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

Section des Unités de recherche

AERES report on the research unit

Centre de Physique Théorique de Marseille

From the

Université de la Méditerranée, Aix-Marseille II

Université de Provence, Aix-Marseille I

Université du Sud Toulon Var

Centre National de la Recherche Scientifique

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Le Président de l'AERES

Didier Houssin

Section des unités  
de recherche

Le Directeur

Pierre Glorieux

February 2011



## Research Unit

Name of the research unit : Centre de Physique Théorique (CPT)

Requested label : UMR CNRS

N° in the case of renewal : 6207

Name of the director : Mr. Marc KNECHT

## Members of the review committee

Committee chairman :

Mr. Jean-François PINTON (CNRS & Ecole Normale Supérieure de Lyon)

Other committee members :

Mr. Jean ORLOFF (Université de Clermont, CNU)

Mr. Malte HENKEL (Université de Nancy, CoCNRS)

Mr. Arne JENSEN (Aalborg University, Denmark)

Mr. Massimo TESTA (Università di Roma 1, Italia)

Mr. Pascal SIMON (Université Paris Sud - Orsay)

Mr. Christopher SACHRAJDA (Southampton University, UK)

## Observers

AERES scientific advisor :

Mme Anne-Marie CAZABAT

University, School and Research Organization representatives :

Mr. Patricio LEBOEUF, DSA CNRS-INP

Mr. Pierre CHIAPPETTA, Vice-président du CS de l'Université de la Méditerranée (Aix-Marseille 2)

Mr. Denis BERTIN, Vice-président Sciences de l'Université de Provence (Aix-Marseille I)

Mr. Philippe TCHAMITCHIAN, Administrateur de l'Université du Sud Toulon Var



# Report

## 1 • Introduction

- Date and execution of the visit :

The AERES visit took place February 14th and 15th according to the planned program. The lab activity report was presented by the current director, Mr. Marc KNECHT, and the project detailed by the proposed next director, Mr. Thierry MARTIN, together with adjunct director, Mr. Serge LAZZARINI. The 10 teams then all presented their activities for the 2006-2009 period and their projects for the coming 5-year period, 2012-2016. A formal presentation was given and the committee also met with the members of each of the teams for informal discussions. A presentation of the activities of the FRUMAM maths federation was given by its current director, Mr. Sandro VAIENTI. The committee met with the « conseil de laboratoire », with PhD students and postdocs, administrative and technical staff, and, privately with the current lab director and his successor. Finally, the committee met with representatives of the CPT governing institutions : CNRS, Université de la Méditerranée (Aix-Marseille II), Université de Provence (Aix-Marseille I) and Université du Sud Toulon Var.

The visit was informative, enjoyable and well organised, with sufficient time for interesting discussions. The committee wishes to thank the director and all CPT personnel for the quality of the visit.

- History and geographical localization of the research unit, and brief presentation of its field and scientific activities :

The CPT was originally a unit attached only to CNRS (Unité Propre de Recherche) and became associated with the universities in 2004. It has been located on the Luminy campus since 1978. CPT now has contracts with the Universities of Aix-Marseille I & II, the University of Sud Toulon Var, while still being attached to the Institut de Physique of the CNRS. CPT is a founding member of the Fédération de Recherche des Unités de Mathématiques de Marseille (FRUMAM, created in 2002) and of the Fédération de Recherche sur la Fusion par Confinement Magnétique (FRCM - ITER, created in 2006). CPT research activities span a wide spectrum of theoretical physics including mathematical physics, high energy, quantum, statistical, nano and nonlinear physics and studies of out of equilibrium systems.

- Management team :

Now : Mr. Marc KNECHT (Director) ; Mr. Serge LAZZARINI (adjunct director)

Proposed : Mr. Thierry MARTIN (Director), Mr. Serge LAZZARINI (adjunct director)



- Staff members (on the basis of the application file submitted to the AERES):

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	36
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	15
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	28
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	5
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	3
N6: Number of Ph.D. students (Form 2.8 of the application file)	36
N7: Number of staff members with a HDR or a similar grade	47

## 2 • Overall appreciation on the research unit

- Summary :

Under the guidance of the present director, the Centre de Physique Théorique de Marseille has undergone a real renaissance over the past 8 years. With the support of its governing institutions (CNRS and local universities), several new research areas have been initiated. High-profile recruitments have led to very successful activities in nanophysics, loop quantum gravity, statistical physics, cosmology and complex systems. At the same time, long standing activities in particle and mathematical physics/mathematics have been maintained at a high level of excellence. As a result, the laboratory now has a group of scientists with a very strong international reputation as well as a large body of scientists making a significant impact at national level.

- Strengths and opportunities :

Certainly the strongest asset of the lab is a research staff who has clearly identified strong areas where efforts have been focused. These efforts have been very successful, and there should be many opportunities of strengthening these fields of excellence in the framework of the creation of the Aix-Marseille Université, and with the continuing active support of the Université du Sud Toulon Var.

- Weaknesses and threats :

Efforts have been made in securing research contracts with national funding agencies, such as the ANR. They should be pursued and extended, particularly at the European level - ERC in particular.

The technical and administrative support of the CPT is a concern. It is now maintained thanks to temporary recruitments (« CDD ») paid on the lab budget, but the long term situation is alarming. Most of the support is from CNRS personnel, and the future commitment of the governing universities is essential. Of particular concern is the computer - information technology service presently run by a single person. This must be alleviated, either by making an additional appointment or by sharing IT staff with other laboratories in the same building.



