LPS - Laboratoire de physique des solides

Rapport Hcéres

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

Department for the evaluation of research units

AERES report on interdisciplinary unit:

Laboratoire de Physique des Solides

LPS

Under the supervision of the following institutions and research bodies:

Université Paris-Sud

Centre National de la Recherche Scientifique - CNRS

December 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 Jean-Louis BARRAT, 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 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 des Solides
Unit acronym:	LPS
Label requested:	UMR
Present no.:	8502
Name of Director (2013-2014):	Ms Dominique CHANDESRIS
Name of Project Leader (2015-2019):	Ms Dominique CHANDESRIS

Expert committee members

Chair:	Mr Jean-Louis BARRAT, Université Joseph Fourier, Grenoble (représentant du CNU)
Experts:	Mr Vincent BAYOT, Université Catholique de Louvain, Belgique
	Mr Steve BRAMWELL, University College London, Grande Bretagne
	Mr Olivier FRUCHART, Institut Néel, Grenoble
	Ms Karin JACOBS, Universität des Saarlandes, Allemagne
	Mr Paul MIDGLEY, University of Cambridge, Grande Bretagne
	Mr Fabio PISTOLESI, Université de Bordeaux 1 (représentant du CoNRS)
	Ms Annie VIALLAT, Aix-Marseille Université, Marseille
	Mr Dirk VAN DER MAREL, Université de Genève, Suisse

Scientific delegate representing the AERES:

Mr Serge BOUFFARD

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

Mr Étienne AUGE, Université Paris-Sud

Ms Véronique DEBISSCHOP, CNRS

Mr Giancarlo FAINI, CNRS

Ms Sylvie RETAILLEAU, Université Paris-Sud

1 • Introduction

History and geographical location of the unit

The Laboratory, established in Orsay more than 50 years ago in the vicinity of the main university campus, has since then maintained a particularly high level of expertise in all fields of condensed matter physics. The range of topics investigated, from electronic structure and crystallography to soft matter and biophysics, has always been very broad. Similarly, the tools of investigation range from in-house experiments to the use of large scale facilities with which the laboratory has strong connections. Theoretical activities, often in relation to experimental studies, are also developed locally. The laboratory has played an important role in the development of graduate studies in the field of condensed matter in France, and has strong connections to a large part of the French community through active collaborations, but also through former graduate students or postdocs.

Management team

Ms Dominique CHANDESRIS, director, assisted by three deputy directors (Mr Gilles MONTAMBAUX for financial affairs, Mr Luc ORTEGA for the technical staff, Mr Marino MARSI for the relation with teaching activities)

AERES nomenclature

Unit workforce

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	35	33
N2: Permanent researchers from Institutions and similar positions	45	45
N3: Other permanent staff (without research duties)	53	53
N4: Other professors (Emeritus Professor, on-contract Professor, etc.)	8	4
N5: Other researchers from Institutions (Emeritus Research Director, Postdoctoral students, visitors, etc.)	23	10
N6: Other contractual staff (without research duties)	5	2
TOTAL N1 to N6	**169**	**147**

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	38	
Theses defended	60	
Postdoctoral students having spent at least 12 months in the unit*	7	
Number of Research Supervisor Qualifications (HDR) taken	12	
Qualified research supervisors (with an HDR) or similar positions	59	57

2 • Overall assessment of the interdisciplinary unit

LPS is an internationally recognized research institute that covers, at an excellent level, many fields of condensed matter physics. The situation of the laboratory is healthy, with numerous topical research projects carried by young researchers, supported by high-level technical staff. The financial situation is good, and the prospects associated with the development of the new physics campus put the lab in an excellent position for remaining at the forefront of condensed matter physics research in the next decade.

Strengths and opportunities related to the context

The scientific output of the laboratory as well as its projects is of excellent quality. The teams benefit from a remarkable technical environment, and have access to world-class scientific equipment, which has been largely renewed during the last decade. Overall, the international recognition of the teams is excellent, with in addition remarkable contributions in terms of outreach and in terms of industrial partnership (for a fundamental physics institute). The laboratory will benefit from a complete renovation of the building. The relocation of many different physics laboratories, and large scale facilities (including nanofabrication at C2N), within a small perimeter close to LPS is clearly an excellent opportunity for the LPS teams to develop further collaborations.

Weaknesses and threats related to the context

Very few weaknesses have been identified in scientific projects or in the organisation of the laboratory; they are detailed in the report, but do not by any mean constitute a serious threat for the lab as a whole. The main difficulty, with relatively well understood reasons, is the small number of PhD students, especially in view of the strong scientific environment. Other sources of worries are the constant growing complexity of both scientific and administrative environment, which results in mobilizing the energy of the researchers into endless organisational tasks.

The renovation of the LPS building is a very positive element in the long term. Unfortunately, many practical aspects remain ill-defined at the date of the report, including in particular the availability of resources for financing the moving of experimental facilities, or the manner in which the potential impact on experimental PhD work will be handled by the University.

An unusually high turnover of the technical staff has been noticed during the reporting period. If such a turnover rate persisted, it could be considered as a serious problem for many experimental activities. Also, a relatively high number of recently recruited junior faculty members or researchers has left the lab during the period (essentially for promotions, which is seen as very positive), which in some activities, however, leads to a significant imbalance in the age distribution.

Recommendations

The committee considers that the laboratory has, overall, a portfolio of excellent research projects and can be confident on its future within the new environment of the Saclay campus. The quality of science should allow the researchers to participate with a good success rate into competitive international calls, and to continue to assume a leading role at the national and international level. The few weaknesses that have been identified in terms of research plans or organisation of the LPS do not impact the overall quality, but should nevertheless be addressed in order to maintain a homogeneous level of scientific excellence. While the relative lack of attractiveness towards PhD students depends on many factors that are beyond the influence of the lab, the quite large disparities between groups in terms of students per permanent researcher suggest that a proactive recruitment policy can be successful.

