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

Department for the evaluation of research units

AERES report on research unit:

Laboratoire de Physique Théorique

LPT

Under the supervision of the following institutions and research bodies:

Université Toulouse 3 – Paul Sabatier – UPS

Centre National de la Recherche Scientifique

October 2014

Evaluation report

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

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

Unit name:	Laboratoire de Physique Théorique
Unit acronym:	LPT
Label requested:	UMR
Present no.:	UMR 5152
Name of Director (2014-2015):	Mr Clément SIRE
Name of Project Leader (2016-2020):	Mr Bertrand GEORGEOT

Expert committee members

Chair:

Mr Emmanuel TRIZAC, Université Paris-Sud

Experts:

Mr Peter HOLDSWORTH, Ens Lyon (representative of the CNU)

Mr Ulrich SCHOLLWÖCK, Ludwig Maximilian University, Munich, Germany

Mrs Patrizia VIGNOLO, Université de Nice (representative of CoNRS)

Scientific delegate representing the AERES:

Mr Marc KNECHT

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

Mr Éric BENOIST (director of the Doctoral School *Sciences de la Matière*)

Mr François DEMANGEOT, Université Paul Sabatier

Mrs Virginie MAHDI, délégation régionale CNRS

Mr Bertrand MONTHUBERT, Université Paul Sabatier

Mr Alexis VALENTIN, Université Paul Sabatier

Mr Bart VAN TIGGELEN, Institute of Physics, CNRS

1 • Introduction

History and geographical location of the unit

The unit, located on the Paul Sabatier – Toulouse 3 campus, was officially created in 2003. It originates from a team of theoretical physicists which arrived in 1992 as a part of the *Laboratoire de Physique et Chimie Quantique*, in an effort to promote fundamental physics in Toulouse. The graft was particularly successful, so that it now forms a separate joint Université Paul Sabatier (UPS) – CNRS unit (*'Unité Mixte de Recherche'*). It belongs to the IRSAMC (*Institut de Recherche sur les Systèmes Atomiques et Moléculaires Complexes*) federation, together with three other units. Two of these share the same premises (building 3R1).

Management team

The present director is Mr Clément SIRE, assisted by Mrs Malika BENTOUR (secretary) and Mrs Sandrine LE MAGOAROU (on a 50 % part-time position, in charge of computer aspects).

AERES nomenclature

ST2 – Physics.

Brief description of activities

The fields of study pertain to condensed matter and statistical physics in the broad sense. The range of topics investigated at LPT is impressive for a unit of this size, from strongly correlated quantum systems to irradiation processes in clusters, including quantum coherence, mesoscopic physics, soft condensed matter, non-equilibrium and disordered systems. Several lines of research are directly relevant to closely related disciplines such as biology, mathematics, chemistry, astrophysics, computer sciences and social sciences.

Unit workforce

The research staff consists of twelve CNRS researchers and nine faculty members. It is organized in four groups, assessed separately in section 3:

1. Strongly Correlated Fermions (headed by Mr Didier POILBLANC);
2. Quantum Coherence (headed by Mr Dima SHEPELYANSKY);
3. Statistical Physics of Complex Systems (headed by Mr Nicolas DESTAINVILLE);
4. Finite Fermionic Systems and Clusters (headed by Mr Éric SURAUD).

Unit workforce	Number as at 30/06/2014	Number as at 01/01/2016
N1: Permanent professors and similar positions	9	9
N2: Permanent researchers from Institutions and similar positions	12	13
N3: Other permanent staff (without research duties)	1.5	1.5
N4: Other professors (Emeritus Professor, on-contract Professor, etc.)		
N5: Other researchers (Emeritus Research Director, Postdoctoral students, visitors, etc.)	6	
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	**28.5**	**23.5**

Unit workforce	Number as at 30/06/2014	Number as at 01/01/2016
Doctoral students	14	
Theses defended	14	
Postdoctoral students having spent at least 12 months in the unit	16	
Number of Research Supervisor Qualifications (HDR) taken	3	
Qualified research supervisors (with an HDR) or similar positions	12	>12

2 • Overall assessment of the unit

Global assessment of the unit

After a very positive round of evaluation conducted in 2009, the LPT has gained even more momentum, maintaining a first rate scientific production, appointing junior staff of excellent level, and securing funds from multiple sources with remarkable success. The research conducted is original, diverse and of excellent pedigree, highly visible and recognized. It is embedded in a convincing network of collaborations. This provides the grounds for a vigorous and sound outreach activity, knowledge dissemination and valorisation. The unit, furthermore is managed in an exemplary fashion, consequently it enjoys an excellent academic reputation and appeal. It ranks highly among theory laboratories in France and competes among the top 10 % at the international level. Twenty-two years after the initial transplant in Toulouse, the LPT has evolved into an outstanding research and teaching organization, constituting an ongoing success story.