Another concern is the very low « équivalent horaire » which is granted by the universities to the CPT governing team. It corresponds to half of the teaching load, allegedly equivalent to 1/4 of a FTE activity ; it is the opinion of this committee, and of both lab directors, that the management of a research unit hosting more than 100 persons does not fit into 1.25 day's work per week, and that the « équivalent horaire » has to be increased to allow the lab management to meet the challenges arising from the reorganization of the French research system.

- Recommendations :

The current momentum is very positive, scientifically very productive and should be continued. In addition to maintaining a body of fundamental research strongly linked to mathematics, the CPT hosts strong research activities in fields connected to observations and experiments ranging from cosmology and particle physics to dynamical networks. The conseil de laboratoire and upcoming director have established a coherent hiring strategy which we trust will be supported by the governing institutions.

- Production results :

(cf. [http://www.aeres-evaluation.fr/IMG/pdf/Criteres\\_Identification\\_Ensgts-Chercheurs.pdf](http://www.aeres-evaluation.fr/IMG/pdf/Criteres_Identification_Ensgts-Chercheurs.pdf))

A1: Number of permanent researchers with teaching duties (recorded in N1) who are active in research	31
A2: Number of permanent researchers without teaching duties (recorded in N2) who are active in research	13
A3: Ratio of members who are active in research among staff members $[(A1 + A2)/(N1 + N2)]$	0.86
A4: Number of HDR granted during the past 4 years (Form 2.10 of the application file)	13
A5: Number of PhD granted during the past 4 years (Form 2.9 of the application file)	33



### 3 • Specific comments :

- **Appreciation on the results :**

The scientific production of the laboratory is generally very good, with some internationally acknowledged recent contributions in the fields of particle physics, quantum gravity, cosmology, statistical mechanics and dynamical networks. The CPT published over 400 research articles in peer-reviewed journals, for an average in excess of 2 articles/year/researcher, with many contributions in high-profile physics and mathematics journals.

In the 4-year period, 33 PhD theses have been defended ; with 47/51 people qualified (HdR) to supervise doctoral students this is a correct ratio which could however be improved.

Local collaborations are well developed and growing, with joint publications with 9 other local laboratories. Research in fusion and plasma physics is supported by collaborations with IRFM / CEA, Euratom and by ANR grants ; CPT is a member of the FCM-ITER project. Biophysics research is slowly developing, with 2 articles published in bio-journals. Nanophysics research is well integrated in the C'nano-PACA network, and has developed strong collaborations with foremost experimental teams. It should also be noted that CPT members have been active in the preparation of proposals for the « Investissements d'avenir », mainly at LABEX level.

CPT personnel are very active in the local universities in terms of teaching duties and undertake responsibilities linked to the administration of research and teaching. At national level, CPT researchers participate in 10 GdR, several scientific bodies such as CNU, CoCNRS, and the French Mathematical and Physical Societies.

- **Appreciation on the impact, the attractiveness of the research unit and of the quality of its links with international, national and local partner :**

3 professors have been distinguished by IUF memberships, among which are 2 junior fellows. It should be noted that a significant fraction (about one quarter) of the CPT permanent research staff is of foreign origin (mainly from Italy, Germany, and Russia) or has started its academic career abroad. This is also the case for postdocs and for research personnel: out of 9 persons who have recently joined the CPT, 5 have been educated abroad. Several are world-class leaders who contribute actively to the current positive dynamics of the laboratory.

All of the teams have well-established links with the international community, with some members being regularly invited to international conferences. The groups have been successful in securing funding from the national agency ANR, often in collaboration with other French laboratories. The CPT's current resources are of the order of 750k€/year, with an increasing commitment to the maintenance of the building of about 180 k€/year. In addition the laboratory attracts over 400 k€/year in project-oriented grants.

- **Appreciation on the management and life of the research unit :**

Since January 2008, these activities are organized according three broad thematic groups, and 10 research teams. The groups are: i) Fundamental Interactions (E1- E4), ii) Statistical Physics and Condensed Matter (E5 & E6) and iii) Classical and Quantum Dynamical Systems (E7-E10), with the following teams :

E1 Particle Physics (Team leader : M. Laurent LELLOUCH) Effective staff: 3;

E2 Geometry, Physics, and Symmetries (Team leader : Mr. Robert COQUEREAUX) Effective staff: 5.5;

E3 Cosmology (Team leader : Mr. Pierre TAXIL) Effective staff: 2;

E4 Quantum Gravity (Team leader : Mr. Carlo ROVELLI) Effective staff: 3;

E5 Statistical Physics (Team leader : Mr. Senya SHLOSMAN) Effective staff: 3.67;

E6 Nanophysics (Team leader : Mr. Thierry MARTIN) Effective staff: 3.5;





E7 Ergodic Theory (Team leader : Mr. Sandro VAIENTI) Effective staff: 1.5;

E8 Non Linear Dynamics (Team leader : Mr. Marco PETTINI) Effective staff: 6.5;

E9 Quantum Dynamics and Spectral Analysis (Team leader : Mr. Philippe BRIET) Effective staff: 2.17;

E10 Collect Phenomena and Out-of-Equilibrium Systems (Team leader : Mr. Claude-Alain PILLET) Effective staff: 2.67;

For the next 5-year period, the project is to merge teams E5 and E10, under the leadership of Alain BARRAT. The committee strongly approves.