Considering the quality of the project and the number of departures of young researchers in the last five years, it seems highly desirable that the recruitment of young faculty staff in the unit is considered as a priority by the university and the CNRS. The high teaching load of scientific personnel employed by the university implies that the teams that are composed in majority by faculty members should be given priority for CNRS recruitment. The possibility - offered by the Faculty of Sciences - to transfer part of the heavy teaching load of the faculty members to CNRS staff, should also be better advertized by the university and exploited within the lab.

3 • Detailed assessments

Assessment of scientific quality and outputs

During the reporting period, LPS has produced excellent research, often at the forefront of the activity in its respective field, on all aspects of condensed matter physics. The publication record is very good, both in quantity and quality, with numerous publications in the best journals. A few scientific highlights will be mentioned in the theme by theme analysis. At the level of the unit, it is remarkable that the level of quality is quite uniform among the different axes (novel electronic states, nanosciences, soft and biological matter) with obviously somewhat larger fluctuations at the scale of the research teams. Essentially all permanent researchers and faculty members have a substantial scientific production, with only a few (4 or 5 out of 80) exceptions. A number of emeritus members also keep a high scientific activity.

Assessment of the unit's academic reputation and appeal

The national and international reputation of LPS is high, as can be judged from the number of invited conference speeches and prizes that have been awarded during the reporting period. Again, this reputation is quite evenly distributed over the different fields or axes. While a majority of invited talks were given by the most senior researchers, a good number of younger researchers are progressively gaining international visibility. The lab members are involved in many ANR national projects, often with a leading position, and have a large number of international collaborations with high level institutions. The laboratory is active within a number of national (GDRs, METSA network) or local (CNano, Labex) research structures. The situation in terms of participation to European projects (Marie Curie, ERC, etc…) is good, but could probably be improved in view of the high visibility of many laboratory members.

The laboratory also frequently contributes to expertise and editorial activities at the national or international level. Researchers from all axes have been involved in the organisation of national or international conferences in their respective fields.

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

The core of the activity of LPS is fundamental research. In spite of this, the unit has a significant record of industrial collaborations, mainly associated with the activity of Axis 3. Several patents associated with the development of scientific instrumentation are also worth mentioning.

LPS researchers from all fields (with a particular mention of Axis 1) have been involved in outreach activities at the local and national level. A number of results obtained in the lab have been reported in the media, lab members have given a number of lectures directed to a general or sometimes more specialized (high school teachers) audience. Also noticeable are the strong involvement in the events associated with the “year of superconductivity” and the “year of crystallography”.

Assessment of the unit's organisation and life

The organisation of the unit is quite standard for a joint CNRS-University unit, with a clearly delimited scientific field, well defined pooled resources (e.g. workshop, administrative support, computing support); the laboratory council meets regularly. The premises are well maintained, with attention being paid to safety concerns. The website is updated, and the internal communication appears to be good. The committee underlines the important role played by the director of the unit over the reporting period. Her scientific perspective, personal qualities and dedication were recognized by the entire staff.

During the reporting period, the direction team as well as the researchers have had a very active and successful policy in terms of securing financing from many different sources. This allows the laboratory to devote a significant funding to the support of emerging projects, and also to maintain and enrich a very significant pool of experimental facilities.

The technical staff is distributed in a flexible way between shared services and scientific teams or axes, which accounts for the diversity of the tasks. This flexible repartition is judged positively by both researchers and staff members. In some cases staff members would appreciate a better definition of the management chain for technicians who have to work with several different research teams, without being affected to one of the common services.

The scientific organisation of the unit relies on three research axes, subdivided into research teams. The specificities of each axis are discussed below in the theme by theme analysis. The scientists in charge of the axis are associated with the scientific management of the unit. The structure is globally coherent, with, in general, a good overlap between the scientific interests of the teams within a given axis, often leading to common projects and joint equipment.

Three teams are transverse to the axis structure.

- The theory group covers the physics of strongly correlated fermions (axis 1), topological aspects in quantum systems (axis 1-2), electronic transport phenomena (axis 2) and soft condensed matter (axis 3). Activities that relate to axis 1 and axis 2 are strongly entangled, and understandably less so for axis 3. The soft condensed matter part of the group is new, but is considered as an important asset to the group and to the laboratory.

- The ODMC (Organisation et Dynamique de la Matière Condensée) team corresponds to the historical X-Ray diffraction activity within the laboratory. ODMC have developed an impressive pool of X-ray generators and sample environments that ensures their competitiveness on the world stage.The team is very productive with typically 50 high quality publications per year. This team has very strong connections to axis 1, for spectroscopic and time resolved photo-emission techniques, and to axis 3, for structural studies in soft condensed matter and nanostructured materials. The connection to the focus of axis 2 is more tenuous. As the two types of activities make use of the same in-house facilities but have distinct objectives, a suggestion is to distinguish more clearly these scientific directions while keeping a common experimental pool of instruments. A first step in this direction may be the “ultrafast measurement” project (time resolved ARPES and synchrotron) mentioned in the perspectives, which overlaps nicely with the topics developed in relation to axis 1.
- The third, newly formed, transverse team “la physique autrement” aims at giving a new dimension to the already remarkable outreach activities developed in the laboratory. This team has two permanent members, both originating from axis 1, but associates to its activities several members of the two other axes. The committee sees this development very positively in the short term, with already a strong support from the university, many collaborations, and support from Air Liquide in the form of a chair. However, disconnecting completely the outreach activity from a research activity for the permanent members may be risky in the long term, unless the activity can develop beyond the limits of LPS within the context of the Saclay campus.

In view of the long history of the institute, the transfer of responsibility for a research group from one generation of scientists to another one is an important aspect of human resource management. During the project period this has been handled skillfully by the LPS management. In the coming years, it will be important for present and future LPS responsibles to remain vigilant in this respect.

