LPTMS - Laboratoire de physique théorique et modèles statistiques

Rapport Hcéres

agence d'évaluation de la recherche
et de l'enseignement supérieur

Department for the evaluation of research units

AERES report on unit:

Laboratoire de Physique Théorique et Modèles Statistiques

LPTMS

Under the supervision of the following institutions and research bodies:

Université Paris-Sud

Centre National de la Recherche Scientifique -CNRS

November 2013

agence d'évaluation de la recherche
et de l'enseignement supérieur

Department for the evaluation of research units

On behalf of AERES, pursuant to the Decree of 3 november 2006[1]*,*

- Mr. Didier HOUSSIN, president
- Mr. Pierre GLAUDES, head of the evaluation of research units department

On behalf of the expert committee,

- Mr. Angel ALASTUEY, chair of the committee

[1] The AERES President "signs [...], the evaluation reports, [...] countersigned for each department by the director concerned" (Article 9, paragraph 3 of the Decree n ° 2006-1334 of 3 November 2006, as amended).

Evaluation report

This report is the result of the evaluation by the expert committee, the composition of which is specified below.

The assessments contained herein are the expression of independent and collegial deliberation of the committee.

Unit name:	Laboratoire de Physique Théorique et Modèles Statistiques
Unit acronym:	LPTMS
Label requested:	UMR
Present no.:	8626
Name of Director (2013-2014):	Mr Emmanuel TRIZAC
Name of Project Leader (2015-2019):	Mr Emmanuel TRIZAC

Expert committee members

Chair:	Mr Angel ALASTUEY, ENS Lyon
Experts:	Mr Erik AURELL, KTH - Royal Institute of Technology, Sweden
	Mr Peter HOLDSWORTH, ENS Lyon (representative of CNU)
	Mr Gerhard NAGELE, Forschungszentrum Jülich, Germany
	Ms Patrizia VIGNOLO, INLN, Nice (representative of CoNRS)

Scientific delegate representing the AERES:

Mr Marc KNECHT

Representative(s) of the unit's supervising institutions and bodies:

Mr Etienne AUGE, University Paris 11

Mr Gilles MONTAMBAUX (University Paris 11, Dep. Director of the Doctoral School ED107)

Mr Barend van TIGGELEN, CNRS

1 • Introduction

History and geographical location of the unit

The LPTMS was founded in 1998 with Mr Alain COMTET as the former director. Mr Stéphane OUVRY was the next director from 2002 to 2009, then followed by Mr Marc MÉZARD (2010-2012) and Mr Emmanuel TRIZAC the present director.

The unit is located on the campus of the Paris-Sud University, which is one of its regulators together with the CNRS.

Management team

The present director is Mr Emmanuel TRIZAC. The administrative staff is directed by Ms Claudine LE VAOU assisted by Ms Géraldine RÉGIS. Mr Vincent DEGAT is in charge of the computer network.

The leaders of the teams are Mr Georgy SHLYAPNIKOV (1), Mr Satya MAJUMDAR (2) and Mr Silvio FRANZ (3).

AERES nomenclature

ST2 Physics

Unit workforce

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	7	5
N2: Permanent researchers from Institutions and similar positions	18	18
N3: Other permanent staff (without research duties)	3	3
N4: Other professors (Emeritus Professor, on-contract Professor, etc.)		1
N5: Other researchers from Institutions (Emeritus Research Director, Postdoctoral students, visitors, etc.)	8	8
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	**36**	**35**

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	14	
Theses defended	18	
Postdoctoral students having spent at least 12 months in the unit	17	
Number of Research Supervisor Qualifications (HDR) taken	3	
Qualified research supervisors (with an HDR) or similar positions	20	19

2 • Assessment of the unit

The LPTMS has been producing fantastic science over the last five years. It has acquired a worldwide reputation, as attested by several prestigious awards. The number of outstanding contributions is impressive, with not only various breakthroughs at the fundamental level, but also a broad range of multidisciplinary applications. The creativity of its members is of course the main ingredient in this success. The remarkable collective dynamics inside the unit played also a crucial role. In particular the mixing of abilities led to the derivation of unexpected equivalences with quite spectacular outcomes. The quality of the hired young researchers is an essential asset for maintaining the high-level scientific standards of the unit. They strongly contribute to the lively and pleasant atmosphere in the laboratory, and thanks to their open mind, new transversal interactions between the various teams were developed. The LPTMS paid a constant and efficient attention to the training of students. Various members are involved in the direction of international schools or programs. Professors and assistant professors, despite their heavy teaching and administrative duties, are at the front of their research fields. The LPTMS is very active in preparing its transfer to the Saclay plateau. It is the driving force in the emergence of the new Institute for Advanced Physics, a rather attractive project which matches multidisciplinary interactions. The unit is a remarkable factory of ideas, with a powerful internal dynamics, and both the CNRS and the University Paris-Sud are strongly encouraged to support it, and moreover to be cautious with threatening issues briefly sketched below and detailed further later in the report.