The CPT holds several seminars. A general interest colloquium takes place monthly and the three main groups (Fundamental Interactions, Statistical physics and condensed matter, Classical and Quantum dynamical systems) each hold a weekly seminar. A "journée du CPT" takes place once a year, with synthetic presentations of all laboratory activities.

CPT governance relies on regular consulting with the conseil de laboratoire. It has been the difficult and very successful achievement of the current director to guide the laboratory through a very positive reconfiguration of its activities. However, in the future, communications within laboratory personnel (research or administrative staff) and with governing institutions / universities have to improve. This is particularly the case for the administrative and technical staff who have appeared as being quite disoriented to the committee. The next director and his team have presented a coherent development plan and should be allowed to press ahead as soon as possible.

Laboratory priorities have to be maintained during the transition period of the grouping of the local universities in Marseille. In areas related to physics, the many links noted in this report will help. As for mathematics-related research, the role of the FRUMAM federation is essential. It has proved to be able to foster collaborative work across the Aix-Marseille-Toulon groups. It must be more involved at management level in the growth and preservation of university links between AMU and USTV.

- **Appreciation on the scientific strategy and the project :**

The project is clearly the continuation and evolution of the present CPT activities. It has an appropriate balance between "risk-taking" directions (quantum gravity & cosmology; biophysics; complex networks), directions that are supported by a strong international dynamics (plasma, particle physics, cosmology) and areas where the laboratory reputation is now well established (nanophysics) or traditionally quite strong (mathematical physics).



#### 4 • Team review, E01

- Name of the team : E01 - Particle Physics

Team leader : Mr. Laurent LELLOUCH

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	0	1
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	3	3
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	2	1
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	0
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	4	
N7: Number of staff members with a HDR or a similar grade	3	4

- Scientific quality and scientific production :

The main themes of the Group's research are the non-perturbative QCD calculations necessary for tests of the Standard Model. The work which has made the largest impact in this period is the Lattice QCD research performed in collaboration with physicists in Budapest and Wuppertal (the BMW collaboration). The main feature of the work of this collaboration is their successful push towards physically light up and down quark masses and their results have featured prominently on the international stage. Their Science article was considered among the top ten breakthrough articles in 2008. The science is well described in the report and the contributions of the CPT group were clarified during the visit. The team is also working very effectively on various other aspects including detailed analyses relating to the CKM matrix (Cabbibo-Kobayashi-Maskawa matrix). This includes a many-author study of the potential of the physics of BES-III experiment in Beijing and a leading role in the work of CKM-fitter (one of the two groups performing detailed global CKM analyses). The Marseille team is also known for its work on refining the theoretical calculations of the hadronic and light-by-light contributions to  $g-2$  which continue towards greater precision. The long-standing work on low-energy effects continues, most recently directed to studies of isospin-breaking corrections in kaon decay modes.

- International reputation, attractiveness, integration in the local / national research community :

The group is fully integrated into the international particle physics community in general and into the Lattice Field Theory, Flavour Physics and Chiral Perturbation Theory subcommunities in particular. The group has a high visibility internationally in these areas, and in the next few years this is expected to be extended into physics beyond the standard model. Its attractiveness as a research environment is illustrated by the number of excellent medium-to-long term visitors it has had in recent years and by the quality of its postdoctoral researchers and students.



- **Project :**

The project in Particle Physics is very exciting indeed and the clarity with which the team has developed its strategic thinking is most impressive. Prof Gripaos will join the group in October 2011. This is a particularly timely appointment, coming as it does at the beginning of the exploitation of the Large Hadron Collider (LHC), and will extend very significantly the range of physics which will be studied by the team. Although, the appointment came too late to be included in the detailed description of the future activities of the team in the paperwork, we heard Gripaos' scientific plans during the visit which reinforced our enthusiasm for the scientific programme. It is anticipated that a further position will become available in this area and we support the case for this very strongly.

The proposed programme of work in Lattice QCD is excellent; the CPT will continue to contribute to this important field at the highest level. The proposed topics mesh very well with the group's overall strategy. The committee supports the case for the hiring of a junior researcher to develop further this successful activity (the team is trying to achieve this through the annual CNRS round of appointments). Other planned noteworthy activities of the team include detailed analyses of the CKM matrix under the umbrella of the CKMfitter collaboration and the efforts to improve the precision on the hadronic contributions to the muon  $g-2$ .

- **Conclusion :**

- **Strengths and opportunities :**

The new appointment in Physics Beyond the Standard Model and the likelihood of a further position in this area, the world-class programme of research in Lattice QCD together with the remaining activities described in the project documentation provide the opportunity of a very exciting high-level programme of research in theoretical particle physics.

- **Weaknesses and threats :**

The team shares the risks with all of the CPT of possible unexpected reduction in help from support staff through illness or resignations. In particular, the team needs reliable support in IT which is provided by a single member of staff and is therefore vulnerable.

- **Recommendations :**

This is a strong team with a clear vision for future excellence in research. It deserves continuing support.