Assessment of the unit's involvement in training through research

As mentioned in the introduction, the laboratory has a long history of training students in all aspects of condensed matter physics, at the master and PhD levels. At the master level, the laboratory coordinates the program “Condensed Matter Physics” of the Master 2 specialty “Concepts Fondamentaux de la Physique” (CFP). It also coordinates the Master 1 “Physique appliquée et Mécanique” and is strongly involved in the redefining of the Master in Physics on the Saclay Campus. Many researchers contribute to graduate teaching in Orsay, Paris or Ecole Polytechnique. The laboratory has been involved in international graduate or PhD programs in the past, but none seems to be active at the moment, which is somewhat regrettable as this had been an effective manner of compensating the scarcity of graduate students.

In terms of PhD training, the quality is excellent; the students benefit from an exceptional scientific environment. They are well supervised within the research teams, and the advancement of their work is also monitored through a tutoring system involving a researcher external to the team. Students also benefit from complementary scientific and “soft skills” training. It is unfortunate that the possibilities of teaching assistantships (missions d’enseignement) are limited. However, the involvement of the lab in outreach activities extends the range of possibilities. In view of the number of foreign students and postdocs, an involvement of the laboratory in helping with various administrative formalities (visas, convention d’accueil), which are presently handled at the level of the hosting team, would be useful. Most of the graduate students appear to continue a scientific career with postdoctoral positions after their thesis, but the statistics concerning their future integration is not followed at the level of the laboratory, but rather at the level of the graduate school.

The laboratory is almost entirely associated with the graduate school "ED 107" (physique de la Région Parisienne), and the deputy director of the school belongs to LPS. A well identified difficulty of LPS as a whole appears to be the small number of PhD students. The committee spent some time trying to identify the reasons for this. The problem appears to have multiple causes, including mere geographical considerations. At the level of the graduate school, the previous policy of funding in priority students graduating from the CFP masters seems to have been detrimental to LPS, in which experimental activities could easily attract students from abroad or from other masters through research internships. As the policy of the graduate school evolves, and in combination with the appearance of a strong graduate teaching program on the Saclay campus in a building close to the laboratories, it can be hoped that this situation will change. Other aspects that could probably be improved are the publicity given to the PhD proposed by the lab, and a search for funding that does not rely on the graduate school.

Assessment of the strategy and the five-year plan

The details of the scientific projects are discussed in the theme by theme analysis. Globally, the portfolio of projects appears as a logical continuation of the existing research, with an effort made to highlight the transverse character at the level of the axis. With a few exceptions, the projects described in the document tackle relevant issues in the fields of strongly correlated electrons, topological quantum matter, nano-sciences and nano-objects, soft matter, biological physics. In addition, several transverse projects involving more than one axis are presented. LPS certainly has the know-how and the infrastructure necessary to carry out this project.

The next five years will bring strong modifications of the environment. First of all, LPS will undergo an in depth renovation of the building. This will imply important perturbations for experimental activities, which appear to be relatively well anticipated, although many aspects (detailed agenda, impact on the activity of the technical staff or on ongoing PhDs) are still somewhat fuzzy. Another important modification of the local environment is the construction of buildings for several laboratories and for teaching at the L3-M2 level in the vicinity of the LPS building. This can be expected to facilitate the development of new collaborations and partnerships for aspects such as computational facilities, which are currently underdeveloped (mostly due to a lack of technical support) at the scale of the laboratory. Nanofabrication will also strongly benefit from the proximity of the newly installed C2N facilities. Overall, LPS appears to be well prepared to take advantage of these changes in the local environment.

The choice of the next director has not yet been decided. In view of the complex issues associated with renovation and the Paris Saclay University, it would be good to identify the future director at least a few months before the start of the mandate, so that a good overlap with the current team is guaranteed.

4 • Theme by theme analysis

Theme 1: Novel electronic states

Manager's name: Mr Philippe MENDELS / Mr Marcelo ROZENBERG

Workforce

Workforce to be given in FTE.

Theme workforce in Full Time Equivalents	As at 30/06/2013	As at 01/01/2015
FTE for permanent professors	16	16
FTE for permanent EPST or EPIC researchers	7.3	7.3
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)	7.3	7.3
FTE for other professors (PREM, ECC, etc.)		1
FTE for postdoctoral students having spent at least 12 months in the unit		
FTE for other EPST or EPIC researchers (DREM, etc.) excluding postdoctoral students	6	5
FTE for other contractual staff without research duties		
FTE for doctoral students	11	
TOTAL	**47.6**	**36.6**

• Detailed assessments

Assessment of scientific quality and outputs

The scientific quality of the research of Theme 1 (Axis 1) continues to be of a very high standard, being built on a long tradition of impactful science underpinned by technical excellence. The research activity of the Axis is largely devoted to pure, rather than applied, science. This makes achieving really high impact more challenging than if there were direct technological interest. Despite this, the five teams of the Axis have achieved substantial impact, with an impressive number of papers in Phys. Rev. Lett. (PRL), for example. Most teams are involved in topical areas of pure condensed matter physics such as pnictide superconductors, highly frustrated magnets and Dirac physics, while topics such as oxytronics and resistive switching have potentially applied interest. Some other topics of research, such as molecular metals, are less fashionable than they used to be, but remain of unquestionable value.

The **HP team** continues its world-class programme of research into molecular conductors and pressure-induced properties and has recently diversified into topical areas such as Dirac physics, C60 based superconductivity, lithium cobaltates and thin films for resistive switching. Sample provision for molecular conductors is based on a long-running collaboration with a chemical group in Rennes. The team has recently developed new pressure techniques (for example a diamond anvil cell driven by a helium membrane), as well as additional thermodynamic probes, including thermopower, Nernst effect and sound velocity experiments. Despite a downturn in international interest, molecular conductors should remain an important fundamental aspect of condensed matter physics. Given that the field is slightly out of fashion, the impact achieved by the team is impressive, with 7 PRLs and 5 JACS (Journal of the American Chemical Society) publications over the assessment period. The JACS papers reflect the interdisciplinary nature of this work (i.e. relevance to chemistry as well as physics).

