

EVALUATION REPORT OF THE UNIT

IPhT - Institut de physique théorique

UNDER THE SUPERVISION OF THE FOLLOWING ESTABLISHMENTS AND ORGANISMS:

Commissariat à l'énergie atomique et aux
énergies alternatives - CEA

Centre national de la recherche scientifique -
CNRS

EVALUATION CAMPAIGN 2024-2025 GROUP E

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In the name of the expert committee :

Barend Van Tiggelen, chairman of the committee

For the Hcéres :

Coralie Chevallier, 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

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Ms Anne-Isabelle Etienvre - CEA-DRF
Ms Sophie d'Ambrosio - CEA-DPG
Mr Bertrand Georgeot - CNRS Physique

CHARACTERISATION OF THE UNIT

- Name : Institut de physique théorique
- Acronym: IPhT
- Label and number: UMR 3681
- Composition of the executive team (31/12/2023): Catherine Pépin (director), Anne Capdepon (deputy director), Grégoire Misguich (scientific deputy director)

SCIENTIFIC PANELS OF THE UNIT

ST Sciences et technologies

ST2 Physique

THEMES OF THE UNIT

The IPhT is a research unit dedicated to theoretical physics. Its activity is characterized by a huge thematic diversity that has also evolved significantly over the last decade and this is clearly visible in this unit. Three main teams exist: A) Mathematical physics, string theory and gravitation, B) Cosmology, astrophysics, high energy and particle physics, and C) Statistical physics, condensed matter physics and quantum information.

These teams cover together a very large part of the spectrum of theoretical physics, with mixtures of traditional topics such as mathematical physics and more timely topics such as gravitational waves, black holes, neural networks and quantum information.

Inside these teams many topics are investigated: In group A, Quantum and Conformal Field Theory, integrable field theories, combinatorics and random geometries, string theory and black holes. In group B, one studies nuclear matter at high density, evaluates scattering amplitudes of elementary particles, tries to develop physics beyond the Standard Model, and contributes along recent discoveries related to dark energy in the Universe and gravitational waves. In group C, the main topics are new emergent quantum phases in condensed matter, in- and out-of-equilibrium dynamics, multidisciplinary applications of statistical physics, and theoretical aspects of quantum information.

HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

Created in 1963 as a CEA service, the IPhT became a CEA Institute in 2008, then in 2014 a UMR co-piloted by the CEA, directly attached to the Direction de la Recherche Fondamentale (DRF), and CNRS Physique. Very recently, CNRS Nucléaire & Particules became also affiliated with the IPhT.

The unit is located at the CEA site of l'Orme des Merisiers - with moderate gate access - on the Plateau de Saclay, sharing the premises with the Service de Physique de l'État Condensé (SPEC, part of the CEA Institute Rayonnement-Matière de Saclay - IRAMIS). The IPhT is associated to Université Paris-Saclay whose headquarters are close. This association means in practice that scientific output is signed with the triple affiliation Université Paris-Saclay, CEA and CNRS, but the university is not directly involved in the scientific steering. The IPhT was and is still involved in many aspects of the restructuring of the Paris-Saclay landscape.

RESEARCH ENVIRONMENT OF THE UNIT

The direct research environment of the IPhT is the large CEA research center on the plateau of Saclay, and in a much larger sense the entire landscape of Paris-Saclay, one of the largest and most prestigious scientific ecosystems in the world. With the creation of Université Paris-Saclay in November 2019, with 48000 students and integrating major protagonists such as the former Université Paris-Sud, the Institut d'Optique, the engineering school Centrale Supélec, the Institut des Hautes Études Scientifiques (IHES) on mathematics and the École Normale Supérieure Paris-Saclay (formerly ENS Cachan), the research environment has been in rapid movement during the last term.

The CEA site facilitates many collaborations with other CEA Institutes such as IRAMIS (condensed matter), IRFU (particle physics and cosmology) and IRIG (quantum technologies). The close connection to the Université Paris-Saclay guarantees an implication in all regional research and training activities. The unit is affiliated to two of its Graduate Schools (physics and mathematics). It has been active in the axis PhOM (Physique Ondes et Matière) that prepared the scientific perimeter of the newly created Graduate School of Physics. The IPhT has many long-term collaborations on mathematics with the IHES, and is involved on a regular basis in long-term meetings at the Institute Pascal in Orsay. The unit has participated in three local Labex (P2IO on physics of two infinities, PALM on atoms, light, and matter, and Hadamard on mathematics) that have currently become axes in the Graduate Schools Physics and Mathematics of Université Paris-Saclay.

The affiliation with CNRS has made it possible to be active in many national and international projects. The IPhT has participated in many (> 10) Research Groups (GDR) and in International Research Groups (IRN), one worldwide network on quantum fields and strings (with 13 other French units), one on neutrinos involving many units of CNRS Nucléaire & Particules and CEA in France as well as European institutions in Italy, Spain, UK and Germany. Lastly, the unit takes part of an IRN on Integrable Probability, Classical and Quantum Integrability with many mathematics units in France, Italy, Belgium, UK, Canada and the US.