#### 4 • Team review, E02

- Name of the team : E02 - Géométrie, Symétrie et Physique

Team leader : Mr. Robert COQUEREAUX

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	7	7
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	2	3
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	4	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	3	
N7: Number of staff members with a HDR or a similar grade	8	7

- Scientific quality and scientific production :

The group has been carrying out very original work on the mathematical techniques and methods required in the description of new fundamental physical laws. Some new mathematical structures have emerged which will require more study in the future and some have found direct physical applications. It is common in mathematical physics that research topics tend to be very specific and its highly specialised nature leads to few people working on a given theme worldwide. The combined competence of the group, which allows them to address an impressive variety of topics in a profound and innovative way, is an important heritage to be preserved, in particular as their geometric *savoir-faire* is becoming a lesser-known method worldwide.

The CPT has a long-standing tradition in the application of geometric tools, notably symplectic geometry, to physics, with the re-expression of geometric concepts into algebraic structures. Interesting new applications include the explanation of the "optical Hall effect" through a geometric spin-optics based on a non-commutative plane endowed with a natural Berry-type curvature; and important conceptual progress on the geometry of non-relativistic space-time transformations. This has allowed understanding the Newton-Cartan structures which may arise when non-relativistic limits of conformal symmetries are taken and has produced a classification of such non-relativistic space-times, based on the distinction between time-like and space-like geodesics. This is of relevance for understanding the possible space-time symmetries of non-equilibrium statistical mechanics and also in the actively studied non-relativistic versions of the AdS/CFT correspondence in stringy contexts. In studying the BRS algebra in gauge theories, a two-decade-old problem how to construct diffeomorphisms from a  $SI(2, \mathbb{R})$  gauge theory has been solved. In the studies of integrable systems a new way for finding matrix solutions to Yang-Baxter equations was obtained and new kinds of integrable open chains were constructed from Hecke-algebra representations.



Very interesting work has been performed on non-commutative geometry, not the least being an alternative route beyond the standard model which does not follow the broadly beaten track of string theory. A real effort has been made to predict the Higgs mass quantitatively. The physical relevance of any theory beyond the standard model will be submitted to experimental tests once LHC data will become available.

- **International reputation, attractiveness, integration in the local / national research community :**

The group has been very productive during the 4-year period. Similarly, the large number of invited contributions and oral presentation at international conferences clearly shows that their work is well appreciated. They attracted a considerable number of PhD students and a large number of long-term visitors from all over the world.

Members of the group participate actively in the management of science and research, both at the local and at the national level. In this respect, the group and its members are still well connected and respected.

A substantial part of the group is rapidly approaching the age of retirement. While the group as a whole is faithfully preserving a long-standing tradition of the CPT, it is becoming urgent that a clear and realistic strategy be defined, rejuvenating the scientific goals and assessing the expertise which will need to be attracted to the CPT in order to achieve these goals.

- **Project :**

Scientifically, the proposed lines of research look like a fine and logical continuation of the ongoing work. In the context of an overall “modernization” of the scientific goals of the CPT, establishing a realistic strategy for a considerable rejuvenation of the group will be necessary. The committee trusts that the direction of CPT will be open-minded for pursuing scientific lines which do not follow the most common route.

- **Conclusion :**

- **Strengths and opportunities :**

Scientifically, the group has several not-so-common competences which distinguish them, in particular their emphasis on geometry-oriented methods. If a recruitment of younger people could be realized in the next few years, this could bring about a necessary “modernization” of the scientific profile.

- **Weaknesses and threats :**

Several eminent members of group are close to retirement age and a policy for their replacement has not yet been clearly defined.

- **Recommendation :**

Maintain the *attractivity* of the field of geometry-oriented mathematical physics for the next generation. Define a clear and realistic strategy for the future scientific goals, assess the expertise which will need to be attracted to the CPT to meet these goals and search actively for possibilities to recruit the corresponding young permanent staff (MCF/CR level).



#### 4 • Team review, E03

- Name of the team : E03 - Cosmologie (E3)

Team leader : Mr. Pierre TAXIL

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	3	4
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	0	0
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	0	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	2	
N7: Number of staff members with a HDR or a similar grade	3	4

- Scientific quality and scientific production :

By definition, Cosmology deals with a non-reproducible, non-controllable experiment, and the only way to promote it into a science goes through proposing new observations, and assessing their (in)dependence on previous ones. From its creation (2003) on, the small but nicely developing “Cosmology” team is clearly devoted to this ambitious goal and has achieved major contributions to the question of Dark Energy, incommensurate with a team of 2 professors and 1 maître de conférences.

In particular, several works should be mentioned on the degeneracies between different parameters of Dark Energy models, on the effect of priors on the extraction of such parameters from observations, and on ways to lift these degeneracies by combining different observables.

Given the systematic errors coming with SN1a supernovae observations, whose effects on parameters determination have been studied, it is crucial to dispose of other probes at high red-shift. One of them is the growth of density perturbations extracted from the 2-point correlations in the density of galaxies, whose full power should start appearing in 2012 with the first VIPERS survey results. Another is the clusters distribution of red-shift v.s. velocity dispersion, for which the team benefits from its unique expertise in efficient cluster-finding algorithms.

But the most original and promising results concern new geometric probes of cosmic acceleration, from galactic diameters to galaxy pairs at high red-shift. If the first may require future observations before becoming competitive, preliminary results recently published in Nature show that galaxy pairs could, already with existing catalogs, provide an SN1a-independent way to confirm the cosmic acceleration, with better precision and different systematics. This major result is a nice accomplishment after four years of coherent work in the spirit outlined above.