Strengths and opportunities in relation to the context

The experts committee has identified a number of strong points and opportunities, starting with the high level of scientific expertise of the staff. The lab shows a healthy age distribution, improved gender characteristics, and in spite of the disparity in size of the different groups, the activity for all is well balanced in terms of community service in the broad sense, and contract management. Praiseworthy are also:

- the collective dynamics within the unit, which is highly positive;
- the skilful and sterling management, be it on scientific or on administrative affairs;
- the success in outreach, knowledge dissemination, transferred knowledge;
- the supporting staff, highly efficient and appreciated;
- the commendably successful effort to establish collaborations with experimentalists, and outside physics;
- the interactions with IRSAMC federation, a convincing and efficient agora, common to four physics/chemistry units, which endows them with an impact and visibility at the local scale, that they would not reach with the same efficiency otherwise.

Weaknesses and threats related to the context

Although no clear weaknesses have been identified in the course of the evaluation, a number of potential threats can be outlined, some of them being rather generic:

- the unit has significantly grown in size in recent years. It awaits appropriate support in terms of office space. Congestion looms;
- there are concerned on the lacuna-rich projection of fundamental unit's activities, such as the LPT, onto the regional, national and European strategies for research. This worry echoes recent ANR trend for 'low energy' theoretical physics activities, which, if not hostile, is at least unfavourable;
- the experts committee deplores the decrease of funding opportunities at doctoral level;
- compared to structures of a similar size and range of activities, LPT presents a notably weak administrative support in terms of numbers;
- career perspectives of supporting staff are thwarted. The experts committee encourages the unit to pursue sustained efforts towards the promotions of the managing secretary, and, at the level of IRSAMC federation, of the engineer in charge of computers, for instance encouraging and supporting the supervision of students. As emphasized above, this pair is of remarkable quality, providing invaluable assistance.

Recommendations

Several issues deserve attention:

- the activity in the realm of biophysics and soft matter has witnessed critical weakening in the last two years. It is currently carried by teaching staff only. Reinforcing this domain of activity seems a priority, and a CNRS position would be highly desirable here;

- two professors have recently left, for personal reasons. Their scientific performances, during their stays at the LPT, were rather exceptional. The experts committee thus hopes that the recent professor position opening, submitted by the unit, will meet benevolence from the governing bodies. The proposed scientific profile is large, and promises a strong competition at the best international level;

- a convergent need has emerged in two groups, to benefit from the support of a computer scientist, in charge of optimization and development. What it at stake is not computer or hardware assistance, duly and competently covered already. Given the heavy and advanced computational nature of numerous LPT's research projects — several millions of CPU hours are used yearly at facilities such as IDRIS/GENCI, or the local excellent CALMIP — , such an opening, at '*Ingénieur de Recherche*' level, is fully justified, and endorsed by the experts committee. Loss of competitiveness is to be feared otherwise. A hiring of this kind has proven invaluable in other units of a similar size and it is evident that all four groups would enormously benefit from interaction with such a person. The experts committee anticipates a rewarding return on investment, not only for the range of activity where numerical efficiency is the keystone, but also for the whole lab;

- as in other institutions, the situation of faculty members (*'enseignants-chercheurs'*) is fragile, and often impeded by a heavy teaching load, to which unofficial but time consuming chores must be added. This work force within LPT, of exceptional quality, would benefit from a partial transfer of duties to CNRS staff. Such an evolution, which requires that the University accepts CNRS volunteers for teaching duty, would be a significant progress;

- finally, LPT took the lead on the *'École des Sciences Avancées de Luchon'*, an endeavour to enhance interdisciplinary exchange between different sciences. It is of interest for a large number of researchers in the Midi-Pyrénées region, with a potential for matching the most notable realizations of the kind. It aims at providing the site with a structure for hosting schools and conferences, thereby contributing to the academic reputation and appeal of the entire Toulouse scientific scene. The experts committee enthusiastically supports this initiative, which merits proper funding. To this end, it is recommended that the School governing body and Scientific Council match, in their diversity, the proposed thematic breadth of the project.

