle physics in 2020 for a promising female long-term postdoc in the group will consolidate the dark matter activities of the group. This commitment should be maintained.

The theme has several postdoctoral fellows and an active visitor programme, which are crucial features for a theory group. These visitors are funded with project money from the labex ILP, the ERC or ANR, which is coming to an end. Hopefully theme members will continue to be successful in applying for ANR and ERC grants. The laboratory should make every effort to support this visitor program in order to maintain the health and attractiveness of this theme. In particular, an extension of the labex ILP would be desirable. It is also important that local administrative support and office space be available for these visitors.

In the particle physics area, efforts have mainly been devoted to the energy frontier, and activities on the intensity frontier have remained small. One CNRS researcher working in astroparticle/cosmology joined LPTHE during the previous evaluation period. However, he left for a position in Italy in 2022. After having occupied a Chair position shared with Nikhef in Amsterdam, one member of the theme was awarded an ERC-advanced in 2021, and appointed Professor by SU. However, she decided to move to LPENS in 2022. These departures have weakened the cosmology/astroparticle area.

The axis has been successful in obtaining fundings such as ANR and ERC grants and in maintaining a rich visitor program.

WORKFORCE OF THE THEME: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	2
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	3
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	7
Enseignants-chercheurs et chercheurs non permanents et assimilés	1
Personnels d'appui non permanents	0
Post-doctorants	3
Doctorants	5
Sous-total personnels non permanents en activité	9
Total personnels	16

EVALUATION

Overall assessment of the theme

The group is productive and visible: it has published more than 200 papers during the reference period. It has educated a large number of PhD students (16), supervised many master and bachelor students (40), and hosted fifteen postdocs.

During the 2017-2022 period, the team members achieved important results. For instance, they obtained high-precision predictions crucial for the Large Hadron Collider (LHC) and for future colliders; they worked out the automation of the calculation of the next-to-leading order electroweak corrections to Standard Model predictions at colliders; they obtained a set of benchmark scenarios for the Minimal Supersymmetric Standard Model, illustrating various aspects of Higgs phenomenology at the LHC; they established new bounds on primordial black holes from the data of the Voyager-1 spacecraft; they derived the equations of motion for states with a spin higher than one propagating in an electromagnetic background. Another tangible outcome was the development and maintenance of numerous (14) codes beneficial to the community, some allowing to automate the interpretation LHC results in beyond the Standard Models, including the treatment of long-lived particles of any kind.

The group cultivated a vibrant research environment, evident from the influx of visitors and postdocs. Additionally, it has been active in organizing many (49) important scientific events, in writing outreach blogs, articles and books, and in outreach activities such as the project Declics Lycée. The group recently suffered from the departure of two members in astroparticle/cosmology, and is in need of new hires. Several grants were secured and leveraged during the reference period, but at present, only one team member leads one ANR grant and one ERC grant.

Strengths and possibilities linked to the context

The strength of this research theme lies in the quality, commitment, and visibility of the researchers. Their quality is evident from substantial contributions to collider physics, astroparticle physics in and beyond the Standard Model of Particle Physics during the reference period, resulting in over 200 publications, many of which had a significant impact. Notably, their predictions in areas such as Higgs phenomenology in the minimal supersymmetric Standard Model and their constraints on primordial black hole dark matter have been highly impactful. Most of the team members have made such widely recognized contributions in the competitive area of collider physics that many of the scenarios and analyses they have proposed are currently used in experimental analyses.

Weaknesses and risks linked to the context

Members of the theme were successful in securing funding through grants, including ERC and ANR. These grants played a vital role in sustaining the theme's activities, such as conferences, hosting visitors, and supporting postdocs. Most of these grants have ended during the reference period. Only one person presently leads one ERC and one ANR grant. Securing new funding is essential to continue these activities at the same place.

The age distribution among permanent staff remains well-balanced. However, two young members in the astroparticle research area have left. It will be crucial to fill these recent vacancies to maintain the cosmology/astroparticle research field on a strong level.

Activities in phenomenology of particle physics focus mostly on high-energy observables (colliders), whereas it would be desirable to enlarge the study also to high-intensity observables which could provide complementary information.

Analysis of the theme's trajectory

SU will probably open a Chair Professeur Junior in cosmology and dark matter, which should come with a postdoc or PhD student position. SU also ensured a two-year postdoc in the dark matter topic. This opportunity will be used to reinforce the astroparticle/cosmology sector of the axis.

RECOMMENDATIONS TO THE THEME

Strengthen the astroparticle/cosmology activity through new recruitment. Continue to be active in securing fundings.