- **International reputation, attractiveness, integration in the local / national research community :**

The reputation of this group is quickly building up, as attested by more than 10 international invitations and 30 seminars, by frequent collaboration with the US or China, and by the successful proposals for observations at international facilities like ESO's VLT. It is too early to measure the attractiveness for postdocs of this rapidly evolving group, but PhD candidates already saturate the advising capacity.

Locally, the group has played a central role in the emergence of an active research community involving the neighbor laboratories LAM and CPPM, which recently developed into a LABEX project.

- **Project :**

The detailed project of the team is extremely convincing, especially as concerns the natural developments of the current most promising activities outlined above, like the study of galaxy pairs. The extension of statistical characteristics of galaxies in deeper and larger surveys to higher order (3, 4 and 5) could also provide new and interesting observables with fruitful consequences on the Dark Matter problem. A careful study of the subtle effect a cosmological constant can have on gravitational lensing is also an interesting project connecting the Dark Energy and Dark Matter problems.

- **Conclusion :**

- **Strengths and opportunities :**

The past and future research programs are highly relevant, coherent and well suited for the group expertise and size, with a wealth of exciting observational results expected in the future. The group has extremely good connections with the local experimental teams but its dynamical propositions for new observations have wider international extensions.

- **Weaknesses and threats :**

The small size of the group and its full teaching duties are only temporarily compensated by an IUF appointment. An age and seniority gap starts to increase between the youngest member of the group (38) and the PhD students.

- **Recommendations :**

The team has recently proven its attractiveness and ability to successfully recruit an excellent university researcher. We therefore support its legitimate aspiration for an extra junior position along the same line of research in the future.

Meanwhile, the team should continue its efforts to finance and recruit postdoctoral researchers, possibly with the support of neighbor experimental laboratories: given the exceptional current dynamics these efforts should rapidly prove successful.

The established expertise of the team in observational cosmology might in the future benefit from further interactions with more theoretical approaches, if the opportunity arises. In this spirit, the team is encouraged to continue its current opening to the GPS (E2) and quantum gravity (E4) groups, for which observational inputs may in turn bring extremely precious stimulations.



#### 4 • Team review, E04

- Name of the team : E04 - Quantum Gravity

Team leader : Mr. Carlo ROVELLI

Staff members

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	2	2
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	1	1
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	5	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	5	
N7: Number of staff members with a HDR or a similar grade	2	2

- Scientific quality and scientific production :

The Quantum treatment of Gravitation is a long-standing and yet unsolved problem.

The group of LQG of the CPT is certainly among the most qualified in the world working on the subject. The scientific quality of its members, both permanent and temporary, is first rate and the scientific production is more than adequate.

Among the scientific production related to the years 2006-2009, the results concerning the construction of coherent states in Quantum Gravity and the proof of the equivalence between the spin foam and the canonical formulation are particularly interesting. In fact, this kind of exploration is a promising research theme, which could somewhat, clarify the connection between the full Quantum Gravity Theory, and the (semi-) classical one, which is more directly related to astronomical observation and Cosmology. The connection with the (semi-) classical formulation is an important issue also because it makes possible the investigation of the minimal assumptions that should be common to all approaches to Quantum Gravity, and their relation to other more involved and detailed approaches such as, maybe, String Theory.

Another very interesting field of investigation deals with the smoothing of singularities of General Relativity, due to quantum effects, both in Cosmology and in Black Hole physics.

- International reputation, attractiveness, integration in the local / national research community :

The Quantum Theory of Gravity, although still missing direct experimental information, is a quickly evolving subject: a relevant number of people pursue investigations in this direction in the world scientific community. There are several approaches to this subject and the relation among them, if any, is not at all clear.





As already mentioned the LQG group of the CPT is widely known among scientists working on the quantum aspects of gravity, also due to the presence of its leader, Carlo Rovelli, who is one of the co-founders of the subject.

The documentation presented provides evidence of an intense scientific exchange with other researchers in the world and looks also very well integrated in the national research community as also shown by the collaboration several groups (such as mathematical physics group in Orsay).

It is finally to be remarked that the CPT group of LQG attracts many young researchers as testified by the high number of its temporary positions. The large number of PhD students and postdocs clearly reveals the attractiveness of the group. Proper support of such a large number of PhD students is however a heavy burden that should in the future be shared more evenly between permanent members of the group.

- **Project :**

The scientific project for the years 2012-2015 looks interesting and promising. In particular the project is aimed to the further investigation of the long distance implications of the LQG. This is a very ambitious subject which could lead to link LQG with observational data and could also shed some light on the problem of ultraviolet structure of the quantum theory of gravity.

- **Conclusion :**

The group of LQG of the CPT looks very healthy, with very interesting achievements and promising projects.



#### 4 • Team review, E05+E10

- Name of the team : E05-E10 Physique Statistique / Physique Statistique et systèmes complexes

Team leader : Senya SHLOSMAN E05 and Claude-Alain PILLET E10 / Alain BARRAT (new)

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	7	7
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	3	3
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	3	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	7	
N7: Number of staff members with a HDR or a similar grade	12	12

- Scientific quality and scientific production :

Since in the future team 05 will be formed from the fusion of the old teams E05 and E10, a separate report on their past scientific production will be given.

The old team E05 has a long-standing tradition of rigorous statistical mechanics, which has been maintained (in spite of the departure of several of its members) and is now being complemented by new activities on complex networks and interdisciplinary applications.