Finally, the IPhT has frequent exchanges with CERN.

UNIT WORKFORCE: in physical persons at 31/12/2023

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	37
Chargés de recherche et assimilés	16
Personnels d'appui à la recherche	8
Sous-total personnels permanents en activité	61
Enseignants-chercheurs et chercheurs non permanents et assimilés	6
Personnels d'appui non permanents	1
Post-doctorants	26
Doctorants	35
Sous-total personnels non permanents en activité	68
Total personnels	129

DISTRIBUTION OF THE UNIT'S PERMANENTS BY EMPLOYER: in physical persons at 31/12/2023. Non-tutorship employers are grouped under the heading "others".

Nom de l'employeur	EC	C	PAR
CEA	0	37	7
CNRS	0	15	1
AUTRE	0	1	0
Total personnels	0	53	8

GLOBAL ASSESSMENT

The IPhT has had an excellent scientific production in quality, in quantity and in topical diversity, covering a large fraction of subjects in theoretical physics and its numerous interfaces, employing many different methods. The unit is alert on new and emerging scientific developments. A major ingredient for this remarkable achievement is the support of its two authorities, CEA and CNRS, which recognize the large diversity of theoretical physics and attribute to IPhT a large degree of autonomy in choosing its scientific topics. The unit is successful in attracting both international senior visitors and young students, often coming from abroad, and is outstanding in getting external funding with no less than 12 ERC grants and 17 ANR projects supported during the last term. The IPhT benefits from a worldwide scientific reputation in theoretical and mathematical physics.

The IPhT is one of a kind in France with all scientific staff being full-time researchers with teaching on a voluntary basis and with relatively few administrative duties, leaving on average 75 % of time dedicated to research, supervising, networks and calls for tender. The unit is managed by an efficient executive committee and supported by a small but comfortable technical and administrative support team.

The financial resources mainly consist of external funding, whose extensive overheads are used for the general benefit, including infrastructure running costs. This enables the unit to execute an internal balanced scientific strategy. This economic model is approved and supported by the scientific authorities, and is currently highly dynamical and successful, yet not likely to be sustainable in the long term. In addition it creates the risk of internal clustering. The reorganization from three "themes" into three scientific "teams" is a first effort to create more organizational structure that could prevent such clustering on smaller scales. This effort is still ongoing and is not yet finalized.

DETAILED EVALUATION OF THE UNIT

A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

Only two recommendations were given.

Améliorer la communication entre la direction et le personnel.

The most important change is that more personal and systematic meetings are organized between director and researchers. Because of the different organizational structures of CEA and CNRS, meetings are more frequent for CEA researchers.

L'IPhT devrait être proactif en ce qui concerne les plans de recrutement et le développement éventuel de nouveaux domaines de recherche. En particulier, il devrait travailler sur un projet scientifique de développement pour les années à venir et rédiger un tel document après discussions et concertation entre les membres de l'Institut. Ce processus devrait améliorer la transparence interne. (Ce document devrait évidemment être mis à jour avec une périodicité raisonnable)

No official mid-term strategy exists, probably because the economic model, based on largely fluctuating external grants, makes this difficult. CEA and CNRS have strongly different strategies of recruitment and the IPhT is more aligned to CEA strategy. This has resulted in the emergence of two new themes (quantum information and many-body computational quantum physics). A CNRS Junior Chair supports a new activity in biophysics. More proactivity, especially in CNRS recruitment, is again a major recommendation of this committee.

B - EVALUATION AREAS

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

Assessment on the scientific objectives of the unit

The IPhT wants to be a world-wide leader in the creation of new knowledge in a wide span of themes in theoretical physics and its many modern applications. The dissemination of produced knowledge is explicitly put forward, and that is a strong point. To accomplish this ambitious objective, IPhT has managed to activate successful international collaborations. The continuous recruitment of young non-permanent researchers (PhD and postdocs), the many long-term visits of recognized scientists, the continuous innovation of scientific topics, and the quality and size of the scientific output contribute to keep scientific excellence and international visibility at a high level.

Assessment on the unit's resources

The administrative and IT support is well-structured, with a Deputy Administrative Director, three administrative staff, two IT engineers, and a communication/documentation officer. Recent years have seen high staff turnover, but authorities have maintained support to stabilize the team. The current Deputy Administrative Director, returning in 2023, plays a key role in the unit.

The unit is highly successful in grant applications with 12 ERC grants (22 from the beginning), 17 ANR projects and 31 Labex fundings that have been or still are active. This has facilitated the recruitment of many postdocs and PhD students.

Assessment on the functioning of the unit

IPhT is managed by a director, a scientific deputy, and an administrative deputy, during the interview all CEA employees but until 2021 a CNRS researcher directed the IPhT, with advisory support from an elected scientific committee. Since this term, the unit explicitly operates with three scientific teams (rather than with three themes as was done before) each managing its own budget. Financial matters are primarily handled by CEA, which redistributes overheads to support research activities, including funding PhDs and postdocs. To foster cohesion, regular social events such as seminars and student meetings are organized.