3 • Detailed assessments

Assessment of scientific quality and outputs

The laboratory has produced excellent research, often at the forefront of the activity in a large gamut of fields, leading to sustained production in high quality international journals (more than 400 articles during the reporting period, with a fraction close to 10% in the top journal Physical Review Letters). All groups have been able to develop tight and fruitful connections with experimental teams. Fundamental breakthroughs were reported, and a number of original applications have been developed –see below- or can be foreseen in astrophysics, mathematics, but also in ecology, biology, social sciences and medicine. This is remarkable and sheds due light on the open-mindedness and creativity of LPT researchers.

Assessment of the unit's academic reputation and appeal

The LPT attracts high level young researchers, as attested by every single CNRS competition, or when a university position is opened (which happened twice during the period covered by the report, with about 50 candidates for each '*maître de conférences'* position). Seven first rate junior fellows where thus appointed between 2009 and 2014 in permanent positions, an exceptional sequence. Likewise, the unit is very attractive at PhD level -- another probe of its reputation-- and it enjoys an active visitor program. A number of high profile scientists thereby spent from several days to several weeks at LPT. The unit's appeal also reflects itself in the unusually large number of external collaborators (more than 300 from about 200 institutions).

The teaching staff has been uncommonly successful at IUF level. The LPT, which amounts to 0.5 % of UPS faculty members, represents 15 % of IUF nominations within UPS. During the period 2009-2014, three members were thus distinguished. We note that a PhD student was awarded the young researcher prize by the Bettencourt Schueller foundation in 2010. Two members were distinguished as Outstanding Referees by the American Physical Society. A substantial part of LPT members has been awarded the '*Prime d'Excellence*', well above the mean national figure in theoretical physics, and science in general. The experts committee also appreciates the high implication of LPT in community service at local (University, Labex, Idex), national (ANR, CoNR, CNU, Institut Henri Poincaré) and international level (European networks, editorial boards of journals such as the Physical Review). In all groups, researchers are involved in the organization of national or international conferences.

Finally, a sizeable number of grants are running (18 European or ANR contracts), from which LPT reaches a high level of external resources. This is implicit praise for the quality of the research performed, but also proves that LPT members are keen on establishing collaborations with diverse actors. The success of the Labex NEXT, where LPT has been and still is a key driving force, also points in the same direction.

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

The LPT plays a prominent role on campus and beyond. As alluded to, it was a major actor within the '*Investissements d'Avenir'* program, and in particular, in the so-called 'Initiatives of Excellence'. Although a priori not prone to economic valorisation, its activity nevertheless led to the development of the Nanoflux software for the chemical and pharmaceutical industries, and several open source libraries. Noteworthy is also its activity, coined 'physics of society', which is original and in resonance with the endeavour towards knowledge transfer and popularization of science, topics on which a particular and rewarding effort has been made. Some members have shown a talent for presenting general topics outside the box, which is highly commendable.

LPT's impact on the social or economic environment largely exceeds what is typical for a theoretical physics unit. A concerted effort is devoted to this sector, and as a whole, the laboratory embraces or creates numerous occasions pertaining to outreach activities, or more generally knowledge transfer. Promising studies are planned at the crossroads of biology and nanosciences, with a focus in irradiation of molecules of biological interest, for applications in proton/hadron-therapy.

Assessment of the unit's organisation and life

The division into four groups provides a convenient canvass for scientific reporting and charting out the landscape, but does not erect boundaries between the different types of activities, or fields. This organization, where groups do not operate as 'teams', does not have financial implications. Collaboration and interactions across these virtual limits are common and promoted by the internal and positive collective dynamics of LPT. The management, collegial and enlightened, is undoubtedly exemplary. All internal decisions are discussed collectively by permanent staff during a regular 'lunch meeting', a very constructive feature inherited from LPT's growth out of an original small nucleus. An essential aspect of life within the unit stems form the supporting staff, efficient and of pivotal importance. Its prominence should be emphasized and acknowledged.

As stressed above, during the reporting period, LPT had a very active and successful policy for securing funding from an important number of sources (ANR, ITN, COST, FET Open, IUF, PEPS, PICS...). Financial and contractual matters are particularly sound, which allows for a healthy scientific life, including a rich visitor program, and a sustained flux of students and postdocs.