The **ODMC team** specialises in studies of symmetries and phase transitions, reduced dimensions and out of equilibrium systems. They generally collaborate with chemical groups to obtain their samples. They also have strong links with facilities like ESRF, SOLEIL, ILL, LLB and XFEL. Scientific highlights include coherent X-ray scattering of charge and spin density waves, diffuse scattering from low dimensional and multiferroic systems, correlated systems under high pressure and ultrafast dynamics of metal insulator transitions. The ODMC group combines a high level of technical skill and close involvement in some of the most rapidly developing aspects of condensed matter physics.

The **RMN team** specialises in NMR, μSR and ARPES on strongly correlated systems and frustrated magnets. The group is famous historically for discovering the “pseudogap” in high-Tc superconductors, using NMR. More recently, the group has procured a new 14 T NMR system that guarantees its position as a world class NMR laboratory for condensed matter research. Judged by published material, the team has continued to achieve an excellent and consistent record in topical science of the highest quality, particularly in the areas of frustrated magnetism, pnictides and cobaltates. It has achieved 14 PRLs in the last five years, and numerous other high quality articles.

The **SUMAG team** specialises in thin films of high-Tc cuprate superconductors, grown by sputtering techniques. Over the evaluation period the group has produced a series of interesting papers, in good quality journals like Phys.Rev.B. These concern doped infinite layer superconductors, which are ideal model-system for cuprate superconductivity, but have received little attention elsewhere for reasons related to the difficulty of synthesising doped samples.

The **THEO team** specializes in the theory of novel correlated phases. Many topics are covered, including superconductivity, fractional quantum Hall effect, oxide interfaces, resistive switching, quasi-crystals, frustrated magnetism, Mott insulators, graphene, organic conductors, multicomponent quantum Hall effect, etc. The group has strong international collaborations, for example with Geneva, Singapore and Argentina, which has led to a series of high impact (e.g. Nature) publications. These outputs are well cited over the evaluation period. Overall the team has very strong outputs, with publications in several top-levels journals: during the evaluation period they published 11 PRLs, 3 Nature Journal papers and 2 Reviews of Modern Physics. The team masters a wide set of analytical and numerical methods, that allows them to tackle problems from different points of view and spans subjects extending from formal theoretical physics to applied research. A large part of the activity of the group is realized through fruitful collaborations with experimental groups, at either national or international level.

Assessment of the unit's academic reputation and appeal

The academic reputation of Axis 1 is reflected by a several honors and awards to its members, including for example, the Prix Jean Perrin of the SFP, and the Prix Science et Innovation of the CEA, plus a number of senior Fellowships of national and international academic organisations, like the APS. International reputation is confirmed by over 150 invited communications at national and international conferences. The members have also been very active in organising such conferences, with several in the field of quantum and frustrated magnetism for example. Members have been lead organisers of networks such as the Highly Frustrated Magnetism network of the ESF. There are a strong number of international partnerships with leading laboratories in Europe, the USA and Japan, as well as many national partnerships with institutions and facilities in France. The teams of the axis have been successful at raising contracts (ANR, regional and RTRA) and recruiting an adequate number of postdoctoral researchers and PhD students. The high academic level and reputation of visitors to the laboratory reflects its strong international appeal and reputation. Other evidence of reputation and appeal include the publication of a Rev. Mod. Phys. on a very topical subject and the general willingness of international materials synthesis groups to supply samples. In general the researchers and teams in Axis 1 enjoy a very high international reputation as judged by objective evidence.

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

The Axis has had a notably impressive and original interaction with the social and cultural environment, which has certainly stimulated public interest in the science of the LPS. Communication and outreach activities have included a large number of TV, radio and newspaper interviews with several members of the Axis. Conferences and talks have been organised (particularly on superconductivity and graphene) for school students, with yearly up to 40 talks reaching 4000-6000 students. Other highlights include several special events for the general public, including three science fairs and participation in the 2011 CNRS Trocadero event on materials. The production of the websites www.supraconductivite.fr, www.toutestquantique.fr and www.vulgarisation.fr has achieved great presence on the internet (the first of these appears to be the world's most visited superconductivity website). Members of the axis have developed many novel animations and educational devices. There has been direct training of highschool teachers and creation of an outreach course at the university. Interaction with the cultural environment is further evidenced by the creation of new shows and exhibits for science museums (Cité des Sciences, Palais de la Découverte, Espace des Sciences, Cité de l'Espace). The impressive outreach activity is underlined by the setting up of a new dedicated outreach team by two member of the Axis, which will ensure the continued promotion of condensed matter physics to the largest public. The UPSud staff and several CNRS staff of the Axis are closely involved in teaching undergraduates and several UPSud staff members have significant education management responsibilities. Finally there is evidence of interaction with the economic environment as evidenced by two patents (here it should be noted that a larger number of patents would not be expected for a pure research laboratory).

Assessment of the unit's organisation and life

In general, the scientific activity and objectives of the Axis are clearly defined and logical. The basic organisation is in terms of five almost independent teams. This structure functions very effectively to maintain scientific continuity and expertise, and to guard against the risk of individuals becoming isolated. Threats to the effectiveness of teams are generally dealt with decisively. For example, the ODMC team has recently suffered a significant wave of retirements but has been strengthened by the hiring of 5 young members. The HP team has responded strongly to the challenges identified in the last evaluation and successfully diversified its approach into new areas of research.

There are significant and well-planned scientific infrastructure developments that serve the present and future scientific needs of the researchers of Axis 1. For example, the new cryogen-free 14 T NMR instrument is a unique facility that promises exciting scientific opportunities for many years to come. The team structure also allows the flexibility and resource to move in new directions, where appropriate. Thus HP has diversified its interests and opportunities by developing new equipment, while RMN has started a limited programme of single crystal preparation which will stimulate new science and guard against risks to sample supply.