Both CEA and CNRS are extremely vigilant in their policy on safety, environment, ethics and data protection.

1/ The unit has set itself relevant scientific objectives.

Strengths and possibilities linked to the context

The IPhT preforms high-level research and covers almost all research lines in theoretical physics and its interdisciplinary borders. The official creation of three teams simplifies the internal operational functioning and may prevent clustering on smaller scales. The unit is successfully present in networks on all scales and of different kinds. Its scientific policy is fairly well synchronized with both authorities, which is a real virtue since both operate in different and complementary ways (due to their different status), with CEA having a much more top-down presence than CNRS with respect to recruitment and accounting. The recruitment of PhD and postdocs is essential to start new projects and is healthy (44 PhD defenses, for 36 HDR researchers, 94 postdocs over the term) supported by a large variety of sources. Finally, the unit plays a significant role in societal challenges: new projects respond to real societal needs (quantum information, societal and biological applications of statistical physics), others respond to societal interest (cosmology, particles physics) or figure among the "great and ambitious challenges in physics" such as the understanding of quantum gravity and strings or the physics beyond the Standard Model.

Weaknesses and risks linked to the context

The strong dependence on external and individual funding comes with a strong pressure on senior staff to continuously apply to calls. Even if the time devoted to research is as large as 75 %, this figure includes a lot of time dedicated to applying for competitive external grants. The classical problem of an economic model based on fluctuating short-term revenue is that any planning on a longer time-scale is impossible. The huge thematic diversity and specialization brings the risk of clustering and dilution inside the unit. This is a major risk for the IPhT.

Despite the many efforts made by IPhT staff in the preparation of the creation of Université Paris-Saclay, its presence in different bodies of the university is modest. Despite considerable teaching elsewhere, including the widely recognized in-house IPhT courses, almost no teaching occurs at Université Paris-Saclay, and no PhD Scholarships can be obtained directly from its Graduate Schools on mathematics and physics, only indirectly with the participation of Université Paris-Saclay in the Doctoral School EDPIF that covers the entire Île-de-France.

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

With 37 CEA and fifteen CNRS researchers, this theoretical physics unit is unique in the number of scientific staff members and, in France, only comparable to CPT of Marseille. IPhT is also one of a kind in France by the total absence of faculty members from Universities. The administrative and IT support is quite comfortable compared to other units: one Deputy Administrative Director (for CNRS "Reponsable Administrative", but here with the role of deputy director), one assistant to management, a team of two administrative supports, two IT engineers and one staff member in charge of communication and documentation. The last term has been particularly turbulent with six departures in the support team and as many arrivals, sometimes departures occurred after just one or two years of service. Fortunately, the authorities maintained their support to keep the staff at the same level. The current Deputy Administrative Director came back to IPhT in 2023 after duties elsewhere at CEA and plays a central role at IPhT.

The unit receives recurrent funding from both authorities but not in the same way. CNRS recurrent support has grown steadily from 36 k€ to 55 k€ during the last term and excludes payroll. For CEA the support is usually calculated with payroll included and exceeds the needs of recurrent support by roughly 140 k€. This difference is discounted in the overheads of the many grant supports that are mostly administered by CEA, except for a few that are run by external partners. CEA owns the premises and running costs are entirely charged to IPhT.

Own resources obtained from calls for tender are large and fluctuate between 1800 k€ and 4600 k€ per year. They come from ERC grants, Marie-Curie (MSCA) postdoctoral fellowships and other actions of H2020/HE, national projects (ANR and PIA) as well as from regional grants.

The strong collaborations with IHES - a nearby unit with worldwide fame in mathematics and full partner of the university needs a special mention. The unit has taken advantage of the many and complementary opportunities the CEA and CNRS offer and is active in many regional collaborations in Île-de-France. National collaborations are facilitated by many CNRS research groups (GDR).

A struggle exists to get PhD scholarships. A lot of different sources are solicited, many of them being thematically constrained. A huge opportunity is to achieve a better integration into graduate schools of Université Paris-Saclay, that could lead to thematically more open PhD scholarships.

Weaknesses and risks linked to the context

Although the unit is currently well supported by the "support team", with nine agents (8 CEA, 1 CNRS), there has been a large and turbulent turnover during the last term, with six agents leaving and arriving on short notices. The presence of a sustainable support team is precious but difficult to maintain. Most accounting issues on CEA side are pooled together with the ones at the much larger IRAMIS Institute. This distant control creates the risk of losing some control over its budget. Some complications have occurred already.

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 IPHT has a management team consisting of one director, one scientific deputy, one deputy in charge of administration and human resources, supported by an assistant, currently all CEA employees, although the former director, active until 2022 was a CNRS agent.

A scientific committee with permanent research staff exists that advises on scientific issues. The members are in principle elected but can also be nominated by the Director. The unit council is made up of the members of the above-mentioned Scientific Council, as well as two elected representatives of students, postdocs, and two support team members. It meets several times per year. This term has been the first where IPHT operates explicitly with three scientific teams having their own budget (consisting of grants of team members and extra credits attributed by the direction), each with a group leader.