Strengths and opportunities related to the context

-Activities with potential multidisciplinary applications which should favor fruitful interactions and collaborations with other laboratories on the Saclay plateau;

-Visibility and well-established reputation should attract high-level researchers and teams both at the LPTMS and at the future Institute for Advanced Physics;

-Quality of teaching and research, should help to attract more students from the surrounding Grandes Écoles.

Weaknesses and threats related to the context

-Actual absence of public transportation ensuring easy connections to the Saclay plateau might discourage LPTMS members and make them succumb to the attraction of other highly reputed institutions, in particular in central Paris;

-Dilution of theoretical physics into large complex structures involving entities with large resources needs;

-Absence of firm engagement from authorities for the support of the activities of the Institut de Physique Avancée (IPA) on a permanent basis.

Recommendations

The committee recommends the LPTMS to make more publicity for his unique expertise in various fields. This will help the unit to enhance collaborations and interactions with other laboratories on the Saclay plateau, which beyond their obvious scientific interest, should strengthen its position at a strategic level. CNRS and University are invited to ensure sufficient human resources to LPTMS. The committee considers the LPTMS to be an outstandingly good lab by any international standards. A strong support of this remarkable lab, a jewel in the crown, in the following funding period is highly recommended.

3 ● Detailed assessments

Assessment of scientific quality and outputs

The laboratory has produced an amazing number of outstanding contributions, as attested by the quite high number of publications in prestigious journals such as Physical Review Letters (around 80) and Nature. New results obtained during the examined period represent both breakthroughs at the fundamental level and a wide range of promising applications in many disciplines including biology, medicine, computer science, ecology, economy, finance. This is a quite remarkable feature for a theoretical physics laboratory, illustrating the creativity and open-mindedness of its researchers. Ideas and methods specific to random matrices and disordered systems have been fruitfully mixed, while various groups have developed tight collaborations with experimental teams expert in cold atoms and the biological properties of cells.

The impressive scientific production of the unit can be illustrated through a few highlights: the prediction of Hawking-like radiation in Bose gases opens the possibility of laboratory experiments with important outcomes. The existence of unconventional phase transitions has also been shown, such as the topological superfluid phase of polar molecules, or the one-dimensional fluid-insulator transition resulting from the competition between disorder and interactions. The derivation of new exact solutions for Brownian motion in two dimensions is as remarkable as unexpected, with various applications in disease spreading or nuclear radiation damage for instance. A fascinating equivalence has been established between extreme value statistics of the eigenvalues of random matrices and the vicious walker problem. In the domain of compressed sensing, the combination of replica and cavity tricks provided a new reconstruction method which can be used for improving data storage or image processing. The progress achieved in understanding the counter-ion induced attraction between equally charged macro-molecules, is essential for further modeling of the static and dynamical properties of colloids. Finally at the physics-biology interface, the importance of the fission mechanism in the behavior of the cells has been demonstrated.

Assessment of the unit's academic reputation and appeal

The laboratory is well recognized at the international level. The quality of the hired resources is indisputable, with one ERC grants, at the senior level. Moreover, various members received prestigious awards such as the Langevin prize, the Gay-Lussac-Humboldt prize, the Tata Excellence Award, the Heisenberg fellowship, or the CNRS bronze medal, while others were offered high-level professor positions in foreign countries. The fact that members of the laboratory sit on the editorial board of prestigious journals, or organize international conferences and schools (in the Institute Henri Poincaré or Les Houches) are further indicators of the reputation of the unit worldwide.

At the national level, most of his members obtained scientific excellence rewards from both the CNRS and the University, and several ANR grants are running. One member was recently nominated Director of the École Normale Supérieure de Paris, a second was nominated director of research for the IDEX Paris-Saclay after having been deputy director of Theoretical Physics at the CNRS. All these top positions in the French scientific administration confirm the prestige of the unit. A professor has been recruited as a “directeur de recherche” in INRA, a rather uncommon transfer which also sheds light on the special position of the unit. Finally, various bright researchers, including post-docs, came to the laboratory, not only from France but also from abroad.

No doubt, the laboratory has a good reputation, both at the international and national levels. However, its visibility could, and should, be enhanced, in line with its high scientific level, which is equivalent to that of the best well-known laboratories all over the world.

Assessment of the unit's interaction with the social, economic and cultural environment

The unit is well integrated into the Paris-Sud campus, in particular through various collaborations involving other laboratories. Nevertheless, and in relation with the above remark about its visibility, the laboratory is encouraged to improve the dissemination of its results, through vulgarization journals or even newspapers. This would favor the emergence of interactions and projects, not only with other academic entities but also with some companies, in accordance with the broad range of potential applications of the fundamental results obtained. Furthermore, the abilities and expertise present in the unit, deserve to be employed in popular large-audience events such as the Fête de la Science for example. Attracting young generations to Science is clearly a major social challenge, for which the LPTMS has many assets.