Another asset for LPT's organisation is the IRSAMC federation, the perimeter of which includes about 200 persons in four units, with a specific dedicated staff of three. Theory is a transverse theme in this appropriate organization, in which LPT is at ease. Very active in outreach and popularization of science, IRSAMC plays an undisputed institutional role, conducting a variety of common operations, such as shaping of medium to large scale projects ('*CPER*', '*mi-lourds'* CNRS, IDEX projects, '*plan campus*'). IRSAMC has reached the right size to be a player of weight on campus, audible and influential. LPT has, undeniably, benefited from this partnership. On a more scientific note, IRSAMC is a catalyst for collaborations. It has fostered and promoted several remarkable achievements, and joint effort between LPT and experimental groups. IRSAMC has in particular supported the development of a cold atoms group in LCAR ('*Laboratoire Collisions Agrégats Réactivité'*), which led to common LPT-LCAR investigations, where the behaviour of atom lasers in disorder was deciphered. Quantum chaos effects can thereby be evidenced and controlled in cold atoms systems, which opens auspicious venues in atomic optics. We finally note that IRSAMC hosts one of the three French nodes of the CECAM ('*Centre Européen de Calcul Atomique et Moléculaire'*), which is beneficial for all partners involved in this federation. Indeed, high performance computing is one of IRSAMC's forces.

Assessment of the unit's involvement in training through research

About 40 % of LPT researchers are UPS employees, and as such, deeply involved in teaching activities as well as in the management of two masters programs: 1) M1 of Physics, *'mention Physique Fondamentale*' together with its second year specialization '*Physique de la Matière*', and 2) M1 '*Physique et Chimie pour le Vivant et la Santé*', together with its second year specialization '*Physique du Vivant*'. LPT plays a key role in reshaping these formations whenever necessary, for they provide a sizeable fraction of its PhD students. Moreover, a large number of CNRS staff does also teach and as a whole, LPT members are deeply involved in training at PhD or masters level. In addition, extensive commitment in the Doctoral School '*Sciences de la Matière*' (ED SDM number 402) is noted, from the process of PhD fellowship allotting, to the scientific and pedagogical management of the School. Overall, the SDM School hosts more than 400 students at a given time. At the level of LPT, a bottleneck lies in the incoming flux of PhD student, which is ascribable to the support provided by the doctoral school, about one fellowship per year. Yet, the lab has succeeded in obtaining a significant number of grants from the Labex NEXT, the Region, ANR, European networks such as ITN, or in directly attracting students benefiting from their own scholarship (among which four from '*École Normale Supérieure de Lyon'*), to such an extent that there are currently 14 doctoral fellows working at LPT. These students have proven highly productive, with a mean above 4 papers published during the course of the PhD, itself defended on average in less than 3 years. In conjunction with the doctoral school, a tutoring system was put in place, where a student is put in contact with a researcher from another unit, with whom scientific and non-scientific matters should be discussed on a regular basis, progress monitored and potential difficulties be identified if any. While this initiative clearly is positive, it would benefit from a stronger involvement of the Doctoral School and lab management, in order to make sure that the pair student-tutor remains sufficiently bound.

It is somewhat regrettable that the scarcity of teaching assistantships does not allow all PhD students to teach, an issue that is completely out of the control of the laboratory. In this respect, the envisioned possible reshaping of the standard '*mission d'enseignement'* from three to two years would presumably bring more flexibility in their allocation, and allow to fill the gaps. Finally, given the high quality of student guidance and supervision, a larger flux of PhD grants from the Doctoral School would be welcome and relevant. The experts committee regrets here the rarefaction of funding opportunities at doctoral level (suppression of CNRS and regional support).

Overall, the level of graduate, and also post-graduate training is excellent.

Assessment of the strategy and the five-year plan

The experts committee would have appreciated that scientific perspectives and projects be more developed in the written documents provided. However, a portfolio of creative projects emerged during the visit. These research directions are in part the logical continuation of the existing effort, and in part more innovative, with evidences of continued thematic mobility.

At the local scale, on the grounds of its wide spectrum of activities, the unit should benefit from the resonance of its expertise with heigh of the twelve strategic axes of Paul Sabatier University. While this important match is an asset for the future, we note incidentally that a similar remark cannot be made when considering the regional, national or European scientific priorities that are currently being put forward and which seem to exclude disciplines, once called mathematics, physics, chemistry or even biology! In spite of this general point of concern, the experts committee is convinced that LPT will maintain high scientific standards, from the richness of its expertise and the scientific efforts engaged, and both its on-site and off-site network of collaborations.

