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## LUTH - Laboratoire univers et théories

Rapport Hcéres

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

Section des Unités de recherche

Evaluation report

Research unit :

Laboratoire Univers et ses THéories  
(LUTH) – UMR 8102

de l'Observatoire de Paris



April 2009



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et de l'enseignement supérieur

Section des Unités de recherche

# Evaluation report

Research unit :

Laboratoire Univers et ses THéories

(LUTH) – UMR 8102

de l'Observatoire de Paris



Le Président  
de l'AERES

Jean-François Dhainaut

Section des unités  
de recherche

Le Directeur

Pierre Glorieux

april 2009



# Evaluation report

## The research unit :

Name of the research unit : Laboratoire Univers et Théories

Requested label : CNRS/UMR

N° in case of renewal : 8102

Head of the research unit : Mr Jean-Michel ALIMI

## University or school :

Observatoire de Paris

## Other institutions and research organization:

CNRS

Université Paris Diderot (Paris 7)

## Date(s) of the visit :

March 16<sup>th</sup> and 17<sup>th</sup> of 2009

# Members of the visiting committee



## Chairman of the committee :

Mr Francis BERNARDEAU, CEA/DSM/IPHT, Saclay

## Other committee members :

Mr Jean-Pierre CHIEZE, CEA/DSM/IRFU, Saclay

Mr Thierry COURVOISIER, Integral Data Center, Genève, Suisse

Mr Andrew KING, University of Leicester, UK

Mr Stephen SCHLEMMER, University of Köln (Cologne), Germany

## CNU, CoNRS, CSS INSERM, (représentant INRA, INRIA, IRD...) representatives :

Mr Jean-Luc ATTEIA, CoNRS

Mrs Geneviève SOUCAIL, CNAP

Mr Sébastien GALTIER, CNU

# Observers



## AERES scientific representative:

Mrs Rosine LALLEMENT

## University or school representative:

Mr Daniel EGRET, President of the Observatory of Paris-Meudon

## Research organization representative (s) :

Mr Jean-Marie HAMEURY, CNRS-INSU (partly)

Mr Alain CASTETS, CNRS-INSU

## 1 • Short presentation of the research unit

- Permanent research staff :
  - University (enseignants-chercheurs) : 5
  - Organisms : CNRS, CNAP : 28
  - Professeurs, Astronomes et Directeur de Recherche : 20
  - Maîtres de Conférences, Astronomes adjoints et Chargés de Recherche : 13
  - Titulaires de l'HDR : 18
  - Titulaires de la PEDR : 3
- Non permanent research staff :
  - PhD students on 1/12/08 : 13
  - Post-docs + ATER : 6
- Permanent technical and administrative staff : 10
  - ITA CNRS : 7
  - IATOS : 3
- Non Permanent technical and administrative staff : 0
- Number of PhDs defended in 4 years : 17
- Number of permanent researchers publishing : 31/33
- Number of papers in refereed (Rang A) journals 2004-2008 : 416
- Number of invited reviews 2004 - 2008 : 77
- Number of books 2004 - 2008 : 53 (including participations and translations)

## 2 • Preparation and execution of the visit

The visit was introduced by a public presentation of the aim and conditions of this evaluation by the representative of the AERES. The Committee members and observers introduced themselves to the whole audience before the director gave a detailed presentation of the laboratory over the last four years, and its project for the next term. It was followed by presentations of the scientific activities of each of the three teams. These presentations offered a detailed account of their recent activities, replacing their activities in a general context, while highlighting the most remarkable results they obtained since the previous evaluation. On the second day scientific presentation focused on transverse projects. The Committee particularly appreciated those very good presentations, the fact that they were presented by the young researchers and that they yielded renewed insights of the scientific priorities of the laboratory.

The end of the morning and first part of the afternoon was devoted to meetings of the Committee with the permanent researchers of each team, with the young researchers (students and postdoctoral fellows), with the ITA members, with the laboratory council and finally the director and his two deputies. All of these meetings were well attended, so that the Committee had a real chance to interact in person with a large fraction of the LUTH population. On the second day, the Committee had also the opportunity to have informal discussions with the laboratory members during a buffet lunch. By the end of the second day, the Committee finally met with representatives of the LUTH-funding agencies (INSU, Observatoire de Paris, CNRS regional office) before holding a closed session to establish its conclusions. The final version of this report was written accordingly.