Assessment of the unit's organization and life

The laboratory is divided into three teams according to rather general topics. However, and fortunately, there are no barriers between the teams, so the LPTMS can be considered as the laboratory of open doors! There exist many interactions and collaborations between researchers belonging to different teams, in relation with the strong overlaps between their fields of interest. Some people work on parallel things, join and then split again. Even members who might feel isolated enjoy the ambiance and benefit from fruitful discussions with their colleagues. The young people, PhD students and post-docs, contribute to this lively and pleasant atmosphere, in particular through the organization of a journal club, an informal seminar, where each two weeks, one of them presents the content of a published paper. Furthermore, all questions concerning the unit's scientific policy or material aspects, such as the transfer to the Saclay plateau, are widely discussed, and important decisions are taken only after a general consensus is reached.

In recent years, the unit has undergone a phase transition in its collective dynamics. It has surely become a reference, benefiting largely from the French style of laboratory organization. It is crucial to preserve this remarkable scientific synergy from various centrifugal forces. One of them clearly arises from the transfer to a new building on the plateau, which might discourage people who are submitted, at the same time, to the attraction of central Paris. Another threat of explosion comes from the broad range of interdisciplinary applications which might tempt the regulators to affect some researchers to other units. It is of paramount importance to keep a sufficiently large number of theoreticians working in the same unit, in order to ensure fruitful exchanges leading to the emergence of new concepts and tools. Accordingly, the creation of the Institut de Physique Avancée (IPA), in the same new building as the LPTMS, is a crucial element in this equation. Sufficient funding for its activities is of course a further key element.

Administrative staff is quite efficient and excellent, well integrated into the collective dynamics of the unit. Two secretaries, one working 60 % of her time, ensure the management of the scientific missions and of the various resources, as well as all the daily tasks with dedication and cheerfulness. One engineer is in charge of the computer network, a rather useful facility for researchers. In addition to its crucial role in the good functioning of the unit, the administrative staff clearly contributes to its friendly atmosphere.

Assessment of the unit's involvement in training through research

The unit is pretty involved in teaching purposes, in particular in the organization of the École Doctorale common to the École Normale Supérieure and Universities Paris 6, 7 and 11. It also manages an international master program on complex systems, as well as a one-month college in advanced physics in Trieste each spring. Various members of the LPTMS give key courses in several national master programs and in a few high-level schools for engineers, like the ESPCI or the École Centrale. The teachers of the laboratory also intervene in basic university courses, and play a central role in the preparation of university students for entrance exams to national Grandes Écoles. They are well-known for their pedagogical skills. The attention paid by the unit to teaching is confirmed by the publication of two monographs, one in quantum mechanics, well appreciated by students, and another one in the applications of statistical mechanics to information theory and computing, which has rapidly become a reference for researchers in this new emerging field.

Within the unit, various original initiatives enforce the skills and knowledge of young people, both PhD students and post-docs. In addition to the Journal Club mentioned above, each year one senior researcher gives a lecture on a new topic at the forefront of modern physics. The daily discussions favored by the friendly scientific ambiance also contribute to the excellent training of young members. Furthermore, the unit provides sufficient support for young people to attend schools and conferences. Thus, PhD students and post-docs are well prepared, as attested by the high percentage, around 80 %, of PhD students and post-docs, who ultimately obtain a permanent position in the academic system. These useful and reliable statistics are obtained by keeping track of Ph.D. students after leaving the unit.

The number of PhD students is relatively low, in obvious strong correlation with the small number of PhD grants available at the École Doctorale. Other sources of grants, in particular those from ANR grants, should be encouraged. The University is encouraged to allow Ph.D; students financed by sources other than the École Doctorale to teach (monitorat), and it should also propose more French courses for foreigners. Of course, if their number increases, PhD students should attend lecture courses proposed by the École Doctorale and attend the seminars designed to promote future careers outside the academic world.

Finally, it must be pointed out, that the teachers appointed by the university, in particular the assistant professors, have produced remarkable results, despite their heavy teaching and administrative duties, which moreover were accomplished to the highest standards. The pressure on university staff was previously reduced through exchange of teaching duties with CNRS members. Unfortunately this arrangement has been stopped and the committee recommends to re-establish possibility of teaching exchanges between university and CNRS staff. Recruitment of assistant professors is also an urgent issue, given the imbalanced between university and CNRS members, namely around 1 per 4 presently.

Assessment of the strategy and the five-year plan

There is a large number of promising and interesting projects planned for the next years. In part they are natural continuations of previous works, while some projects are more innovative, and even risky including strong thematic changes, like that from condensed matter towards econophysics. This leads to some dispersion, which is partly related to the creativity of the unit spread among many researchers, a very positive aspect of the unit! As proved by the impressive scientific production of those last five years, such diversity does not alter either fruitful interactions or the emergence of new ideas which arise through spontaneous collaborations.