Most of the financial matters (grants and scholarships) are handled by the CEA and many tasks are centralized by the DRF/IRAMIS administration. The overheads on external grants taken by CEA are entirely returned to the IPHT (and partly for those managed by CNRS) and redistributed by the management team to cover conferences, workshops, computer equipment and even to hire four PhD's and nine postdocs during this term. To maintain social coherence inside the unit, regular social events are organized such as "wine and cheese" seminars (shared with neighbour SPEC), "outside wall" seminars (in the Vercors in 2022) and pizza meetings among students.

Both CEA and CNRS are extremely vigilant in their policy on safety, environment, ethics and data protection. Because CEA plays the role of hosting provider, the official policy is that CEA safety procedures apply for data, premises and equipment, as well as the CEA action plan for sustainable development. Some are executed and monitored by CEA services, such as the psychosocial risk (PSR), and a special installation-safety officer exists, supervising the entire SPEC-IPHT premises. The HR management of CEA employees and most PhD and postdocs is dealt with directly by CEA/DRF and the one of CNRS agent or students is carried out by the DR04 of CNRS. Sensitive data on HR or contracts are protected on a highly secured CEA INTRA network, whereas less sensitive research data are stored on a more open CNRS network, whose servers have been installed at a site outside IPHT.

Weaknesses and risks linked to the context

No active contemplation exists about the carbon footprint of the unit and efforts on how to reduce it are absent. The travelling of students is still a priority and is not subject to environmental constraints.

During the evaluation period, some harassment cases have occurred and constitute a risk for they may disrupt the daily life at the IPHT. Fortunately, they have been dealt with by an anti-harassment team that has been set up, which has led to sanctions.

EVALUATION AREA 2: ATTRACTIVENESS

Assessment on the attractiveness of the unit

Indicators for attractiveness that are applied here are 1) the recruitment of highly qualified young researchers, 2) the well-being of employees, 3) attractivity for PhD students and postdocs, 4) number of national and international invitations on conferences, 5) integration in local, national and international networks and committees, 6) thematic mobility towards modern themes, 7) success rate in international calls. The IPhT has been outstanding in all these respects, as specified in more detail below.

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

With 36 habilitated researchers, more than 40 PhD theses have been defended during the last term, with many different sources of funding (including CEA, EDPIF doctoral school, Université Paris-Saclay, ENS, CNRS and ERC grants). No less than almost 100 postdocs have been active during the last term. Around 100 visitors have stayed at IPhT, during a few days and sometimes as long as a few months. The unit has a dedicated budget taken from overheads.

New scientific recruitment have been fruitful on CR level (7 CEA, 2 CNRS), and even on DR level, IPhT having recruited young CEA agents, who often benefitted from a starting package.

More than 450 presentations were given at conferences, workshops and schools by roughly 50 permanents staff members (almost 10 on average each). The support staff is highly satisfied and feels appreciated by unit and management.

The unit is active and successful in calls for tender (12 ERC, 10 Marie-Curie fellowships, 17 ANR and many local projects). The well-being of the new recruited is supported by continuous exchanges with the management.

IPhT personal has taken its responsibilities in different administrative committees (section 02 of CoNRS, representative of CEA at IHES board of directors, different instances of Université Paris-Saclay, piloting committees of several large programs...).

The presence of a large diversity of scientific methods (numerical, analytical, mathematical, phenomenological, and observational with a few links to experimental groups especially with SPEC next-door and with CERN) is highly attractive.

The recent arrival of an administrative and experienced deputy director increased the well-being of the support team.

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

A significant pressure (by the direction) exists on permanent staff to find external funding. Although understandable in today's Anglo-Saxon model of research funding and stimulated by the CEA policy to count payroll as part of recurrent funding, this jeopardizes their well-being and limits time for research.

Large time delays exist for newcomers to get security clearance at CEA. A roadmap exists but has room for improvement. Many new students and postdocs do not know what needs to be done to access existing tools such as scientific journals, how to get the right email address, where to find software licenses (Mathematica or Zoom), etc. . The absence of social security of some young foreign students due to bureaucracy somewhere in the chain is a severe problem that has to be solved immediately one way or the other.

The location of the IPhT is far from animated areas and not attractive for young students. Large travel times back and forth from the intramural Paris area, up to one hour and a half, promote teleworking and jeopardize the joint unit spirit among the many sub teams.

The coffee room/library has been renovated and has been inaccessible for a long time, which did not stimulate on-site interaction among researchers either.

EVALUATION AREA 3: SCIENTIFIC PRODUCTION

Assessment on the scientific production of the unit

The scientific production is published in high-quality peer-reviewed journals, and is impressive in quantity. It is also characterized by a large topical diversity covering almost all themes in theoretical physics, applying a large variety of methods, and with an impressive balance among the three teams, even remarkable in view of the well-known different habits of different communities. The production follows new trends which is a good sign.