The teams interact very effectively with each other in scientific terms – notably there is a general interest in superconductivity across several teams of the Axis. Teams further benefit from generally available resources such as the 14 T NMR instrument mentioned above.

The general impression of Axis 1 is of a well-functioning, effective and collegial organisation. Any small problems arising appear to have been dealt with swiftly and effectively at a local level and no significant structural problems are noted.

Assessment of the unit's involvement in training through research

The team structure of Axis 1 appears to work very well in guiding PhD students, who have many local experts to call upon. Students emerge with a very strong scientific grounding and become highly competitive for research positions elsewhere. They also have significant and exciting opportunities for close involvement with outreach programs. In general the standard of doctoral training and the level of the PhD students recruited seems to be very high. In some cases, undergraduate students benefit from training through research. For example, there is a 4-circle X-ray diffractometer dedicated to teaching (run by the ODMC team). In general the members of Axis 1 are highly involved in training through research and alert to innovative training opportunities arising from the latest scientific developments.

Assessment of the strategy and the five-year plan

The strategy and five-year plan of Axis 1 aims to maintain and extend even further the already high scientific output of the axis. It is draws an optimum balance between risk and caution and is original, feasible and convincing. One striking aspect is the integration between teams, such than most projects involve several teams working in partnership. The effect of this will be to bring added value to the research and competitiveness of the individual teams. The planned themes that run across the whole axis include unconventional superconductivity, oxytronics, charge and spin density waves, Mott transition, resistive switching, novel magnetic states, Dirac/Topological matter and spin-orbit effects. In most experimental teams there has been a forward-looking development of experimental facilities, which will serve the research of the laboratory well in the next five years. The theory group is highly integrated into many of the experimental projects and itself has a particularly ambitious and exciting five year-plan. The axis and its teams have a suitable awareness of the strengths, weaknesses, opportunities and threats concerning their five-year program.

Conclusion

In general the science and outputs of Axis 1 are of a very high quality and highly competitive with those of top laboratories worldwide.

The most important strength is evidently the high academic level and international reputation of the individual scientists that comprise the five teams of the axis, as well as the excellent level of technical support, training and outreach. Another significant strength is the maintenance of cutting edge experimental facilities (e.g, the X-ray expertise of ODMC, the new 14 T NMR instrument of RMN etc.), which facilitates topical and innovative experimental science. A third strength is the level of integration between the five different teams and between theory and experiment.

No serious general weaknesses are noted.

As regards specific teams, the SUMAG team is now surely at subcritical size, having recently suffered the departure of its most experienced scientist, and the planned departure of another member. The LPS should consider either merging it with another team interested in superconductors, or investing to rebuild the team, especially with a view to exploring new growth techniques.

There also appears to be a threat to the RMN team in that, despite significant efforts, the group failed to secure the appointment of a new CNRS researcher. With the return of one senior member to a full teaching load and the departure of another member to form a new outreach team, RMN may be depleted in strength in the next few years.

On the basis of this team's consistent and outstanding performance, it would clearly be appropriate to recruit more than one new researcher to replace these losses.

Concerning the THEO (theory) group, in the evaluation period two junior permanent staff members (MdC, CR2/1) moved to others laboratories in France. This situation, added to the fact that one other junior researcher of the theory group of Axis 2 also left, has weakened the group, unbalancing the ratio of junior to senior members. Consequently, for the theory group, it will clearly be important to recruit junior permanent staff.

Theme 2: Condensed matter physics in reduced dimensions

Manager's name: Mr André. THIAVILLE

Workforce

Workforce to be given in FTE.

Theme workforce in Full Time Equivalents	As at 30/06/2013	As at 01/01/2015
FTE for permanent professors	9	7
FTE for permanent EPST or EPIC researchers	20.3	21.3
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)	8.3	8.3
FTE for other professors (PREM, ECC, etc.)	4	
FTE for postdoctoral students having spent at least 12 months in the unit	4	
FTE for other EPST or EPIC researchers (DREM, etc.) excluding postdoctoral students	8	2
FTE for other contractual staff without research duties	1	
FTE for doctoral students	15	
TOTAL	**69.6**	**38.6**

• Detailed assessments

Assessment of scientific quality and outputs

There is no doubt that the work performed by researchers in theme 2 (axis 2) is, overall, of very high quality. The scientific output, as can be seen from publications during the evaluated period, is excellent, with some teams or sub-teams exhibiting outstanding performances. The committee appreciated the quality of the scientific work performed within this axis. All the members are encouraged to take advantage of this unique scientific and technical environment to develop their research activity.

IDMAG tackled a wide range of important magnetic problems, primarily using various magnetic microscopies, their deep experimental expertise. They are clearly at the forefront of several topics in nanomagnetism and spintronics, by the suitable combination of instrumentation (magnetic microscopy) and modelling/simulation expertise. The key outputs include current-induced (spin-transfer torque) and magnetic field-induced domain wall dynamics in ferromagnetic metals and magnetic semiconductors. There has also been important research undertaken in thermally-activated magnetic reversals, electric field interactions in multiferroics and the study of rare-earth-transition-metal ferrimagnets. The group has an impressive array of experimental capabilities, new or available following the leave of retired staff, including a magnetic STM-BEEM imaging instrument with remarkably high spatial resolution (sub 10nm) and low temperature AFM shared with MESO and NS2, a deposition, a UHV deposition setup, a variable-temperature FMR. This may induce the team to develop their strategy where their best strengths in experiments will lie.

The MESO team appears as a reference group in the field of mesoscopic transport and hybrid systems. During the evaluation time, it strengthened its position by obtaining a series of important results in the field. Among them we cite the proof of the difference between elastic scattering time and transport scattering time in graphene by measurement of magnetoresistance oscillation, the measurement of quantum (frequency asymmetric) noise in SIS and Kondo systems, the study of proximity effect and Andreev states in several low dimensional conductors, the investigation of high frequency transport. The scientific interests and expertises of the MESO team are close to those of NS2. The committee appreciated the growing interaction between these two excellent teams.