The committee believes that the unit will maintain its high scientific standards, in particular thanks to the extremely high quality of young researchers. Nevertheless, a more global thinking about a few big common projects would certainly help the LPTMS to better exploit its fantastic abilities, by identifying potential interactions either inside the unit or with other laboratories. Furthermore, the committee feels that, in general, the remarkable advances made by the LPTMS are undersold. This relative weakness in communication might also be corrected through a more structured plan, which highlights the strengths of the unit and sets up some banner or flagship in relation with its specific expertise. Such a communication policy would be particularly worthwhile for the LPTMS, considering all the projects which display a wide range of applications, for example from biology to medicine or ecology.

In the next five years, the LPTMS will have to face its transfer to the Saclay plateau. There is a reasonable consensus about this vast operation, despite some members worries that important decisions were taken too quickly. Today, the position of the unit is rather pragmatic, trying to make the most of the opportunities associated with the large-scale project surrounding the new location on the Saclay plateau. The new building should offer more space which is urgently needed. The insertion of the LPTMS into the new structures, in particular the LABEX PALM, is important for strategy purposes, ensuring a priori some resources and protection. The unit is also very active in the emergence of the new Institute for Advanced Physics, a rather attractive concept which matches multidisciplinary projects. The natural connections that the unit has with the LPS and the FAST on the plateau should be enhanced and the committee encourages the unit to develop interactions with other disciplines, such as mathematics for instance, and to strengthen the collaborations with experimentalists in other laboratories on the campus and in engineer schools.

In conclusion, the committee invites the CNRS and the University to strongly support the LPTMS, especially with respect to its new localization on the Saclay plateau. Reducing the education duties of assistant professors and professors should be considered as well as reinforcing the number of University teachers with respect to CNRS researchers. The university should pay a special attention to the access to scientific journals and reviews, which has recently undergone some perturbations and breakdown. More generally, the committee recommends the CNRS and the university to provide all the resources needed by the LPTMS in order to maintain, and even increase, its remarkable output.

4 • Team-by-team analysis

Team 1 : Team name Condensed Matter and Quantum Fluids

Name of team leader: Mr Georgy SHLYAPNIKOV

Workforce

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	3	3
N2: Permanent EPST or EPIC researchers and similar positions	6	6
N3: Other permanent staff (without research duties)		
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	2	4
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	11	13

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	4	
Theses defended	7	
Postdoctoral students having spent at least 12 months in the unit	6	
Number of Research Supervisor Qualifications (HDR) taken	1	
Qualified research supervisors (with an HDR) or similar positions	7	7

• Detailed assessments for Team 1

Assessment of scientific quality and outputs

The group consists of 10 permanent researchers, including an emeritus, 3 U-PSUD and 6 CNRS. The research interests of the group pertain to several domains of the physics of quantum gases, strongly correlated systems, fractional quantum Hall effect, low dimensional devices or Kondo phenomenon. Through the evaluation period the group produced 125 scientific publications in leading international refereed journals, including several Physical Review Letters (29) and 3 Nature Physics. This high level of scientific activity is all the more remarkable given the fact that some members have heavy administrative responsibilities (one member was deputy director for physics at the CNRS, while a second was the head of the predoctoral program of Les Houches) and other members have heavy teaching duties being "enseignants-chercheurs".

The most original results concern (i) the study of Hawking radiation in Bose gases which opens the possibility to experimentally observe the Hawking radiation in a laboratory; (ii) the prediction of the topological p_x+ip_y superfluid phase for microwave-dressed polar molecules in 2D; (iii)the breakthrough of a finite temperature phase-transition between two distinct states, fluid and insulator, in one-dimensional disordered bosons where it is known that conventional finite-temperature phase-transitions cannot occur since thermal fluctuations destroy long-range correlations; (iv) the study of the role of integrability and finite size effects on sudden quenches of interactions and on thermalization of cold atomic bosons; (v) the emergence of the Pfaffian wave function as a robust option for the 5/2-fractional quantum hall state in the second Landau level.

Moreover the prediction of novel Feshbach resonances induced by microwave fields could be of great impact in the evolution of ultracold-gas experiments and the study of the role of the interactions in some atomic species. This possibility has been excluded by theory until now.

Generally speaking these studies have all been developed, keeping in sight the objective of their experimental realizability, and quite often in close connection with outstanding experimental groups in France and abroad.

Assessment of the team's academic reputation and appeal

The team has long a standing reputation for providing leaders both in the fields of condensed matter and quantum fluids. During the report period the group has been reinforced at the junior level by the recruitment of two very brilliant and active researchers (a CNRS junior researcher and an assistant professor) who have strengthened the connection of the team with the other members of the laboratory. Several outstanding postdoctoral fellows have contributed to the dynamics of the group and its evolution.