Highlights of group A include interactions in quantum and conformal field theories, critical points of statistical systems, the holographic correspondence, the string landscape, integrability, black hole physics and quantum gravity, using tools such as string theory, bootstrap, random matrices or topological recursion.

Highlights of group B include studies of high density nuclear matter, imaging nuclei at colliders, jets and QCD. Effective field theories and quantum field theory are a main tool for the study of different physical situations as for example scattering amplitudes, dark matter, axions, the hierarchy problem, neutrino physics, baryogenesis, flavour. Gravitational waves and properties of compact objects are studied in relation to LISA (Laser Interferometer Space Antenna) and large-scale surveys beyond lower order statistics with the space telescope EUCLID, both run by ESA.

Highlights of group C include the derivation of a remarkable growth equation relating the rank of a city to its population, the surprising discovery of a relation between a bound on quantum chaos and the fluctuation-dissipation theorem, and the derivation of the out-of-equilibrium behavior of a box ball system using generalized hydrodynamics.

- 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

The number of publications (a total of 1100 for the full term) gives around 3.5 per year per full-time researcher, which is large as compared to a national scale (average somewhat about 2). This number varies hardly from one team to the other. Around 75 papers are published in high impact multidisciplinary journals, in particular 57 Phys. Rev. Lett. Many (12) monographs have been published. Worth mentioning is the large implication of PhD students in scientific publications, and the many international co-authors, sometimes as part of large international collaborations and sometimes as long-time visitors. A reasonable fraction of publications exists that has been signed by members of different teams, showing that team borders are dashed lines.

Since a long time already, all publications have been systematically deposited on ArXiv and since recently also on HAL.

Group B is connected to the SCOAP3 open access model piloted by CERN and with CNRS, CEA and Université Paris-Saclay as official members. Lecture notes are published in the "diamond" open access journal SciPost, recognized by Université Paris-Saclay. A network of scientific integrity exists at CEA and the IPhT is engaged.

New research themes continue to emerge, supported by new recruitment, mostly by CEA. During the last term, this concerned quantum information theory and interdisciplinary applications of statistical physics.

The perseverance on long-term difficult and important problems such as the physics beyond the standard model, quantum gravity, topological materials, dark energy and the physics of life that is about to start is remarkable.

The unit exploits successfully experimental partners (the direct neighbour SPEC and CERN in particular) and works actively with data sets put at their disposal by precious collaborations.

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

The objective of the IPhT to be a unit working on the "theoretical physics of almost everything" is attractive yet quite ambitious and has the risk of dilution and clustering, unlikely to be sustainable, although no sign of this exists at the moment.

EVALUATION AREA 4: CONTRIBUTION OF RESEARCH ACTIVITIES TO SOCIETY

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

As a research unit working on theoretical physics, direct links with the economic world usually hardly exist but efforts start at IPhT, in particular via the new private foundation that is planned for the next term. Group C has a significant activity inspired by, and relevant for, many societal challenges of today such as the spread of viruses or the growth of cities, not to forget quantum information. The participation of IPhT in scientific outreach is huge, with public conferences on topics of general interest, radio interviews and movies accessible on their own Youtube channel, among which the outstanding one realized on the occasion of the 60th anniversary in 2023. Many seminars of general interest (collider physics, science fiction and science, gravitational lenses, quantum computers, black holes, EUCLID mission of ESA) are accessible on the Youtube channel. Important to add is the possibility for high school students to spend a short internship at the IPhT.

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

The IPhT is conscious that interactions with the non-academic world are important for their research unit and is engaged in promoting the public understanding of the wider role of theoretical physics in the society.

The emerging theme on quantum information (quantum cryptography and quantum computing) in group C has increasing connections to industrial partners such as the company PASQAL (quantum information) in Massy-Palaiseau.

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

This is all the more important in that the IPhT members do not have a teaching duty, which limits the dissemination of their activities through students.

ANALYSIS OF THE UNIT'S TRAJECTORY

A new director of IPhT will be appointed for the term 2026-2031. The unit has already identified three qualified and available candidates.

The IPhT intends to create a private foundation that should eliminate a part of the unpredictable fluctuations in the funding coming from competitive external grants and secure the activity of themes with less funding.

In team A, two ERC grants will come to an end in 2025, so that a new ERC is desirable. There were recent recruitment in the bootstrap subgroup, but the activity on integrability may become subcritical due to upcoming retirements.

The reinforcement of the cosmological activity in team B has been given high priority by the unit council. The recent recruitment of a young scientist in quantum field theory guarantees a positive track for those activities in the future, but the unsuccessful attempt of hiring a young woman scientist in collider physics leaves a gap to be filled in the important field of QCD phenomenology at high-energy colliders.

Team C has started a few new emerging activities, with which it will have no problems in finding external funding. This is true for quantum computing and quantum cryptography, with likely implication in start-ups, on biophysics with the arrival of a CNRS junior chair, on artificial intelligence, on many-body quantum physics supported by a CEA recruitment that will be active at the Center for Computational Quantum Physics at the Simons Foundation in New York City, and statistical physics of networks with lots of interdisciplinary applications.