The NS2 team's performance was also excellent during the reporting period. Despite its relatively small size, the team tackled a large number of important topics such as microwave cooling, quantum noise in tunnel junctions, injection in SFS and SNS hybrid sysems… The work on full counting statistics is particularly encouraging for future breakthroughs in quantum correlation studies. The team is developing new important instruments such as low-temperature SGM, jointly with the MESO and IDMAG teams.

ODMC is mainly set in axes 1 and 3, with a small fraction attached to axis 2. While the relevance of such configuration should probably be re-examined, the work performed during the reporting period is very original and of very high quality. The physics of nanotubes and other carbon based nanostructures is the core business of this team. The output on the physics of 1D chains of fullerenes in nanotubes (liquid and crystal-like behaviors) is particularly noteworthy, as well as the one on the flow of water molecules. This interdisciplinary research implied an important effort in synthesis and instrumentation, some also of use for other teams.

STEM is a large and highly succesful team. The scientific quality is excellent and the publications and work discussed in the report are of a very high standard and with international recognition. The work is focussed primarily in electron energy loss spectroscopy at very high spatial and energy resolution. Work progresses in parallel in the development of instrumentation and also in its application to a variety of materials, primarily nanostructures (rods, tubes, quantum wells etc) – interacting with other teams (and axes). There is a strong development in spectral processing and more recently ab initio theory with a permanent theoretical team member, an expertise which may also be useful for several other teams. Electron diffraction is also being developed to study structural ordering.

The THEO group is a clear reference in the field. The group investigates classical and ground-breaking problems in mesoscopic physics (dynamical Coulomb blockade, graphene, topological insulators, majoranas) obtaining results at the top level and publishing in highly ranked journals. While the group has lost recently a few of its members, which should be considered in future hiring issues, and has some members less active than in the past, it has performed remarkably well. Among the key outputs, one can emphasize: the work on noise in Kondo quantum dots (in relation with MESO and NS2 teams) and in general non-linear transport systems, the key issue of topology and Dirac points in graphene, the strong activity on spectroscopy of Andreev and Majorana states. The new interest in the physics of cold atoms is worth emphasizing. The THEO group is indeed a multi-axis component of LPS with numerous interactions with experimentalists, which proved to be very efficient in addressing key problems.

The editorial path through which most of the results have been published is a clear indication that the research undertaken in axis 2 is at the forefront of several topics and is clearly among the most important areas of condensed matter physics shared by the international scientific community. This is true for all the teams involved in the axis. The major progresses made during the last five years were numerous and won't be listed here to not forget any.

It is also worth emphasizing that, while the scientific life is mainly within teams, many inter-team instrumental and scientific interactions have made this success possible. We believe that these interactions will be naturally strengthened in the future. The team size seems appropriate, except maybe for the ODMC component which should benefit from a more clearly identified team-like connection with one of its two other components in axis 1 or 3. The numerous fruitful collaborations with the THEO team should also be emphasized as a good example of the usefulness of the axis structure.

Among experimental teams, the activity in terms of development of high-end novel instrumentation is impressive. These developments are sometimes beyond single teams which is clearly positive. The quality of the technical support should here be recognized and emphasized. The close collaboration between engineers and researchers, aided by the axis structure, should be encouraged.

The activity of the axis in terms of grants is at the level of what is above: excellent.

Assessment of the unit's academic reputation and appeal

With some inhomogeneity related to age, career constraints… the academic reputation of the researchers in axis 2 is excellent. Citations, numerous prizes, invitations to conferences, national and international collaborations, participation to selective cenacles, granted research projects and networks… all aspects of which point towards the very high reputation of axis 2 members. Logically, the teams attract many post-docs which is essential. The fact that a relatively small number of PhD students choose LPS as their destination seems substantially related to social life and transportation issues about which the lab has close-to-zero impact. On the other hand, the work done at the master and doctoral school levels, in which some staff of axis 2 are involved, as well as the coming "plateau de Saclay", should hopefully enhance its attractiveness for PhD students in the near future.

Despite their excellent reputation and scientific/technical environment, some teams have seen a substantial reduction in the number of permanent staff.

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

Axis 2 is involved in a number of actions towards the "outside world" in the form of expertise, communication to the media, patents, industrial contracts, outreach activities. This last point – certainly not the least – appears to take momentum in LPS with the "physique autrement" inter-axis team being ever more active. Beyond the two researchers that are fully dedicated to outreach activities in LPS, it is good to see that many axis 2 members put significant efforts in this direction. The connection between outreach activities and research activities should be maintained as they will surely feed each other.

The contacts with the industrial world are also essential, as exemplified by the co-development of a new ground-breaking electron microscope (CHROMATEM) by the STEM group. Other teams have also shown efforts in this direction during installation of new high-end equipment.

Assessment of the unit's organisation and life

As already mentioned, the axis momentum is growing in the direction of stronger links between teams. Joint seminars are organized and advertized properly so that interactions grow favorably. The axis is a rather new concept in the organization of the lab, but its leadership is efficient and positively considered. Each team is very dynamic and its members are strongly involved in team life. The team clearly remains the main structural entity, which looks rather efficient, but intra-axis interactions enrich the spectrum of opportunities. Inter-axis interactions are also essential, while somewhat weaker, except for THEO, ODMC, and outreach, obviously. Except for the ODMC component of axis 2 which might look sub-critical and might therefore benefit from a stronger integration with its two other components in axis 1 or 3, the research organization seems efficient. Its openness to inter and intra-axis opportunities will be essential in the future.

Assessment of the unit's involvement in training through research

Particularly through one of its members, axis 2 plays a major role in the doctoral school, which is essential. Though inhomogeneously distributed, many members of the axis participate in teaching at the master level. The number of PhD students remains relatively low with respect to the attractiveness of the axis teams which may hopefully change in the future with the re-organization of master programs and/or plateau de Saclay. The counterpart is that PhD students are globally very well trained and happy to work in LPS. The committee would like to encourage the axis teams to sometimes communicate more efficiently on the very interesting PhD projects they propose.