The reputation of the group is attested to by a number of academic distinctions, including one advanced ERC grants, a senior BEC award, one *Triangle de la Physique* external junior chair together with a Triangle senior chair, and an outstanding APS referee award. The scientific standing of the group members and their original research ideas has led to the award of 6 ANR grants over the reporting period, plus numerous other sources of funding, including an ECOS-SUD grant. Both the senior and the junior members of the team are regularly invited as speakers at international conferences. The senior members have participated as editors of leading physics journals and also have been organizers of a number of prestigious international conferences.

Assessment of the team's interaction with the social, economic and cultural environment

See general assessment on the unit.

Assessment of the team's organization and life

See general assessment on the unit.

Assessment of the team's involvement in training through research

The team includes three outstanding assistant professors who provide a connection between the LPTMS and students of the Paris-Sud University and other institutions in the Paris area. They are providing key courses in quantum mechanics, statistical physics and condensed matter, are involved in several masters programs, including "Concepts fondamentaux de la physique" and motivate the Paris-Sud Licence programme which includes preparation for students trying to integrate "Les Grandes Écoles", giving university students an important help within the French education system. It is regrettable that the CNRS members are not more involved in teaching at University Paris-Sud. At present an administrative rule excludes this possibility, preventing the sharing of teaching responsibilities. CNRS members are however involved in teaching and research training both at local level, by organizing the "LPTMS"courses for the students and postdoctoral fellows of the laboratory, and at international level with the organization of several *Les Houches* and *Institut Henri Poincaré* international sessions. During the report period the group has directed the PhD of 7 students and 3 are still in progress. These students benefit from an active scientific environment based around a successful biweekly "journal club".

Assessment of the strategy and the five-year plan

The scientific objectives for the next 5 years follow the lines of the main research topics of this group in the last past years. This ensures consistency and the achievement of targets.

Several original ideas emerge from the project: (i) exploiting the particular density of states of an interacting Bose gas in quasi-periodic potentials to create localized states at "high" temperature; (ii) study the manifestation of the sonic Hawking radiation in the measurement of momentum correlations in a 1D Bose condensed gas; (iii) exploiting novel Feshbach resonances in low dimensional systems to study the "death of multi-particle entanglements"; (iv) manipulating the symmetry of Fermi superfluid pairing in 2D with the aim of achieving d-wave symmetry and developing models that simulate the behaviour of high-temperature superconductors; (v) understanding the topological properties on non-abelian quasi-particles in the 5/2-fractional quantum Hall state. Although one might have looked for more new and original projects, the ensemble of subjects presented here is interesting and exciting and there is no doubt that the team will developed them successfully. However it is also worth pointing out that one member of the team has proposed a radical switch of research activity from strongly correlated electrons to complexity and game theory, motivated by economics and computer science. This is exciting and courageous and preliminary indications suggest it will be successful.

Conclusion

- **Strengths and opportunities:**

Excellent expertise in condensed matter and quantum gases; collaborations with top experimental groups in the field of cold atoms.

- **Weaknesses and threats:**

Heavy teaching and administrative charges on various members.

- **Recommendations:**

Enhance collaborations inside the group.

Team 2 : Team name Statistical physics, dynamical systems

Name of team leader: Mr Satya N. MAJUMDAR

Workforce

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	1	
N2: Permanent EPST or EPIC researchers and similar positions	8	8
N3: Other permanent staff (without research duties)		
N4: Other professors (PREM, ECC, etc.)		1
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	3	1
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	12	10

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	4	
Theses defended	4	
Postdoctoral students having spent at least 12 months in the unit		
Number of Research Supervisor Qualifications (HDR) taken		
Qualified research supervisors (with an HDR) or similar positions	7	

• Detailed assessments for Team 2

Assessment of scientific quality and outputs

Team 2 “Statistical physics, dynamical systems” comprises 9 permanent staff, 4 PhD students and 2 post-docs. The team has published 142 papers during the evaluation period, including 21 in Physical Review Letters, 10 in Journal of Statistical Physics, 8 in Nuclear Physics B, two in PNAS (Proceedings of the National Academy of Sciences) and one in Reviews of Modern Physics. Junior team members stand behind 41 of the 63 papers produced by staff appointed since January 1, 2008 (without co-authorship of other lab members) and team members are implicated in 15 out of 15 common scientific papers (across-teams) produced in the laboratory.

The team has achieved very surprising and far-reaching exact results on the convex hull of collections of Brownian motion and branching Brownian motion in 2D, with potential applications to ecology (animal disease spreading) and nuclear radiation damage and other fields. The team has also achieved outstanding results on extreme value statistics of eigenvalues of random matrices including the unexpected equivalence to the vicious walker problem. Among many other results obtained by the team using random matrix theory we highlight a new description of quantum entanglement, results on the distribution of the index of random Gaussian and Wishart matrices, and results on the ratio of nearest level spacings, a new statistics adapted to high-dimensional (many-body) systems. The team had further achieved interesting results on typical secondary structures of RNA molecules, and in conformal field with applications to the fractional quantum Hall effect or conformally invariant random processes.