4 • Theme-by-theme analysis

Theme 1: Fermions Fortement Corrélés (*Strongly Correlated Fermions; FFC*)

Manager's name: Mr Didier POILBLANC

Workforce

Theme workforce in Full Time Equivalents	As at 30/06/2014	As at 01/01/2016
FTE for permanent professors	3	3
FTE for permanent researchers	5	6
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)		
FTE for other professors (PREM, ECC, etc.)		
FTE for postdoctoral students having spent at least 12 months in the team	2	
FTE for other researchers (DREM, etc.) excluding postdoctoral students		
FTE for other contractual staff without research duties		
FTE for doctoral students	5	
TOTAL	**15**	**9**

• Detailed assessments

The group is composed by five CNRS researchers, two university professors and a young '*maître de conferences*' who recently joined. The work addresses a field of research which over the last few decades has attracted brilliant minds, as it presents intriguing open problems of modern condensed matter physics, among which high-temperature superconductivity, the nature of frustrated quantum magnets in two dimensions, the existence and nature of topological quantum phases of matter, the use of ultracold atoms as highly precise and highly versatile simulators of condensed matter systems, also under circumstances that cannot be reached in condensed matter experiments (e.g. ultra-strong magnetic fields). This domain is extremely competitive and is characterized by an interplay of advanced analytical techniques and powerful numerical algorithms for simulating quantum many-body systems available.

The group is among the strongest nationwide, and has been extremely well known internationally for more than a decade. It has been able to attract, from small beginnings, top scientists with both numerical and analytical expertise, and the quality of the PhD students of the group, some of which have gone on to highly successful careers of their own, has been excellent throughout. Moreover, thanks to its reputation and the quality of its research projects, the group obtained in the last five years three ANR grants.

In all three fields (1/ Mott insulators & quantum magnets; 2/ quantum information as a diagnostic tool; 3/ correlated electrons, ultracold atoms and topological matter) outstanding contributions have been made, of which only a few will be highlighted. The theoretical research on magnetic ladder structures has been matched by

experiments; the group is very capable of linking up with experimentalists. In the case of frustrated magnets, the contributions to the timely topic of the ground state of the Kagome magnet have been highly visible internationally and yielded important insights both analytically and numerically. It is remarkable that the group is also extending its already large range of methodological tools by using quantum information: powerful numerical fidelity measurements have been developed to investigate quantum phase transitions and are leading to tensor networks for the characterization of topological phases; this latter topic is expected to have a brilliant future as it works where the time-honoured Landau framework for phase transitions with a local order parameter fails in topological systems. Last but not least, the group continues its long-time research into high-temperature superconductivity, also using entirely new methodology (tensor networks). The results on SU(N)-symmetric systems with N>2 are very timely: while electrons obey SU(2), ultracold atom gases may form systems with SU(N>2), yielding entirely new physics, into which the group has gained first insights from both numerical and analytical perspectives. These topics promise to constitute long-time research programs, as the fields are in part just emerging.

In the last five years, the group has published more than 100 papers in peer-reviewed journals. It should be remarked that almost all papers are in highly renowned international journals (mainly Physical Review), and a substantial number (20) in the top journal Physical Review Letters. This reveals that the output of the group is both of high quantity and quality, and internationally recognized. A large number of papers originated from collaborations with leading international colleagues, and in several cases one can recognize long-standing successful cooperations. It should also be emphasized that among the papers published by the group, the PhD students have made major contributions, showing that they have been incorporated extremely well into the research environment.

The group has delivered around 100 talks at national and international conferences. The number of invited (and not merely contributed) talks at international conferences is high, confirming the international renown of the researchers of this group. They have also been very active as scientific advisors or organizers of international conferences. Last but not least, the members of this group have been active in administrative responsibilities on a national level both at the CNU and the CoNRS.

Overall, a picture of a very strong group emerges, that produces internationally highly respected research. It is remarkable that the group unifies most of the important methods of the day, which makes it well placed for the future. In some cases, the research performed is opening up entirely new fields of research. A dozen of very good PhD students who have been supervised very adequately during the reporting period, will assure the future of this field in France. It is hard to detect any weaknesses of relevance at all. In order to keep up with the output of this group, it will be important to maintain, or even enlarge, its personnel strength, and ensure sustained funding. This concerns in particular computational aspects, where the group is particularly strong. Competing groups may in the future dispose of larger computing facilities both locally and on the national supercomputing level, which it will be important to match, to keep the group as competitive as it is today. The experts committee reiterates here the importance of appropriate optimization and development support for computational questions, a conspicuous vacancy in LPT staff. The appointment of an '*Ingénieur de recherche*' with such a competence would be invaluable.

Theme 2: Cohérence Quantique (Quantum Coherence; *Quantware*)

Manager's name: Mr Dima L. SHEPELYANSKY

Workforce

Theme workforce in Full Time Equivalents	As at 30/06/2014	As at 01/01/2016
FTE for permanent professors	1	1
FTE for permanent researchers	4	4
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)		
FTE for other professors (PREM, ECC, etc.)		
FTE for postdoctoral students having spent at least 12 months in the team	2	
FTE for other researchers (DREM, etc.) excluding postdoctoral students		
FTE for other contractual staff without research duties		
FTE for doctoral students	2	
TOTAL	**9**	**5**

Detailed assessments

The group consists of five permanent researchers, including one UPS professor and four CNRS researchers. Two of them are junior fellows who joined in 2010 and 2012. A senior professor left the group in 2013 for the University of Tübingen.