Assessment of the strategy and the five-year plan

While the team remains an important place for the definition of research projects, the axis is growing in importance in defining research strategies. Beyond the very high quality of the proposed projects, their intra-axis component appears clearly. The projects are well in line with hot topics in the various fields and successes in the reporting period. The numerous challenges in terms of experimental developments are at the the level of prior achievements: excellent, again. Among intra-axis interactions, those between experimentalists and theorists are also extremely relevant.

The issues of nanofabrication and characterization are central for axis 2 and LPS in general. They are changing quickly and the need for more expensive and more shared equipment will grow. We encourage the axis members to consider these issues in the context of the changes associated with the new Saclay campus, not in the short term, but in the medium and long term as large investments are rare opportunities.

Conclusion

The theme has an excellent research output, with a very good organisation of the activity that is developed at different level within the teams and the axis. It has a continuing and reknown expertise in condensed matter physics of reduced dimension, with a very high reputation of the team members at the national and international level. It develops state-of-the-art instrumentation with very strong implication in novel developments. Clear forces and funding are devoted to instrumental developments of a world-class sophisticated instrumentation, paving the future. Collaboration across teams within the axis is also a strong point, which could be further developed.

The project shows a continuation along the lines of the previous research, but also an improved collaboration and sharing of resources between the different teams. This seems an important asset for the axis, the local visibility of which could be improved, also in presence of the large reorganization of the Plateau area. One important issue is the possible lack of manpower, in general and to operate the equipments newly developed or left in order by staff recently retired. Hiring in the theory group should be considered, as the departure of a few members changed the balance Senior/Junior among permanent researchers.

Theme 3: Soft condensed matter and biophysics

Manager's name: Ms Françoise LIVOLANT

Workforce

Workforce to be given in FTE.

Theme workforce in Full Time Equivalents	As at 30/06/2013	As at 01/01/2015
FTE for permanent professors	10	10
FTE for permanent EPST or EPIC researchers	17.3	16.3
FTE of other permanent staff without research duties (IR, IE, PRAG, etc.)	4.3	4.3
FTE for other professors (PREM, ECC, etc.)	4	3
FTE for postdoctoral students having spent at least 12 months in the unit	3	
FTE for other EPST or EPIC researchers (DREM, etc.) excluding postdoctoral students	9	3
FTE for other contractual staff without research duties	1	
FTE for doctoral students	14	
TOTAL	**62.6**	**36.6**

• Detailed assessments

Assessment of scientific quality and outputs

Overall, the research within this axis is of excellent quality, both on soft matter and biophysics aspects, with some fluctuations across the teams. The research combines fundamental aspects and more applied questions, which take inspiration from each other.

The AFPO (Adhesion, Friction and Polymers) team is a vivid young team whose activity is focused on adhesion, friction and polymers. With the background of a distiguished emeritus researcher and some unique methods like the capillary bridge technique, the team publishes in highly-ranked journals and attracts a high number of PhD students. The team therefore gains international recognition. The technical facilities are excellent, some of the apparatus have been home-built, also thanks to the mechanical workshop of the LPS.

The FIBRES (Tissues and biological fibres) team, concentrates on the biomechanics of cells and tissues, topics that were initially introduced by a now emeritus researcher. It is a very small team with very few full-time researchers. After the last assessment, the team was challenged to focus its research interests and to develop a clear perspective for the future. Unfortunately, this does not seem to have been fully achieved. Interesting synchrotron based technological developments for biomedical applications can be mentioned for the last period, but the activity on mechanical testing of cells does not appear to be state of the art in a very competitive international environment. The scientific output is moderate in specialized journals. The organisation of the team involves several disconnected subjects carried out by single researchers.

The MOUS (Liquid interfaces) team, formed by three permanent researchers, who are all experts in their fields, publishes in highly ranked journals and is backed by an internationally renowned emeritus scientist. The team is well-organized, feature very good technical facilities and are very well embedded into Axis 3 (theme 3) with very close collaborations with team 1. The activity is an exemplary combination of application driven and curiosity driven research, covering all aspects of soft interface and foam physics as well as physical chemistry.

The ODMC (Organization and dynamics of condensed matter) team specializes in the application of X-Ray scattering techniques to various soft condensed matter systems. This leads to a good production (with however quite strong disparities between the members) that appears in reference journals in physical chemistry. The team has made interesting studies of both static and dynamical properties of a variety of soft matter systems, involving in particular the combination of nanoparticles and mesophases.

The SOBIO (Structure and dynamics of self-assembled objets) team is an interdisciplinary, powerful group that features an excellent track record with excellent impact and a clear perspective for the future. The team's cryo-TEM technique is world-wide unique. The development of the new project on the dynamics and deformation of biofilms by young researchers is very promising. Outstanding is the in-house production depth for the biological samples: from growing cells and plants to preparing viruses docking on bacteria over advanced TEM analysis techniques to the mechanical testing of biofilms and the modelling of lipid-DNA. They are nicely embedded in axis 3 and feature collaborations with other teams. They expect to intensify this cooperation in the near future, especially with the THEO team.

The THEO (Theory) team is a newly formed entity, which has been created following the recommendation of the previous assessment committee. By the recent recruitment of two researchers with an excellent track record and high level publications in modelling of soft matter systems (mostly outside the context of LPS) the team has excellent starting conditions and is already interacting strongly with the experimental activities of the axis.

Assessment of the unit's academic reputation and appeal

A number of researchers in this axis enjoy an excellent international visibility, concentrated on but not limited to the most senior members, and with younger members gaining progressively a high international recognition. This translates into a very good number of invited talks at conferences and several prestigious awards as well as a participation in European networks (especially for the MOUS and AFPO teams). The teams of the axis have also been active in organisation of international conferences, and most of them are able to attract excellent students and postdocs. The attractiveness is also displayed by the ability to attract funding from many different sources, with a diversity in terms of disciplines (e.g. funding related to biomedical research) and of institutional origin (ANR, EU, industry).