Assessment of the team's academic reputation and appeal

Various awards were attributed to several team members, like the Prix Langevin de l’Académie des Sciences (2008), the Tata Excellence Award (2009), and the CNRS Bronze medal (2010). A member is Divisional Associated Editor of Physical Review Letters (since January 2009). He is also Adjunct Professor at Tata Institute, Bombay, India (since 2005), at the Weizmann Institute, Rehovot, Israel (since 2011), and at ICTS, Bangalore, India (since 2011), and has given several invited lectures. He was a plenary speaker at STATPHYS25 (Seoul, South Korea, July, 2013). During the evaluation period the team has hired two CNRS CR, and welcome two CR (mutations). All of these three have excellent publication records and have demonstrated independence, for instance by producing a large number of papers without co-authorship of other team or lab members. Most of the postdocs and PhD students in the team are recent hires and have not yet produced a significant number of papers. The committee was however able to verify that the atmosphere in the team was very positive and encouraging to young researchers.

Assessment of the team's interaction with the social, economic and cultural environment

See general assessment on the unit.

Assessment of the team's organization and life

See general assessment on the unit.

Assessment of the team's involvement in training through research

The team is comprised almost exclusively of CNRS researchers, the only enseignant-chercheur soon to retire. Other team members are nevertheless involved in undergraduate teaching at École Centrale and at École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris. The team leader has given invited lectures at two leading summer schools (Les Houches 2008, Leiden 2009). Two of the junior team members have given the yearly internal advanced lecture course at LPTMS (in 2011 and 2012, respectively).

Assessment of the strategy and the five-year plan

With the passing away of one emeritus member and two impending retirements, the team will comprise of 3 Senior Scientists (DR) and 4 Associate Scientists (CR), and will be markedly young. The proposed plan for the next five years comprises eight projects, many of them with the common themes of using/extending random matrix theory and of exploiting the breakthroughs achieved by the team in the preceding period.

The committee noted the proposed extension of the work on convex hulls of stochastic processes from two to three dimensions, and the extension extreme statistics from maximal/minimal events to near maximal/minimal events, or to the distribution of the k'th largest/smallest events. The team pioneered these directions and is likely the best placed to pursue them, world-wide. The commission also noted the stated ambitious long-term goal "to build a comprehensive theory and classification of […] statistics for strongly correlated variables".

The committee further noted connections to be made between random matrix theory and principle component analysis (PCA) which ties in with recent developments in the statistics literature (e.g. Noureddine El Karaoui, "Spectrum estimation for large dimensional covariance matrices using random matrix theory", Ann of Statistics, Volume 36, Number 6 (2008), 2757-2790). The committee suggests that perhaps such potential connections to mathematics / statistics could be exploited more in the following contract period.

On the renewal side the committee notes the proposed application of random matrix theory to the Multiple-Input-Multiple-Output (MIMO) problem in information theory. Research in this direction is already pursued in many places, and the team, with their depth and breadth of expertise in random matrix theory may here achieve significant impact. The committee believes that the impact may be enhanced if the team strives to publish results to be obtained in this direction in high-profile journals in information theory, and also that there could be potential synergies with engineering schools in the future Paris-Saclay center such as e.g. Supelec.

The committee further notes the proposed new direction on the intersection between physics and finance / economy / game theory. The proposed work from the team is interesting and innovative. The commission particularly notes the combination of (backwards) Hamilton-Jacobi-Bellman equation for a stochastic optimization and (forwards) Fokker-Planck for the development of the state which has many applications to mathematics and physics well outside this indicated application area. The proposed work on the game of Go is interdisciplinary and somewhat speculative, but could well interest and attract undergraduate / post-graduate students, and therefore serve a secondary purpose to broaden the team's and the lab's recruitment and teaching base.

Conclusion

- **Strengths and opportunities:**

Unique expertise in random matrix theory with a large variety of applications.

- **Weaknesses and threats:**

Absence of assistant-professors and professors.

- **Recommendations:**

Enhance contacts and collaborations with researchers in mathematics or in engineer schools on the Saclay plateau.

Team 3 : Team name Disordered systems, soft matter and physics-biology interface

Name of team leader: Mr Silvio FRANZ

Workforce

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	3	2
N2: Permanent EPST or EPIC researchers and similar positions	4	4
N3: Other permanent staff (without research duties)		
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	3	3
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	10	9

Team workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	6	
Theses defended	7	
Postdoctoral students having spent at least 12 months in the unit	11	
Number of Research Supervisor Qualifications (HDR) taken	2	
Qualified research supervisors (with an HDR) or similar positions	6	5