Notably, the framework of complex networks has been used to analyse social bookmarking internet sites. Remarkably, evidence has been found there for a semantic network of keyword, apparently followed unconsciously by users upon selecting keywords, and which might become useful in countering spams. A remarkable synthesis with more traditional interests in this group has been the introduction of "Random Cameo Graphs", which still admit a rigorous mathematical treatment which will facilitate studies of specific realistic models. Complex networks also serve as support for dynamic phenomena, such as network traffic. Interestingly, a phenomenon roughly analogous to ageing in spin glasses occurs in that the Poisson hypothesis, which states that at least for a Markov process an equilibrium state is reached within a finite time, is not valid in all networks - rather the corresponding infinite system undergoes a phase transition into a periodic state and hence a stationary state is never reached.

Several interesting rigorous results on phase transitions have been obtained, notably on droplets, crystal growth and condensation phenomena. A particular focus has been given to geometric aspects of continuous phase transitions, by comparing thermodynamic properties with those derived from cluster percolation. Furthermore, it has been shown that several geometric-topological indicators, such as the mean Euler-Poincaré characteristic or mean Betti numbers display a change of their behaviour at the critical point.



As to the other component of the future E05 team, the old E10 team, it has clearly performed outstanding quality research in several important areas of mathematical physics. The work on open quantum systems, in particular the mathematical study of non-equilibrium steady states (NESS), is groundbreaking. A mathematical justification for linear-response theory is given using techniques from operator algebras. It is based on further development of the operator algebra method, combined with the progress in commutator methods during the last 15 years. Significant progress in the understanding of transport phenomena in continuous disordered systems has been obtained.

Another area of progress concerns the mathematical understanding of Bose-Einstein condensation (BEC). A focus point has been the influence on BEC of disorder in the infinite-range Bose-Hubbard model. Remarkably, there is a suppression of BEC at some fractional density of impurities. Technically, it is based on a systematic development of approximate Hamiltonians, defined on the Hilbert space of harmonic oscillators.

In summary, both parts of the future team E05 have performed leading world-class research at the highest level. A substantial number of papers in some of the best journal in mathematical physics and pure mathematics have been published.

- International reputation, attractiveness, integration in the local / national research community :

The whole of the newly formed team E05 is internationally recognized for outstanding work, and have shown their attractiveness by realizing several recruitments for permanent positions recently. This is further attested by several PhD students of foreign origin and very frequent long-time visits from well-established scientist from all over the world.

The quality of the group is also recognized by the support of the *organismes de tutelle* for the several recent recruitments. Active participation in international scientific conferences with a large number of invited contributions and oral presentations; and numerous conferences and workshops organized by members of the group amply attest their international reputation and integration.

Members of the group participate actively in the administration of science and research, both at the local and at the national level.

- Project :

The project builds on the respective strengths of the two former groups now being combined. They will continue their work on Bose-Einstein condensation, and shall use the results and techniques acquired to study interacting Bosons out of equilibrium. In these studies, particular emphasis will be given to open quantum systems and quantum version of the well-understood large-deviation relations of classical statistical mechanics. On the other hand, the interdisciplinary studies of networks and especially their dynamical properties will be continued, in particular allowing going beyond the 'fermionic' restriction of a single degree of freedom per node. Innovating applications to epidemic processes, travel networks, web sciences and social networks will be pursued.

- Conclusion :

Outstanding group with a very productive and creative research environment, the fusion of the two old teams E05 and E10 to form the new team E05 will most likely enhance the very positive elements of both old teams further.



#### 4 • Team review, E06

- Name of the team : E06 - Nanophysics

Team leader : Mr. Thierry MARTIN

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	3	3
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	2	2
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	4	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	5	
N7: Number of staff members with a HDR or a similar grade	4	4

- Scientific quality and scientific production :

This scientific team has obtained excellent results in various areas of mesoscopic transport as the large amount of high quality publications can attest.

The team has continued to develop its traditional work such as the study of the transport in one-dimensional correlated electronic systems (nanotubes, wires, etc.) and the detection of current moments (noise and the full counting statistics) in nanoscopic systems. The team has now turned toward calculations of the full noise power spectrum which is now accessible experimentally.

The recent evolution of the team toward molecular electronics and spintronics has been successful (an ANR has been obtained on this topic) with many key results published in top journals. The study of the influence of the molecule vibronic modes on electronic transport is original and important to correctly interpret experiments. Several interesting works on transport through a nanoscale system (molecule or quantum dot) contacted between superconducting leads can also be noted. These studies are clearly of high quality and especially timely in view of the large amount of experiments on this topic worldwide. The recent hiring of Jérôme RECH as a CR2 will undoubtedly consolidate the analytic expertise of the group in the study of transport through correlated mesoscopic systems.

To summarize, the theoretical works carried on in this group are strongly coupled to the experimental national and international landscape though no such experiment exists in Marseille. This strong coupling between theory and experiment is clearly a major strength of the group and should be maintained.



- International reputation, attractiveness, integration in the local / national research community :

The group has an internationally recognized expertise in mesoscopic physics, particularly in the study of the noise and higher moments of the current in nanoscopic systems as the organisations of two major international conferences in the field can attest. The group has also regular international collaborations with some leading groups in Germany, Russia and Japan.

As underlined above, the group activity is strongly tied to national experimental and theoretical groups (both in Paris and Grenoble) and is therefore perfectly integrated into the national landscape. The group is very active in the participation and organization of the various meetings of the GDR "Physique mésoscopique".