Theme 2: Strings, branes and fields

Name of the coordinator: Mr Boris Pioline

TOPICS OF THE THEME

The theme focuses on a large spectrum of topics in theoretical high-energy physics, ranging from the most fundamental and mathematical aspects of string and quantum field theory to phenomenological applications in particle physics and cosmology. The problems that were addressed during the last five years include, among others, the analysis of flux backgrounds and non-geometrical compactifications as well as precision results about the counting of black hole microstates on the fundamental side, while on the more phenomenological side inflation by supersymmetry breaking and dark dimensions were studied.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The recommendation of the previous report to reinforce the group has been implemented with the hiring of CNRS researcher.

WORKFORCE OF THE THEME: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	2
Maitres de conférences et assimilés	1
Directeurs de recherche et assimilés	1
Chargés de recherche et assimilés	1
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	5
Enseignants-chercheurs et chercheurs non permanents et assimilés	2
Personnels d'appui non permanents	0
Post-doctorants	3
Doctorants	9
Sous-total personnels non permanents en activité	14
Total personnels	19

EVALUATION

Overall assessment of the theme

The String theory theme consists of seven people, of whom two retired during the evaluation period and one is about to retire (ETPR= 5.0). The group (i.e., theme or axis) productive and visible: it produced more than 120 papers (4 publications/year/ETPR). It has educated a large (16) number of PhD students, and hosted six postdocs.

The group members have a high reputation on a worldwide level, and have written important and influential papers during the period in question. For example, they have proposed an extra dark dimension which seems to fit naturally into the Swampland Conjecture; they have used generalised geometry methods to solve long-standing problems in supergravity; they have made remarkable progress towards understanding higher genus superstring amplitudes as well as BPS indices, using refined mathematical methods; they have found interesting non-geometrical compactifications; and finally they have managed to prove the Split Attractor Flow conjecture for one interesting model.

The group is embedded in the vibrant theoretical physics environment of the Paris area and is active in organizing seminar series and conferences. In addition, the group has an active visitor program which contributes substantially to its intellectual vitality.

Strengths and possibilities linked to the context

The most important strength of the axis is the high quality of its scientific staff, reflected by the high quality of the research produced and the excellent student supervision. The location of the group in Paris is, of course, a great asset, as is its long tradition of excellence.

Weaknesses and risks linked to the context

The most visible weakness in the group is the departure of several researchers (retirement or transfer) which has only been compensated by a single permanent position, pushing the group below its critical mass.

In addition, the group did not recently succeed to attract project money to hire postdocs; this is unfortunate, given the obvious strength of the group.

Analysis of the theme's trajectory

The string group continues to perform at a high level. The team is prominently involved in the International Research Network (IRN) "Quantum Field and Strings" which will guarantee that it will remain internationally very well connected. To strengthen the group further (after the recent departures) it would be very desirable if the new MC position in Mathematical Physics could be filled with a candidate who also has research interests in String Theory.

RECOMMENDATIONS TO THE THEME

The arrival of a CNRS researcher has had a positive impact, but given the fact that recently three members of staff have retired (and one is about to retire), the moment has come to ensure that the group continues to excel. The hiring of two researchers was about to make this happen, but unfortunately they both left. The need to recruit thus still exists.

Theme 3: Mathematical physics
 Name of the coordinator: Mr Yacine Ikhlef

TOPICS OF THE THEME

Rich activities are organised around the theme of classical & quantum integrability. This covers works on 1D quantum systems focussing on exact correlators & studies of the entanglement entropy; geometric studies in statistical mechanics focussed on the fractal properties of critical interfaces and on random geometry; combinatoric questions such as the Horn's problem, the computation of Littlewood-Richardson coefficients and partition function on surfaces of higher genus; foundations of quantum-field theory notably form factors and their use in perturbed conformal field-theories as applied to specific models (Toda chains). Finally, discrete dynamical systems have been investigated, notably discrete Painlevé equations and the characterisation of those systems using the algebraic entropy.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

From the previous report:

"The main weakness in the group is the departure or the retirement of several excellent scientists (although retired members are still present as emeritus) while only one junior (CNRS) member has been hired in 2012. One should also note the (quasi) absence of the middle-generation in the group.

It is certainly urgent to use the outstanding expertise and attractiveness of the senior members of the group to develop an active policy of recruitment for example in the direction of quantum integrable models and their applications. This should not be delayed any further as within five years, other members will retire or be very close to retire. A professor position at the University and a junior (CNRS) position would be the minimum necessary input to guarantee the future of the group."

Efforts made in hiring a young researcher to strengthen the mathematical physics group have so far not been successful. The situation might, however, improve after the recent arrival of a new research faculty, who may decide to join the mathematical physics axis. In any case, the age imbalance of the group has now become even more acute, and it is urgent to reinforce the group without delay, using all possible means.