RECOMMENDATIONS TO THE UNIT

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

It is recommended that the IPhT creates and regularly updates a roadmap, e.g. a wiki page on the IPhT intranet, that explains what tools exist or are available (at IPhT, CEA, CNRS, or universit  Paris-Saclay) and how to access them. It should contain information relative to the highly recurrent issues before coming to IPhT such as how to obtain a visa for non-EU citizens and their families, or how to obtain lodging. Bottlenecks, typical time delays (e.g. for security clearance at CEA) should be identified and anticipated, and helpdesks to contact should be mentioned. The roadmap can also address more daily issues while arriving at IPhT, such as what email should be used to be recognized by local servers, how to access scientific journals, how to use (floating) licenses of available software.

To stimulate a joint IPhT spirit among the many newcomers and visitors, offering a guided tour of the building might be appropriate. To avoid clustering inside different teams, one day per week may be identified, in which the presence of all staff members is warmly encouraged, with a colloquium, preceded by a short informal colloquium by a student to attract fellow students.

The IPhT is highly encouraged to install a think-tank on its carbon footprint, to create a pie chart that visualizes its CO₂ emissions, and to think about possible future actions to undertake. More advanced projects in neighbouring units can serve as an example.

The unit IPhT must remain vigilant on the sensitive issue of harassment.

The IPhT benefits from the precious support of two highly complementary authorities. Room for improvement exists to exploit this complementarity even more and also to better communicate among its staff where this complementarity is not always understood.

Recommendations regarding the Evaluation Area 2: Attractiveness

The committee strongly recommends strengthening the links with Universit  Paris-Saclay, that is still in its initial phase. These links constitute a strong opportunity for active involvement in teaching at master levels (now still absent at IPhT) that may attract more Master and PhD students in the recently created Graduate Schools on physics and mathematics (also not yet activated).

The roadmap discussed earlier will undoubtedly make the arrival of visitors and their families easier and more attractive. The parity gender problem is difficult and its solution must be sought far outside IPhT.

The unit could be more proactive in raising the interest of female scientists, with the hope of getting a better gender parity in the future.

Proactivity accompanied by an active lobbying after selection by CoNRS is crucial for CNRS recruitment (Theoretical physics section) that go through an initial scientific phase that disregards future affiliations.

Recommendations regarding Evaluation Area 3: Scientific Production

Continue as such.

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

The IPhT is promoting the public understanding of the wider role of theoretical physics in the society. The committee encourages all staff members to continue like this. This is all the more important in that the IPhT members do not have a teaching duty, which limits the dissemination of their activities through students.

The committee highly encourages the IPhT to realize its ambitions to become more involved in start-up activities, and to formulate a plan.

TEAM-BY-TEAM OR THEME ASSESSMENT

Group A: Mathematical physics, string theory and gravitation
 Name of the supervisor: Mr Sanjay Ramassamy

THEMES OF THE TEAM

Group A is organized in four subgroups, respectively concerned with: 1) Quantum field theory, conformal field theory and bootstraps; 2) Integrable systems and integrable field theories; 3) Various aspects of mathematical physics, including combinatorics, random geometry and topological recursion; 4) String theory and black holes.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The most urgent recommendation was to hire new research staff in the mathematical physics theme in order to maintain the attractiveness of that line: this was addressed mainly by the recruitment of the current coordinator of the group, but in part also by other three recruitment on neighbouring themes. One of which is connected to an ERC grant, and that established a new collaboration with IHEs on conformal bootstraps.

Another suggestion of the previous report was that the model provided by the string theory group in their use of ERC grants for the benefit of the whole team could be followed by other groups: the model is endorsed by the current management of the unit and was followed with the other ERC grants started during this term, but its impact is limited by trends and fluctuations in the success of the four subgroups in obtaining ERC grants.

WORKFORCE OF THE TEAM: in physical persons at 31/12/2023

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	12
Chargés de recherche et assimilés	6
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	18
Enseignants-chercheurs et chercheurs non permanents et assimilés	3
Personnels d'appui non permanents	0
Post-doctorants	9
Doctorants	16
Sous-total personnels non permanents en activité	28
Total personnels	46

EVALUATION

Overall assessment of the team

Group A is active in many different areas of mathematical and theoretical physics, with many applications to various domains. The work of its 46 researchers, including 17 currently active permanents, 41 postdocs and 35 students through the evaluation period, resulted in four ERC grants (two running during assessment) and roughly 70 publications/year (4.1/year/permanent staff, a huge number) in the last three years, in prestigious physics or mathematics journals.

Strengths and possibilities linked to the context

The group remains one of the leader groups in Europe in quantum field theory, string theory and mathematical physics, as confirmed not only by the large number of high-quality and impactful publications but also by the amount of external funds and recognitions, for example the four new ERC grants that were started during the current evaluation period (out of the six started in the whole unit). This was certainly instrumental to increase considerably the number of PhD students with respect to the previous evaluation period (e.g. they were 10 PhD's on 30/06/2018 and 16 PhD's on 31/12/2023).