The expertise is in classical and quantum chaos, mesoscopic and many-body physics, together with complex networks. These concepts and the related methods are applied to various branches of physics: electron transport, cold atoms and quantum optics, quantum information, networks of Web and games, up to astrophysics. Since 2009, the group has produced about 130 scientific publications in international refereed journals, including 7 Physical Review Letters. Some of the most original results concern (i) the exploitation of the decoherence for precision measurements by suppressing it *via* destructive interference; (ii) the synchronization theory of microwave stabilization of edge transport and zero-resistance states; (iii) the disorder versus anisotropy phase diagram of the Anderson metal-insulator transition; (iv) the realization of a beam-splitter for atoms based on chaotic effects, which opens new perspectives in atomic optics, in a fruitful collaboration with LCAR laboratory; (v) the development of new tools for analysing spectral behaviour of random quantum channels, in the framework of free probability theory; (vi) information retrieval and ranking from a combination of analytical tools inspired from random matrix theory and quantum chaos, and efficient computational techniques in complex networks; (vii) the determination of entanglement of cultures from top ranked historical figures of multilingual Wikipedia. This partial overview illustrates the diversity and richness of the research performed. It has developed on a number of fronts, some unexpected. Overall, the activity is outstanding.

The group enjoys a long standing reputation of hosting leaders in the fields of classical and quantum chaos and of disordered systems. During the reporting period, the group has been reinforced at junior level by the recruitment of two brilliant researchers, one expert in quantum information and the other expert in the dynamical Anderson localisation and on disorder effects. The academic reputation of the members is attested by the large number of

invited conferences (72 in the last five years) and by the several collaborations they have in Toulouse, France, and abroad. In the last four years, the originality of their research projects has been awarded abundant funding grants, including two European grants, six ANR grants and one PICS with Argentina. Moreover their work has provided the material for 4 press communications. One senior member, distinguished as an outstanding referee by the American Physical Society, is an editor of the Physical Review E.

The main interaction with the social, economical and cultural environment lies in the study of complex networks. These networks appear in a wealth of contexts: web, internet, commercial and social networks or games. Surprising as it may seem, the tools of complex networks had never been brought to bear for the study of human games. The possible applications are the understanding of network structure and weaknesses, epidemiology, identification of communities/links, popularity or impact measures... Of particular interest is the proposed CheiRank method, which allows for ranking nodes on a graph according to the number of outgoing links instead of the incoming links, as routinely done in Google-like searches relying on the PageRank algorithm. These studies are performed in collaborations with several partners, among which the Organisation for Economic Co-operation and Development (OCDE) and a telecom company. It is remarkable that the Quantware researchers have been able to envision and develop this application of their work. This body of work has attracted substantial media coverage (The Independent, The Guardian, Washington Post, atelier.net, medium.com).

One of the senior members of Quantware is the current director of the IRSAMC federation. The same person is proposed by the unit to be the next LPT director. These heavy administrative commitments, which are very valuable and essential to the community, could weaken the activity. This is a potential threat for the group. In the next years, it would thus be appropriate to reinforce this activity with the recruitment of a senior or a junior researcher.

During the reporting period the senior members have directed the doctorates of five students. They are involved in teaching and training at L3 and M2 level. One member of the group launched, with the municipality of Luchon, the foundation of the '*École des Sciences Avancées de Luchon*', in collaboration with NEXT and IRSAMC. Its scope goes beyond physical sciences. It has the potential for faring favourably against the most notable successes, such as Les Houches or Cargese, possibly closer to the latter from the projected thematic breadth. This initiative deserves full support, and cannot be sustainably upheld by LPT alone. It is a fantastic opportunity for the whole scientific community in the Midi-Pyrénées region, for knowledge transfer to young researchers and industrial partners, that should be seized and appropriately funded.