WORKFORCE OF THE THEME: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	2
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	4
Enseignants-chercheurs et chercheurs non permanents et assimilés	3
Personnels d'appui non permanents	0
Post-doctorants	0
Doctorants	2
Sous-total personnels non permanents en activité	5
Total personnels	9

EVALUATION

Overall assessment of the theme

The Mathematical Physics axis is highly recognised world-wide, with several outstanding scientists among its members. Currently, the axis houses no faculty members and consists of three CNRS researchers and three emeriti, and five PhD thesis have been prepared. However, two CNRS researchers are about to retire, and the axis therefore has an unbalanced age profile and is about to become sub-critical. Given that this state of affairs has now endured for quite some time - the repeated struggle to recruit new young researchers in the axis has not been successful so far - the very existence of this axis is jeopardized.

Strengths and possibilities linked to the context

The group has high scientific reputation. The outreach and breadth of themes that are actively studied is impressive.

Weaknesses and risks linked to the context

The group is clearly sub-critical. Two of its three active members have reached the age of retirement and will likely retire in the period of the next contract. Following repeated recommendations, attempts have been made to hire new staff members, but they have so far not been successful. There is a very recent hiring of a young researcher with a profile compatible with this axis; however, since he actually has a multi-axis profile his final orientation has not yet been settled. Given this situation, it is unclear whether an independent axis "Mathematical Physics" will be sustainable in the future.

Analysis of the theme's trajectory

Given the upcoming retirements and the already small work force present in this axis, its trajectory is fragile and not sustainable without the hiring of new staff members. An opening for assistant professor (Maitre de Conférences) at SU is announced and may save the future of this axis.

RECOMMENDATIONS TO THE THEME

Maintaining the axis "Mathematical physics" and its long-standing scientific tradition has always been a top priority for LPTHE. In view of the sub-critical size of this axis, it appears to be important to strive at a re-organisation of the activity on Mathematical Physics. Doing so within the current structure would require to hire more than one young researcher. A useful alternative might be to incorporate the mathematical physics activities into the axes on string theory and condensed matter. Given the already existing collaborations across axes this would not really imply a change in scientific policy.

It would be desirable if the axis could be supported by postdocs (e.g. via ANR projects), and the group members should think about ways of enabling that.

The Committee recommends the axis to start an active preparation for the job-opening of an assistant professor (MC) at SU.

Theme 4: Statistical physics and condensed matter physics

Name of the coordinator: Ms Leticia Cugliandolo

TOPICS OF THE THEME

The activity of this team is characterized by a huge diversity in topics such as stochastic processes among which random (Lévy) walks, critical percolation during continuous phase transitions in classical Ising and Potts models, Renormalization Group theory (applied to polymerized membranes), modelling of active matter, thermalization of integrable systems in large dimensions, largest eigenvalues of large random matrices, supersymmetry (of Random Field Ising Model in 5 dimensions), conformal field theory, entanglement entropy, Dirac fermions, decoherence of qubits in superconductors and their protection against it, skyrmion lattices of fermion and fractional quantum Hall effect. The methods used are also numerous and are both of analytical and numerical nature.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

As usual in France, it is very difficult to obtain funding for post-doc positions. The ANR with its very low mean success rates (even lower for theoretical projects without immediate industrial applications) cannot be considered a reliable source and the effort required to obtain this funding can often exceed its benefits.

Despite this disfavoured situation that still persists as an external threat, the axis 4 has been quite successful in national and regional calls for tender (4 ANR grants, one PICS) and managed to recruit eleven PhD and four postdocs.

The fight against missing means (« manque de moyens ») is a constant struggle in all research laboratories in France.

During the assessment period, the axis did not suffer from missing means.

There is the possibility of personnel changes in this group. If these were to occur, reinforcement action would be required.

One member retired and became emeritus, and two members working on qubits and quantum technology (one CR and one DR CNRS) left on-leave to Google and are not likely to return. No fresh recruitment at CNRS or SU have occurred during the assessment period but one DR CNRS moved from LPTMS in Orsay to join the LPTHE. With three faculty members, three CNRS researchers and one active emeritus, the reinforcement action is so far not urgent.

WORKFORCE OF THE THEME: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	1
Maitres de conférences et assimilés	2
Directeurs de recherche et assimilés	3
Chargés de recherche et assimilés	0
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	6
Enseignants-chercheurs et chercheurs non permanents et assimilés	1
Personnels d'appui non permanents	0
Post-doctorants	1
Doctorants	11
Sous-total personnels non permanents en activité	13
Total personnels	19

EVALUATION

Overall assessment of the theme

Axe 4 currently houses three faculty members of Sorbonne University (among which the leader that benefitted from a senior IUF dispense), three senior CNRS researchers (among which 1 arrived in 2021), two CNRS researchers have left on a permanent leave in 2019 and 2021, and a still active emeritus CNRS researcher. With this varying configuration, we estimate a research force equivalent to ETPR = 5 on average during the assessment period 2017-2022. With around 120 peer reviewed publications in HAL this implies four publications/ETPR/year, which is much larger than the national average of 2. Several members of the axis are often invited in international events and strongly involved in international collaborations. Especially one member is actively involved in many international Steering Committees.