• Detailed assessments for Team 3

Assessment of scientific quality and outputs

Team 3 consists of overall 7 staff members, 7 PhD students and 2 post-docs. One senior staff member is on "détachement", and another one holds currently an ENS director position. One junior staff member has been appointed in 2011. During the evaluation period, the team was scientifically highly productive, with overall 188 peer-reviewed publications in high-level journals also outside physics, including 5 in PNAS (Proceedings of the National Academy of Sciences), 22 in Physical Review Letters, 1 in Cell, and 1 in Nature Communications. Of all three teams, the research directions of team 3 are the most diverse ones. They range from the statistical physics of disordered systems (spin- and structural glasses, avalanche dynamics) to cavity methods with applications (superconductor-insulator transition, compressed sensing), soft matter systems (strongly charged colloids), granular gases (non-elastic Boltzmann and fluctuating hydrodynamics equation methods), Casimir interactions of arbitrarily shaped bodies, bio-mechanical studies (e.g., cytoskeleton contraction) and system biology activities (biological networks). Most of these research activities are of a distinctly interdisciplinary character, with strong links to computer science and information theory, electrochemistry and colloid science, microbiology, and medicine.

Among the many high-profile and far-reaching results of team 3, the Compressed Sensing activities have made the strongest impact so far. The new "seeded Belief Propagation" reconstruction method developed in collaboration with members of the team allows for reaching the theoretical compression limit. It is based on insights from crystal nucleation theory, and replica and cavity methods for disordered glassy systems. The method can be used for improved data storage and extraction, the speeding up of magnetic resonance and X-ray imaging (dose reduction), and for imaging applications in astronomy. Various applications and extensions are under development.

The committee further highlights important advances achieved using cavity methods that account for fluctuations in a local environment within an overall mean-field environment. This is essential for extracting a meaningful phase diagram for glassy, disordered or frustrated systems. Collaborations involving LPTMS members have applied this technique with success to quantum systems. Pertinent results include the mapping of quantum path integrals of glassy or frustrated systems onto a classical dynamical system, and the projection of the cavity Hilbert space onto approximate spaces in the study of disordered superconductors. The model superconducting phase becomes stable to a finite level of disorder only through the inclusion of cavity fluctuations. These are important developments in this difficult field.

The work on the strong coupling expansion for strongly charged colloids, and here in particular the precise calculation of ground-state micro-ion distributions and associated phase diagram, has very significantly advanced the understanding of the effective interaction of strongly repelling charged colloids. It has led to the first clear physical picture of counterion-induced like-charge attraction between closely spaced and equally charged bodies. This interdisciplinary work should prove very useful in future theoretical modeling of the stability, phase behavior and dynamics of charge-stabilized colloids and protein solutions.

A member of the team has developed a universal and exact approach for computing the Casimir forces between objects of arbitrary shape and material composition described on the continuum level. A general scattering series approach, with the object properties encoded in individual scattering matrices, has been developed for this purpose. Explicit results have been obtained in particular for objects with sharp edges and tips. An extension of the scattering series method to heat transfer problems has also been made. This is a truly interdisciplinary project with a plethora of possible applications in various fields.

The committee notices also the excellent works at the physics-biology interface, namely on the relation between protein folding and function, the stress built-up and buckling of contracting actomyosin bundles, and on the modeling of intra-cellular networks. We highlight particularly the joint theoretical-experimental validation of the fission mechanism, published in a paper in the top-ranked journal Cell with a member of the team as co-author.

Assessment of the team's academic reputation and appeal

The excellence of the staff members of team 3 is visible also through prestigious awards and promotions to high profile positions. A former LPTMS director has received the Gay-Lussac-Humboldt prize, and has been appointed as the director of the ENS in Paris. A university professor in the lab has become research director at INRA, but will continue to work part time at the LPTMS. This person is directing now a plant genetic unit, and acts as deputy director of IMSV (Institut de Modélisation des Systèmes Vivants). Another member of the lab received a German Heisenberg fellowship. A Paris-Sud senior chair of excellence was awarded to one of the remaining university professors of team 3. One very promising young staff scientist has joined the lab in 2011. Both researchers have excellent independent publication records, and they have added significantly to the attractiveness and visibility of the research at the LPTMS by opening, in particular, new activities at the bio-physics interface, and by establishing new collaborations with groups outside the LPTMS.

Assessment of the team's interaction with the social, economic and cultural environment

See general assessment on the unit.

Assessment of the team's organization and life

See general assessment on the unit.

Assessment of the team's involvement in training through research

Team 3 has the largest number of PhD students and post-docs. While most are recently hired, some of the young scientists have already produced a number of papers. The committee noticed the very friendly and productive atmosphere inside the team, percolating throughout the lab. Members of team 3 have been involved in various teaching activities. One professor organized the Spring College of Advanced Physics in Trieste and is directing, together with a second professor, the international master program “Physics of Complex Systems”. Another professor is co-directing the graduate program “Physique et Systèmes Biologique”, and he has organized a conference on Physics and Biology. Further points to note include the organization of a seminar series at the physics-biology interface, in cooperation with the LPS and ISMO institutes, and the publication of a monography “Information, Physics and Computation” (2011) which has already become a standard textbook in the field.