Theme 3: Physique Statistique des Systèmes Complexes (Statistical Physics of Complex Systems; PhyStat)

Manager's name: Mr Nicolas DESTAINVILLE

Workforce

Theme workforce in Full Time Equivalents	As at 30/06/2014	As at 01/01/2016
FTE for permanent professors	3	3
FTE for permanent researchers	2	2
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)		
FTE for other professors (PREM, ECC, etc.)		
FTE for postdoctoral students having spent at least 12 months in the team	1	
FTE for other researchers (DREM, etc.) excluding postdoctoral students		
FTE for other contractual staff without research duties		
FTE for doctoral students	3	
TOTAL	**9**	**5**

Detailed assessments

The statistical physics of complex systems activity is currently carried by a group of five researchers. During the evaluation period, the group has provided a sustained and rich stream of 123 publications in the preferred journals of the theoretical physics community, but also beyond these premises. Indeed, a number of notable contributions have been published in astrophysics, as well as in biology, gene therapy, molecular biotechnology, water treatment, or hazardous material journals, to name but a few. The fields addressed consequently span a wide range of topics, from soft matter and biophysics to long range interacting systems, including the theory of stochastic processes in various settings. These original lines of research are for some the continuation of previous investigations where LPT members have gained substantial recognition, and for some others newer trends. The experts committee highlights significant advances:

1. in the statistical mechanics of soft condensed matter and biology where the work ranges from fundamental questions inspired by biophysics, to close collaborations with experimentalists. The stability of bio-membranes under external fields has been worked out, together with the mechanisms at the root of nano-domain specialization or patterning. The physical properties of nucleic acids also provides a number of subtle problems, where the group has made key advances: denaturation/renaturation scenarii or force induced structural transitions illuminating the sequence dependence for DNA-like molecules. Finally, a powerful variational field-theory has revealed a new kind of phase transition in charged confined electrolytes, akin to capillary evaporation;

2. in the understanding of many body problems featuring long range interactions. They naturally emerge in astrophysics (self-gravitating systems), or in contexts like physical/geophysical turbulence and bacterial

chemotaxis. In particular, an original model has shed new light on the loss of stability of supernovae. A fold bifurcation has been unveiled, which explains the formidable mismatch in time scales between the explosion and the otherwise slow pace of supernovae evolution. In a related endeavour, a general potent framework has been developed for extending the kinetic theory of gases so that due account is taken of long range forces;

3. in the realm of driven lattice gases, that can be mapped onto interface growth models. Taking advantage of Bethe-ansatz techniques, first insight could be obtained into the difficult crossover regime of these strongly out of equilibrium systems, where the interface is studied on time scales comparable to its relaxation time (itself strongly size dependent);

4. in the physics of societies, be they animal or human, an emerging line of research to which we come back below.

The group members enjoy international esteem and reputation. Their research is thriving. They have been invited in a sizeable number of conferences and workshops (about 70). One researcher has been distinguished as an outstanding referee by the American Physical Society, and a PhD student has been awarded the Young Investigator Prize of the Bettencourt Schueller foundation. Some members have played and do continue to play an important role at local (IRSAMC, University, Labex, Idex) and national level (Institut Henri Poincaré, AERES, CoNRS).

The group is involved in diverse teaching activities from Licence to Doctoral level. Two '*enseignants-chercheurs*' are in charge of coordinating two different Master programs, a heavy responsibility. In addition, six PhD students have been supervised during the reporting period. Some of them have already been appointed to permanent positions in the academic sector, which attests to the quality of both the students and the training provided.

A strong feature lies in outreach activities and diffusion of knowledge, where some members have become particularly proficient. This popularization goes through very general topics. In addition, some of the research performed in the group is conducive to such exercises, such as the 'physics of society' project, which has already produced a number of engaging results, in the field of competitive systems (such as social games or sports) or to understand the collective motion of fish schools and human groups (in collaboration with first rate biologists on campus).

The group has suffered the severe loss of two very active senior members during the reporting period (a professor, and a director of research). These two departures impinge on the crossroads where statistical physics and soft matter meet biology. They are major sources of concern for the future evolution of the group, together with other features that contribute to jeopardizing the research potential. Indeed, three members are '*enseignants-chercheurs*' with a heavy teaching load, one of them having important responsibilities at the university level (vice president of the university, and member of the '*conseil d'administration*'); a CNRS researcher is still the LPT director, deeply involved in the various 'Initiatives of Excellence' program, the IRSAMC federation, and the Doctoral School. In light of these recent evolutions, it seems urgent to reinforce the soft matter / biophysics theme, where forceful collaborations have been established locally (IPBS, CRCA, LMGM), waiting to reach full gear. A CNRS appointment would be ideal.