- Project :

The project proposed by the team plans offers a good continuation of the existing research activity together with new directions connected to recent experimental developments. One of them notably concerns some theoretical support to experiments carried in the ENS Paris aiming at performing experiments analogous to ones realized in quantum optics but with electrons. This is currently a highly developing field with potential high impact. Another fully new direction the group aims at taking concerns the physics of cold atoms in optical traps with the implementation of time dependent density renormalization group. This is quite a sophisticated technique which depends expertise the group plans to acquire by hiring a young permanent member. Such hiring may indeed create connections with other teams.

- Conclusion :

- Strengths and opportunities :

Very reactive and dynamic team with an excellent connection to the national experimental landscape which enables them to address relevant issues in the field.

- Weaknesses and threats :

The team suffers from a lack of a local formation in condensed matter theory, in order to attract PhD students. The team leader plays a key role in the choice of problems to tackle and through its investment to keep the team connected with experimentalists in the field (which are not located in Marseille). His future responsibility at the head of the laboratory may weaken the group in that respect.

- Recommendations :

The team should continue his efforts to attract postdocs and PhD students nationally but also internationally. The younger members are strongly encouraged to share the team management.



#### 4 • Team review, E07

- Name of the team: E07 - Ergodic theory

Team leader : Mr. Sandro VAIENTI

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	3	3
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	0	0
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	0	0
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	0
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	1	
N7: Number of staff members with a HDR or a similar grade	2	3

- Scientific quality and scientific production :

This is a small team, with three active researchers. They cover diverse topics in dynamical systems and ergodic theory. The statistical properties of non-uniformly expanding dynamical systems have been analyzed. Examples have been obtained of quantum ergodic maps which are not quantum uniquely ergodic. Some interesting results have been obtained on recurrence, i.e. the distribution of returns around periodic points.

Random perturbations of dynamical systems have also been considered. Here the statistical approach is important, and interesting results have been obtained.

Concerning mathematical billiards, progress on the illumination problem has been obtained, however, much remains to be investigated. These are long-standing open problems, so even limited results are of interest.

Part of the research has been focused on translation surfaces, investigating geometry and dynamics of these surfaces. These are complicated problems, requiring a substantial amount of techniques from algebraic topology and geometry.

The research emphasizes the mathematical aspects, with little documented work on physical systems. The publications range from some in highly respected pure mathematics journals to dissemination of research.

- International reputation, attractiveness, integration in the local / national research community :

The team has relations in particular with Brazilian research groups in dynamical systems and participates in several international research projects. The team is participating in the work of the strong international community in dynamical systems. Currently one PhD is co-directed with researcher from University of Porto.



- Project :

The project is a continuation of the current lines of research, with no major changes. Some attention will be given to climate models in the new period.

- Conclusion :

- Strengths and opportunities :

Strong mathematical background enables the team to deal with the deeper aspects of dynamical systems and ergodic theory.

- Weaknesses and threats :

Limited work on physically relevant systems. Appears to an outside observer to be somewhat isolated within CPT.

- Recommendations :

More work on systems more directly of interest in theoretical physics.



#### 4 • Team review, E08

- Name of the team : E08 - Nonlinear Dynamics

Team leader : Mr. Marco PETTINI

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	5	2
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	4	4
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	5	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	6	
N7: Number of staff members with a HDR or a similar grade	7	6

- Scientific quality and scientific production :

The team has obtained numerous results in the area of fusion plasma physics and Hamiltonian chaos. The total scientific production and communication of the team is high in the last four years with about 50 publications, some of them in major journals, and 30 oral communications in workshops and conferences.

Part of this team has also been initiating and reinforcing a new direction of research in biophysics in collaboration with the "Centre d'immunologie of Marseille-Luminy" on allelic exclusion and the mechanisms at play in the process. The first results are very encouraging and have been published last year in an important journal in immunology.

- International reputation, attractiveness, integration in the local / national research community :

The team has a well established reputation in the area of control of Hamiltonian chaos. The team is very well connected at the international level as can be seen by the high numbers of collaborators from foreign institutions. The team is also very active in the organization of workshops in order to foster collaborations in this community.

The team is consolidating his strong local bonds with the IRFM at CEA Cadarache with the perspective of the ITER project inside the ITER national research federation. In this respect, the team is very well integrated at the local and national level. The local collaboration with the CIML is an interesting and promising line of research at the frontier between two a priori disconnected disciplines (an ANR grant has been obtained on this project).





- **Project :**

The team aims at further developing analytical and numerical techniques in order to model the nonlinear dynamics of turbulent plasmas in connection with the ITER project. The other main part of the project is focused on the interface between nonlinear dynamics and biology. One project aims at consolidating an existing collaboration with the CIML on allelic exclusion, the other concerns the eventual role played by long-ranged electrodynamic forces on the dynamical organization of living matter.

The team aims at hiring permanent staff in these two directions. The hiring of a junior member doing numerical approaches to plasma physics seems more urgent to sustain the existing and fruitful collaboration with Cadarache.

The activity on biophysics may need to be further matured before eventually planning some hiring of a permanent staff.

- **Conclusion :**

- **Strengths and opportunities :**

The collaboration with Cadarache in the ITER project definitely constitutes a genuine opportunity for this team to irradiate internationally.

- **Weaknesses :**

The scientific production is unevenly distributed between team members.