Assessment of the strategy and the five-year plan

The proposed plan for the next five years comprises five projects, which are partially building on the impressive pool of results obtained by the team in the preceding period. The project on a quantitative field theory of dynamical glass transition aims at going beyond mean-field like theories using mode-coupling methods. The project builds on an impressive series of papers on replica field theory and mode-coupling theory approaches to the glass dynamics published over the past three years with leading participation by team 3. Even so, there remains a great challenge that requires all the expertise of the LPTMS members.

The committee further notices the planned extensive studies of avalanches in diverse systems with a view to making universality class classifications. This project is very interesting. For an enlarged visibility outside the lab, it would be gratifying to develop applications to the dynamics of stress-loaded amorphous solids.

The interface project between statistical physics and information theory (computer science) includes two research directions. In the first one, the compressed sensing reconstruction method developed in the last period will be extended and applied to various problems related to dictionary learning, tomography, non-linear measurements, and information processing by the brain. The involved team members very reasonably exploit here the ground-breaking results gained in the preceding period. The second direction goes under the label optimization on networks and aims at developing self-managed algorithms with applications to communication scheduling and routing, resource allocation, and other network features. The team has strong competence in the proposed statistical physics based methods. The commission suggests to strengthen further the visibility and potential impact of this work through collaborations with communication networks and information theory groups.

In the soft condensed matter project, future applications of the strong coupling approach are outlined. Most notable are the planned investigations of the dynamics of micro-ion condensates in external electric fields. With their deep knowledge of effective interactions and correlations of charged particle systems, the team is excellently prepared for this ambitious task which is highly relevant for the understanding of electro-kinetic effects in charged soft matter and biomolecular systems such as DNA and proteins. We believe that the expected high impact could be even further enhanced by analyzing, in addition, the electrophoretic motion of strongly charged interacting colloids.

Future work in the project about Casimir forces will include new situations, for instance objects kept at different temperatures or moving bodies. The planned work is of great generality, with the prospective of a vast application range both to quantum-mechanical and classical systems. It partially builds on a general scattering series expansion method developed by a team member during the last period.

Two research lines are outlined in the physics-biology interfaces project. In the first line, well- established biological network activities will be extended to the modeling of the regulation of cell differentiation in plants. This research line will be guided by interactions with plant biologists. The second line deals with the geometrical organization of filaments (cytoskeleton contractility). This new development appears very promising, with the prospect of potentially learning more about diseases such as Alzheimer. It takes advantage of established collaborations with experimentalists.

Conclusion

- **Strengths and opportunities:**

Excellent and complementary abilities in disordered systems and statistical physics with a wide range of applications including other disciplines like computer science and biology.

- **Weaknesses and threats:**

Heavy administrative duties for various seniors.

- **Recommendations:**

Make more advertisements in order to develop fruitful collaborations with other groups in information theory or charged soft matter.

5 ● Conduct of the visit

Visit dates:

Start: Tuesday, 3rd, December, 2013, at 10 am

End: Wednesday, 4th, December 2013 at 4:30 pm

Visit site:

Institution: LPTMS

Address: Bât 100, Université Paris-Sud, 91405 Orsay Cedex

Conduct or programme of visit:

Tuesday December 3rd 2013 :

10 am-10:30 am:	Private meeting of the committee
10:30 am-11:20 am :	Overview by the director of the LPTMS
11:20 am -12:20 am:	Scientific presentations by team leaders
Lunch	
2 pm-3 pm :	Scientific presentations by young researchers
3 pm-5:30 pm :	Discussions with researchers
5:30 pm-6 pm :	Private meeting of the committee

Wednesday December 4th 2013 :

Meetings with

9 am-9:20 am :	Administrative and computer staff
9:20 am-9:40 am :	Laboratory Council
9:40 am-10 am :	PhD students
10 am-10:20 am:	Post-docs
10:20 am -10:50 am:	Director
(coffee break)	
11 am-11:30 am :	Director of Doctoral School
11:30 am-12:15 am :	Representatives of Paris-Sud University and CNRS

(private lunch of the committee)

2 pm-4:30 pm :	Private meeting of the committee.

6 • Supervising bodies' general comments

UNIVERSITÉ PARIS SUD

Comprendre le monde,
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Le président de L'Université Paris-Sud

A

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Orsay, le 04 Mars 2014

Réf : 34/14/JB/LM/AL

Objet : Rapport d'évaluation d'Unité de Recherche
N° S2PUR150007930

Monsieur le Directeur,

Vous m'avez transmis le 10 février dernier, le rapport d'évaluation de l'Unité de recherche – Laboratoire de Physique Théorique et Modèles Statistiques – LPTMS – N° S2PUR150007930 et je vous en remercie.

L'Université se réjouit de l'appréciation portée par le Comité sur cette unité et prend bonne note de ses suggestions..

Je vous prie d'agréer, Monsieur le Directeur, l'expression de ma sincère considération.

Le président de l'Université Paris-Sud

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Professeur Jacques Bittoun