Theme 4: Systèmes de Fermions Finis – Agrégats (Finite Fermionic Systems; Clusters)

Manager's name: Mr Éric SURAUD

Workforce

Theme workforce in Full Time Equivalents	As at 30/06/2014	As at 01/01/2016
FTE for permanent professors	2	2
FTE for permanent researchers	1	1
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)		
FTE for other professors (PREM, ECC, etc.)		
FTE for postdoctoral students having spent at least 12 months in the team	1	
FTE for other researchers (DREM, etc.) excluding postdoctoral students		
FTE for other contractual staff without research duties		
FTE for doctoral students	4	
TOTAL	**8**	**3**

Detailed assessments

This group of three researchers (two University staff and one recently appointed CNRS fellow) has three main research themes:

1. formal developments, working to improve on local mean field descriptions of the dynamics of small clusters. Here, in first approaches electron degrees of freedom were described using mean field techniques to give an effective electron potential. Successive improvements on so called local density approximations have been implemented, allowing the inclusion of self-energy-or reaction field contributions to the mean field description – time dependent density functional theories, stochastic electron hopping dynamics in which the parameters for the stochastic hops are extracted self-consistently from time dependent mean field descriptions. Non-local developments to the density functional descriptions have been compared with techniques where the electron current density is the quantity on which self-consistent techniques are applied to describe correlations. The new self – consistent techniques have been applied to different experimentally relevant situations with great success. For example, the photo-emission spectra from silicon clusters have been accurately modeled, particularly in the case where perturbations extrinsic to the silicon clusters are taken into account. These developments have been put in the context of the field with an extensive review article;

2. methodological developments in which techniques are worked out to analyze electron dynamics in irradiation processes. The motivation here comes largely from photon spectroscopy of simple test molecules and more complex clusters such as fullerenes. Interest in experimental studies has dramatically increased over recent years with the development of atto-second pulsed laser sources, allowing time resolution of single electron dynamical processes. Descriptions of scattering processes have been developed concentrating on details of atomic spectra and on radial scattering intensities. In several cases very detailed and impressive agreement has been achieved between theory and experiment. Latest

developments include the description of atto-pulse experiments in test cases such as pulsed nitrogen molecules. In these experiments a molecular orientation response function can be resolved;

3. technical developments. The group has been active in the setting up of an open source library of numerical software for simulation and numerical application of density functional approaches to small cluster dynamics – the TELEMAN package. Over the last five years effort has been made to improve the resolution and efficiency of these codes in the form of grid definition improvements, and parallelization procedures. Recently the group has developed an interactive web page. The TELEMAN project will shortly be combined with a molecular dynamics package developed in collaboration with groups in Frankfurt. This will allow combined attacks on both the electronic and ionic degrees of freedom in small cluster problems.

The group is extremely dynamic, with a well-defined scientific program covering complementary directions. It has published 60 articles in international journals during the reporting period while 8 PhD students have been supervised. The group members have been invited in more than 90 conferences, an impressive performance. The two university employees have both been distinguished as IUF nominees, and overall, the group is extremely active in conference organization, contract management and community service (in particular within ANR, which includes a Franco-Chinese collaboration). The direction that the group wishes to take over the next five years is clear, with all three sections promising innovative progress. In particular the development of attosecond analysis for more complex scenarios will be fruitful, while the TELEMAN project promises to make an important contribution to this community. The constructive and ongoing projects put forward, also includes irradiation of living tissues in collaboration with nuclear medicine departments.

The group's activity belongs in CNRS sections 04 (Atoms and Molecules) and 05 (Condensed Matter, Organization and Dynamics), but is core target for neither of them. In spite of this shortcoming, a junior CNRS position has opportunely reinforced its activity. Overall, the group is doing remarkably well, and the outlook for the future is bright.

5 • Conduct of the visit

Visit dates

Start:	Thursday, October 30th of 2014 at 9am
End:	Friday, October 31th of 2014 at 4pm

Visit site:	Building 3R1
Institution:	Université Paul Sabatier – Toulouse 3
Address:	118, route de Narbonne, 31062 Toulouse Cedex 4

Program of the visit:

On the 30th of October, after a short welcome and an overview given by the director of the LPT, the experts committee listened to oral presentations (two per group) covering the varied research activities carried out. In the afternoon, the proposed future director presented the prospects and perspectives for the future. The experts committee then split to discuss during three hours with all lab members (but one absent), met in groups of two or three, in an informal atmosphere.

The following day opened with the presentation of the IRSAMC federation. The experts committee subsequently met with the PhD students, the post-doctoral fellows, the deputy director of the doctoral school, the supporting staff, and then the whole body of permanent members. Afterwards, a two hours discussion with the representatives (University Paul Sabatier and CNRS) took place. The experts committee finally held a closed session dedicated to the preparation of the evaluation report.