Weaknesses and risks linked to the context

While diversity is an asset of the team and should be maintained, trying to cover all aspects of mathematical physics, quantum field theory and string theory brings along the risk of leading to excessive fragmentation, which could weaken internal interactions and impact.

Recent and upcoming retirements may weaken some themes, in particular the one on integrability.

Analysis of the team's trajectory

With the four new recruitments in the fields of mathematical physics, quantum field theory and conformal bootstrap, the team has started its renewal process, which will continue in the next evaluation period, with the perspective of a new ERC grant.

RECOMMENDATIONS TO THE TEAM

The group is recommended to think about its (broad) scientific priorities for the future, trying to identify the most promising directions, in order to optimize the impact of future recruitment.

Group B: Cosmology, astrophysics, high-energy physics and hadronic matter

Name of the supervisor: Mr Brando BELLAZZINI

THEMES OF THE TEAM

Group B is devoted to the study of the theory and phenomenology of the fundamental interactions, along with four main themes that intersect with each other: 1) high density nuclear matter, heavy-ions, jets and QCD at colliders, 2) scattering amplitudes applied to strong interactions and gravitational physics, 3) particle physics beyond the standard model, 4) cosmology, astrophysics and gravitational waves.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The main point raised in the previous report was linked to the fact that group B experienced the departure of several key members, which was feared to impact significant research areas. The suggestion was made that the team look out for new recruitment. This recommendation on group B was taken seriously and three researchers have been recruited. In the subject of physics beyond the standard model, a recruitment was made in 2019. Two positions in quantum field theory, from amplitudes to gravitational waves were filled in 2023. However, two departures for personal reasons reduced the net count of recruitment, thus the lack of permanent scientific staff in certain subjects remains an issue.

WORKFORCE OF THE TEAM: in physical persons at 31/12/2023

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	12
Chargés de recherche et assimilés	4
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	16
Enseignants-chercheurs et chercheurs non permanents et assimilés	2
Personnels d'appui non permanents	0
Post-doctorants	10
Doctorants	8
Sous-total personnels non permanents en activité	20
Total personnels	36

EVALUATION

Overall assessment of the team

Group B is conducting competitive and state-of-the-art research along diverse and often interdisciplinary subjects, which results in publications in prestigious journals. Additionally, they are successful in securing grants and in achieving international visibility with relevant roles in international networks. They are actively connected to existing and future experimental facilities, both in particle physics and in gravitational physics and cosmology.

Strengths and possibilities linked to the context

Group B has published 384 articles in peer-reviewed journals between 2018 and 2023 showing a good scientific production (4/ year/permanent staff). The team has been involved in two ERC projects (one as a participant and one as a PI). It has also attracted ANR funding as five members have been PI's of ANR grants during the evaluation period. Group B has also been involved in two projects of the Labex P2IO: (Gluodynamics and BSM-Nu). This shows the positive scientific environment and dynamics of the group. There is also a part of the research output which involves mostly internal collaborations inside the team, showing that scientific discussions at the team level exist actively.

Obtaining both one more ERC grant in 2021 and the prestigious Galileo Galilei Medal in 2023 gave worldwide visibility and recognition to the activities on the scattering amplitudes theme. Considerable attention was also attracted by the work on charting the landscape of consistent and effective field theories, on hadronic physics at colliders and on gravitational waves, all promising directions for future developments.

Weaknesses and risks linked to the context

Taking into account two recent departures, as well as one recent recruitment and one declined offer, group B has currently fourteen permanent members, and remains smaller than the other two groups of IPHT. This leads to a real challenge in keeping a critical mass in some research subjects, especially given the broad range of research areas studied by the group. Despite the efforts made, a serious lack of gender diversity remains, in particular among permanent members.

Analysis of the team's trajectory

The team trajectory is performing well in all aspects (research output, research funding and attractiveness) with the new subjects enriching the old ones.

The arrival of a newly recruited scientist in the field of amplitudes and gravitational waves will reinforce an expanding area of theoretical research connected to important present and forthcoming experimental programs.

RECOMMENDATIONS TO THE TEAM

The team should make more effort to improve on gender balance in future recruitment. Given the fact that female theoreticians in the field covered by group B are rare and internationally highly demanded, the passive procedure to just wait for applications from competent women to arrive in the next openings is not sufficient. To solve the gender problem of group B, more proactive scouting efforts should be made before the next positions are open, and make sure that strong female candidates will exist to join the group. This strategy has proved to be efficient in groups with similar problems.

Group C: Statistical physics and applications, condensed matter, quantum information

Name of the supervisor: Mr Thierry JOLICOEUR

THEMES OF THE TEAM

Group C is broadly devoted to the theory of low-energy physics and is split into four subgroups studying: 1) quantum condensed matter (such as strongly correlated superconductors, moiré materials made of graphene, etc.); 2) in- and out-of-equilibrium classical and quantum dynamics (e.g. large deviation potentials, quantum chaos, cellular automata and generalized hydrodynamics, macroscopic fluctuation theory); 3) disordered systems and other applications of statistical physics (glasses, spin glasses, optimal transport, biophysics and cities' growth); and 4) quantum information, quantum computing, quantum communication and quantum cryptography.

CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

In the previous report, one of the recommendations was to be proactive in the recruitment and development of new scientific domains. Concerning group C, this recommendation was taken seriously and several recruitment were performed in order to open new research directions. A few years ago, two CEA senior researchers have been recruited on the subject of quantum information theory. More recently, one CEA researcher was hired to work on topological materials. And this year, there was also the recruitment of a CNRS junior chair working on statistical mechanics of neural networks and artificial intelligence. In the near future, there is the plan of hiring a numerician working on the many-body problem, in a joint project with the Flatiron Institute at the Simons Foundation in New York City.

Another recommendation was to improve the communication between the direction of IPhT and the staff. As the current IPhT director belongs to group C this point was certainly improved.

WORKFORCE OF THE TEAM: in physical persons at 31/12/2023

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	12
Chargés de recherche et assimilés	4
Personnels d'appui à la recherche	0
Sous-total personnels permanents en activité	16
Enseignants-chercheurs et chercheurs non permanents et assimilés	2
Personnels d'appui non permanents	0
Post-doctorants	10
Doctorants	8
Sous-total personnels non permanents en activité	20
Total personnels	36

EVALUATION

Overall assessment of the team

Group C has produced top research published in high-quality journals (334 peer-reviewed articles for the period 2018-2023 that is 3.5/year/permanent staff). It is also successful in getting distinctions (for example, a Langevin prize from the Société Française de Physique) and in obtaining grants (for example, 3 ERC including a recent starting grant).

Strengths and possibilities linked to the context

The team is made of excellent researchers, at the world top level. They have the opportunity of collaborating as they have a critical mass and cover a large spectrum in condensed matter and statistical physics. They also have ceased the opportunity to interact with nearby experimentalists (and other theoreticians) at SPEC and at the University Paris-Saclay.

Weaknesses and risks linked to the context

The researchers do not teach a lot so that the produced knowledge is not shared with undergraduate students. There is the risk for the team to be split in independent research groups made of individuals (and their students) due to the project-based funding of research. This would be a pity, as historically, a strength of this group was the ability to collaborate in-house. This remark applies to group C but was stated earlier to be valid for the entire IPhT.

Analysis of the team's trajectory

The recent trajectory is very promising with the opening towards new subjects (quantum information and technology, topological materials, artificial intelligence) and the corresponding recruitment. The future trajectory involves the recruitment of a junior member to work on advanced numerical physics for the many-body problem (in a joint position with the Flatiron Institute of the Simons Foundation in New York city). Group C will undoubtedly have an open eye on emerging subjects.

RECOMMENDATIONS TO THE TEAM

The team is recommended to involve itself more in the teaching activities at Université Paris-Saclay.

There is the opportunity to create more contacts both with theoreticians and experimentalists at the nearby SPEC unit.

CONDUCT OF THE INTERVIEWS

DATES

Start: The 4th of December 2024 at 02 p.m.

End: The 6th of December 2024 at 01 p.m.

Interview conducted: on-site

INTERVIEW SCHEDULE

Mercredi 04 décembre

14:00 - 14:15 Huis Clos : réunion de préparation du comité
 14:15 - 14:20 Session plénière : présentation des membres du comité
 14:20 - 15:10 Session plénière : présentation du directeur (50 min)
 15:10 - 15:40 Session plénière : questions (30 min)
 15:40 - 15:55 Pause-café
 15:55 - 17:10 Groupe A : Physique Mathématique, théorie des cordes et gravitation
 Présentation 45 min + 30 min de questions
 17:10 - 18:10 Rencontre avec les chercheurs
 18:10 - 19:00 Session fermée du comité
 19:30 - 21:30 Dîner à huis clos du comité

Jeudi 05 décembre

09:00 - 10:15 Groupe B : Cosmologie et astrophysique, physique des hautes énergies, matière Hadronique. Présentation 45 min + 30 min de questions
 10:15 - 10:30 Pause-café
 10:30 - 11:45 Groupe C : Physique statistique et applications, matière condensée, information quantique. Présentation 45 min + 30 min de questions
 11:45 - 12:45 Rencontre avec les doctorants et post-doctorants
 12:45 - 14:15 Déjeuner - possibilité de session poster en même temps
 14:15 - 15:15 Rencontre avec les personnels techniques et administratifs
 15:15 - 16:00 Visite Clusteur Calcul (n'a pas eu lieu)
 16:00 - 16:15 Pause-café
 16:15 - 17:15 Réunion avec les tutelles
 17:15 - 18:15 Session fermée du comité
 19:30 - 21:30 Dîner à huis clos du comité

Vendredi 06 décembre

09:00 - 10:00 Réunion avec la direction de l'unité
 10:00 - 13:00 Session fermée du comité

GENERAL OBSERVATIONS OF THE SUPERVISORS

The institution responsible for submitting the application, which is also responsible for coordinating the response on behalf of all the research unit's supervisors, did not submit any general observations.

The Hcéres' evaluation reports are available online:
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