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

Overall, the interaction with the economic environment is excellent in the context of an institute dedicated to fundamental research. This interaction takes the form of multiple contracts and expert activities, especially in the AFPO and MOUS teams. These activities are strongly connected to the fundamental aspects of the research carried out in the teams, and often result in excellent job opportunities to the involved students and postdocs.

The axis (and in particular AFPO and MOUS teams) has also contributed very significantly to the outreach activities of the institute.

Finally, the commitment of the axis (SOBIO team) to the Cryo-TEM activity within the national infrastructure METSA is remarkable.

Assessment of the unit's organisation and life

Collaborations, team spirit and scientific achievements and output of Axis 3 are exemplary. The structuring of the LPS into axes has turned into everyday life here. Most of the future projects involve researchers from several different teams, and the present scientific interaction between the different teams is already very good. The scientific atmosphere at the level of the axis is highly appreciated by students and researchers alike.

Assessment of the unit's involvement in training through research

The axis has a good number of PhD students in the AFPO, MOUS, ODMC and SOBIO teams, which benefit from an excellent research environement. Since the THEO team has an excellent potential for graduate training, it will surely be able to attract PhD students, too. Many researchers participate in the graduate teaching in soft matter in Orsay or Paris, and several faculty members play an important role in the organisation of teaching at the university.

Assessment of the strategy and the five-year plan

The presented proposal has been elaborated at the level of the axis, and involves many promising collaborations between different teams. Most of the proposed directions appear to be innovative and based on an excellent expertise of the teams involved. This is especially true for the projects lead by the AFPO , MOUS and SOBIO teams, and for the theory/experiment interactions. In contrast to this general statement, the biophysics projects involving the FIBRES team are clearly subcritical and do not correspond to the international state of the art. It is strongly recommended that the team members try to reformulate their research ambitions by taking advantage of the strong thematic overlap with the activities of the SOBIO and ODMC teams. The proposed activity in the field of self assembly and nanomaterials corresponds very well to the expertise of the ODMC group, but could be better motivated either in terms of fundamental physics issues or of potential applications.

Conclusion

The soft matter and biophysics activity within LPS, in spite of the retirement of several leaders in the field, maintains an activity at the highest international level. The reinforcement of the theory group has been one of the very positive outcomes of the reporting period.

Most of the groups have recruited reasonably well during the reporting period. The activities of the THEO group, which are strongly computational in nature, would benefit from a better technical support in this area. The projects of the AFPO group rely in part on the involvement of an emeritus professor, and could easily motivate the recruitment of a new researcher. The SOBIO team, which in addition to developing several excellent research projects provides a significant service to the community, would also justify a reinforcement.

Coming to the specific team structure, it is clear that the FIBRES teams has to reconsider its project, and that a reasonable option would be to merge with teams with similar objectives (SOBIO, ODMC).

Overall, the structure of the axis is scientifically very healthy, with many motivated young researchers playing an increasing role, an excellent scientific animation and a reasonable number of postdocs and students. The few weaknesses that have been identified do not affect this very positive assessment, and can be corrected without any strong inflexion of the general scientific directions within this axis.

5 • Conduct of the visit

Visit dates:

Start:	Wednesday, December 4th, 2013 at 9.00 am
End:	Friday, December 6th, 2013 at 4.00 pm

Visit site:	LPS
Institution:	Paris 11 University
Address:	rue Nicolas Appert, Bât 510, 91405 Orsay

Conduct or programme of visit:

Wednesday, December 4th

8.30-9.00 am:	Welcome of the committee
9.00-9.35 am:	Closed session of the committee
9.35-10.15 am:	Presentation of the laboratory
10.15-11.05 am:	Presentation of the three axes
11.05-11.20 am:	coffee break
11.20-12.50 pm:	Presentation of some highlights
12.40-2.00 pm:	Lunch
2.00-7.10 pm:	Visit of the team (3 sub-committees)
7.10-7.30 pm:	Closed session of the committee

Thursday, December 5th:

9.00-10.00 am:	Presentation of some highlights
10.00-10.30 am:	Coffee break
10.30-12.30 pm:	Visit of the team (3 sub-committees)
12.30-2.00 pm:	Lunch
2.00-5.00 pm:	Visit of the team (3 sub-committees)
5.00-5.30 pm:	Coffee Break
5.30-6.35 pm:	Meeting with PhD students & postdocs
6.35-7.00 pm:	Closed session of the committee

Friday, December 6th:

8.50-9.50 am:	Project presentation for the lab and the three axis
10.00-10.45 am:	Meeting with the "conseil d'unité"
10.45-10.55 am:	Coffee break
10.55-11.25 am:	Meeting with technicians
11.25-11.40 am:	Meeting with the Director of PhD school
11.40-12.35 pm:	Meeting with Paris-Sud University and CNRS
12.35-1.15 pm:	Meeting with the laboratory director
1.15-4.00 pm:	Closed session of the committee

6 • Supervising bodies' general comments

UNIVERSITÉ PARIS SUD

Comprendre le monde, construire l'avenir®

Le Président de l'Université Paris-Sud

à

Monsieur Pierre GLAUDES
Directeur de la section des unités de recherche
AERES
20, rue Vivienne
75002 Paris

Orsay, le 28 mars 2014

N/Réf. : 78/14/JB/LM/AL

Objet : Rapport d'évaluation d'unité de recherche
N° S2PUR150007928

Monsieur le Directeur,

Vous m'avez transmis le 13 mars dernier, le rapport d'évaluation de l'unité de LABORATOIRE DE PHYSIQUE DES SOLIDES – LPS– n° S2PUR150007928 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.

En dehors des corrections factuelles signalées, le laboratoire n'a pas d'observations particulières à apporter au rapport.

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

Jacques BITTOUN
Président

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