- **Recommendations :**

The team should further reinforce its links with fusion / Cadarache and continue its activity on biophysics to bring it to fruition.



#### 4 • Team review, E09

- Name of the team : E09 - Quantum dynamics and spectral analysis

Team leader : Mr. Philippe BRIET

Staff members :

N1: Number of researchers with teaching duties (Form 2.1 of the application file)	6	6
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	0	0
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	3	
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	5	
N7: Number of staff members with a HDR or a similar grade	3	3

- Scientific quality and scientific production :

The research of this team is focused on applying the methods from functional analysis, operator theory, and partial differential equations to problems and questions from theoretical physics and related areas. The focus points are spectral problems and quantum dynamics.

This team has a very diverse scientific production, covering many different topics.

The results on magnetic Hamiltonians are significant, although many problems still remain open for these Hamiltonians. Work on resonances for magnetic Hamiltonians has been initiated, promising progress on this difficult question.

The highly simplified models using graphs are of direct interest to physics, since many of these structures can be realized in experiments in mesoscopic physics. There are very substantial mathematical questions that need to be resolved, and the team is making a good effort and obtains significant results in these areas. Wave guides have received special attention. A working group has been formed with LAPT, with a high profile and a high level of activity. Of interesting results one can mention the creation of bound states in wave guides, arising from deformation of the geometry of the wave guide. In particular, depending on the rate of twisting, one can get infinitely many bound states accumulating at the bottom of the essential spectrum.

A very promising new development for the team is the initiation of work on non-perturbative approaches to quantum field theory. Recent technical developments make it possible to obtain rigorous results that are based on physically relevant models. The current emphasis is on quantum field theories on curved space-time. The existence of the ground state in the Nelson model is being investigated.

The work on semigroups and evolution equation is a continuation of a long term effort. What is new is the consideration of non-autonomous systems. These methods are being applied to quantum transport, analyzing the Gibbs semigroup.

The scientific production is substantial, with publications in respected mathematical physics and pure mathematics journals.



- International reputation, attractiveness, integration in the local / national research community :

Members of the team are well known internationally and have many collaborators in different countries. They are very active in organizing workshops in France and abroad. They have a substantial number of visitors from many countries and the team members spend extended periods at other universities every year. They have a record of educating several PhDs jointly with universities in the Czech Republic and in Denmark.

- Project :

The project shows two very promising directions that will be pursued. One is the expansion into the non-perturbative approach to quantum field theory, based on the recent strengthening of the team with a young high-profile researcher in this area. Other members of the team will be joining the new researcher in this endeavor. The other direction is inverse problems, where a new team member is being recruited. After recent retirements and loss of a team member the team is on the way to new and promising directions.

- Conclusion :

- Strengths and opportunities :

With two new members and two new promising directions of research the team has the opportunity to strengthen an already strong team.

- Recommendations :

Continue with the renewal initiated with the project.

Intitulé UR / équipe	C1	C2	C3	C4	Note globale
CPT - Centre de Physique Théorique	A	A	A	A+	A
Particle Physics	A+	A	Non noté	A+	A+
Géométrie, symétrie et Physique	A	A	Non noté	B	B
Cosmologie	A+	A	Non noté	A+	A+
Quantum gravity	A+	A+	Non noté	A+	A+
Physique statistique, systèmes complexes E5 + E10	A+	A	Non noté	A+	A+
Nanophysique	A+	A	Non noté	A+	A+
Ergodic Theory	B	B	Non noté	A	B
Non linear dynamics	A	B	Non noté	A	A
Quantum dynamics	A+	A	Non noté	A+	A+

- C1 Qualité scientifique et production
- C2 Rayonnement et attractivité, intégration dans l'environnement
- C3 Gouvernance et vie du laboratoire
- C4 Stratégie et projet scientifique



**Statistiques de notes globales par domaines scientifiques**  
(État au 06/05/2011)

Sciences et Technologies

Note globale	ST1	ST2	ST3	ST4	ST5	ST6	Total
A+	6	9	12	8	12	11	58
A	11	17	7	19	11	20	85
B	5	5	4	10	17	8	49
C	2	1	2				5
<b>Total</b>	<b>24</b>	<b>32</b>	<b>25</b>	<b>37</b>	<b>40</b>	<b>39</b>	<b>197</b>
A+	25,0%	28,1%	48,0%	21,6%	30,0%	28,2%	29,4%
A	45,8%	53,1%	28,0%	51,4%	27,5%	51,3%	43,1%
B	20,8%	15,6%	16,0%	27,0%	42,5%	20,5%	24,9%
C	8,3%	3,1%	8,0%				2,5%
<b>Total</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>

Intitulés des domaines scientifiques

Sciences et Technologies

ST1 Mathématiques

ST2 Physique

ST3 Sciences de la terre et de l'univers

ST4 Chimie

ST5 Sciences pour l'ingénieur

ST6 Sciences et technologies de l'information et de la communication

Objet : Réponse au rapport d'évaluation - S2UR120001624 - CPT - Centre de Physique Théorique - 0131843H - de l'unité CPT - Centre de Physique Théorique

Observations d'Aix-Marseille Université

Aucune observation n'est formulée

En accord avec les deux autres établissements d'Aix-Marseille

Le Président  
de l'Université de la Méditerranée



Yvon BERLAND



Le Vice-président du Conseil Scientifique  
de l'Université de la Méditerranée



Pierre CHIAPPETTA