The large variety of topics and methods is remarkable. One member works on (reduced) QED which is part of Dirac physics but to some extent outside the axe perimeter. No less than 8 PhD students have been or are (co-)supervised during the assessment period for six habilitated axis members. The scientific productivity and international visibility are both excellent.

Strengths and possibilities linked to the context

The axis has managed to evolve their rich variety of themes to modern topics such as Dirac fermions, active matter and quantum entanglement entropy. It has a good equilibrium between faculty members (among which one senior IUF with reduced teaching load) and CNRS researchers and is therefore well connected to the Master courses at ENS and Sorbonne University. One member is in charge of the undergraduate courses in physics at Sorbonne University. The axis has been able to get enough funding to recruit PhD and Master students. It has developed a genuine team spirit and several collaborations exist inside the axis.

Weaknesses and risks linked to the context

The large variety of themes is fragile and likely not to be sustainable. The title of Axis 4 merits to be made more attractive and contemporary. The lack of fresh recruitment is not an immediate problem but may become a threat on the long term. There is no explicit sign of outreach of this team e.g. in high schools. A growing risk is the ever-increasing cost of life in the Paris *intra muros* area which complicates the hiring of young scientists.

Analysis of the theme's trajectory

The axis has many ambitious projects on active matter, theoretical exology, geometric quantisation, and even want to make connections to High Energy Physics and Artificial Intelligence.

RECOMMENDATIONS TO THE THEME

Three positive elements must be preserved as much as possible: 1) internal coherence inside team with collective actions, 2) the precious link to Master courses in Paris and 3) the continuous appearance of new topics, perhaps by sacrificing more obsolete topics. All theoretical groups in France should make an effort to advocate theoretical physics in high schools with the opportunity to enhance parity gender. A more enhanced visibility in the national "Plan Quantique" is a huge opportunity.

CONDUCT OF THE INTERVIEWS

Dates

Start: 05 November 2023 at 19:00

End: 07 November 2023 at 16:00

Interview conducted: on-site

INTERVIEW SCHEDULE

Sunday, november 5

20h00

Committee dinner

Monday, november 6

8h30 – 9h00

Committee closed meeting

9h00 – 10h30

Presentation of the committee members: 5 min

Presentation of the director: general overview of the laboratory: 50 min; questions: 35 min

10h30 – 10h45

Coffee break

10h45 – 11h45

Particle Physics and cosmology

Presentation: 35 min; questions: 25 min

11h45 – 12h45

Strings, branes and fields

Presentation: 35 min; questions: 25 min

12h45 – 14h00

Buffet /poster session with scientific coordinators

14h00 – 15h00

Mathematical physics

Presentation: 35 min; questions: 25 min

15h00 – 16h00

Statistical and condensed matter physics

Presentation: 35 min; questions: 25 min

16h00 – 16h15

Coffee break

16h15 – 16h45

Meeting with IT (administrative staff) (canceled)

16h45 – 17h45

Meeting with researchers and academic staff

17h45 – 18h45

Meeting with doctoral candidates and post-doc

18h45 – 19h30

Committee closed meeting

20h

Committee Dinner

Tuesday, november 7

8h30 – 9h30

Meeting with the supervising bodies: Sorbonne université, CNRS

9h30 – 10h30

Meeting with the director and the executive team

10h45 – 15 h

Closed session: Work of the committee – writing of the report

Lunch of the committee

PARTICULAR POINT TO BE MENTIONED

Due to a sick leave of the administrator, the meeting with administrative support was cancelled. A discussion was set up with the secretary that had just been hired on a temporary contract.

GENERAL OBSERVATIONS OF THE SUPERVISORS

Marie-Aude Vitrani
Vice-Présidente Vie institutionnelle et démarche
participative
Sorbonne Université

à

Monsieur Eric Saint-Aman
Directeur du Département d'évaluation de la recherche
HCERES – Haut conseil de l'évaluation de la recherche
et de l'enseignement supérieur
2 rue Albert Einstein
75013 Paris

Paris, le 29 mars 2024

Objet : Rapport d'évaluation LPTHE - Laboratoire de physique théorique et hautes énergies

Cher Collègue,

Sorbonne Université vous remercie ainsi que tous les membres du comité HCERES pour le travail d'expertise réalisé sur l'unité de recherche « LPTHE ».

Sorbonne Université n'a aucune observation de portée générale à formuler sur le rapport d'évaluation transmis.

Je vous prie d'agréer, Cher Collègue, l'expression de mes cordiales salutations

Marie-Aude Vitrani
Vice-Présidente Vie institutionnelle
et démarche participative



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