### 3 • Overall appreciation of the activity of the research unit, of its links with local, national and international partners

Prior to this visit, the laboratory provided very detailed documents that report on their activities over the previous term and projects for the next four years. These documents were found to be extremely detailed and precious - although they probably could have gained in precision were they more synthetic. The Committee is well aware that the laboratory is a rather new entity - it has existed as such for about eight years within the Observatoire de Paris - that brings together teams and individuals of previously different laboratories, and who did not a priori share many common scientific interests. The Committee appreciated the fact that the LUTH has nonetheless evolved as a mature laboratory with a genuine collective life. Clearly, the laboratory houses individuals and teams that have enjoyed international recognition for many years and which continue to thrive and benefit from a sustained flux of students, postdocs and visitors. The laboratory has also been able to give room to new research activities with the arrival of young permanent researchers. This is in particular the case for nuclear physics, plasma physics, physics of the early universe, and interstellar medium. The laboratory also takes advantage of its geographical location to have a large number of regular collaborators - some of them are associate researchers - that contribute to the scientific production of the Laboratory. The laboratory thus cultivates a truly remarkably large number of collaborations with many laboratories from its immediate vicinity - within Observatoire Paris-Meudon, APC at university Paris 7, CEA Saclay, University of Paris 11 to many laboratories in Europe and the US.

Given its size, it has been able to attract a considerable amount of students and postdocs, from various origins, over the last four years. Discussions with those junior researchers have shown that they appreciate the laboratory and the support they get from their senior colleagues. The fact that many of the permanent members of the LUTH have high-level teaching activities in various nearby institutions is clearly a key element to this success. More generally the whole personnel of the laboratory was very satisfied with the way the management, clearly organized to be as transparent and collective as possible, is done. If LUTH members had demands to formulate - and we will evoke some of them later on - none of them were directed against the management of the laboratory.

It is also to be noted that the LUTH has a large opening in scientific communication and a truly remarkable record in public outreach whether it is with the organization of international conferences for professional researchers, general public or with the production of numerous books for audiences of various level. In this domain the laboratory has a level of activity that cannot be matched by any other laboratory of similar size that we know! This has been made possible by the genuine talent of a few individuals but also by a clear involvement of the management in such activities.

From a scientific perspective, the trademark of the LUTH is its interest for the exploration of involved, nonlinear physical processes that are at play in many domains of astrophysics, from the development of large-scale structure, the physics of objects with strong gravitational fields to plasmas in many astrophysical situations. In all these fields progresses are extremely difficult to obtain and require advanced analytical, numerical or experimental tools the development of which can be extremely slow. We will see that such developments appear to be a transverse preoccupation throughout the laboratory. The laboratory has undoubtedly an excellent scientific production. Most of the themes pursued in the laboratory are clearly in good agreement with the topics that have been prioritized at the local (i.e. Observatoire de Paris), national or international levels whether it concerns investigations on dark energy, high energy astrophysics, gravity waves or virtual observatory developments. In all these subjects, the laboratory is enjoying large national and international recognitions.

### 4 • Specific appreciation team by team and/or project by project

The laboratory is organized into three different teams. It appears that this separation can be in some cases rather artificial and does not necessarily reflect genuine collective work. We will nonetheless stick to this organization in our assessment of the laboratory scientific production and projects.



### Cosmology and gravitation (COSGRA)

This team is centered on expertise in general relativity and quantum field theory. A significant part of the research work of this team is devoted to various aspects of fundamental theoretical physics. That includes topics such as the foundation of mechanics and quantum theories to the physics of the early universe. The problem of dark energy has been in particular explored from various perspectives, from a pure general relativity effect, to a signature of new physics. The Committee has been interested in the development of a comprehensive set of high-resolution numerical simulations aiming at diagnosing the effects of dark energy models on the growth of the large scale structure of the universe. This is a subject that has attracted a lot of attention over the previous years in the international community with the emergence of ambitious observational projects for which the group could play a significant role. Another new and promising theme is the physics of the Cosmic Microwave Background, where theoretical and observational developments are also very spectacular, and in which the team starts to work.

The COSGRA team has also enjoyed a solid reputation, built over the last two decades, for its works in numerical relativity. The group has developed a coherent research program for the determination of gravity wave signatures from various astrophysical sources. That program includes the development of a public and portable code package, LORENE. This code is based on a resolution method, the so-called spectral method, for which the group is the recognized world expert. This package is now used in various institutions around the world. This group has been recently strengthened by a new recruitment that fruitfully complements its expertise in the domain of nuclear and high-energy physics. This nicely corresponds to the evolution of the scientific activity of the group that aims at solving more and more realistic astrophysical configurations. For instance the group has investigated the emission of gravitational waves by supernovae and hypernovae, based on the development of a new code that makes use of a new formalism for solving the Einstein equations and relativistic hydrodynamics shocks.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A	A+

### **Fluides et Plasmas Astrophysiques (FPA) to become Astrophysique Multi-Echelle (AME),**

The activities of the group FPA / AME are multiple, including theory work, with both pure and computational components, atomic physics calculations and their applications to stellar physics, or laboratory experiments on dynamo or high energy density plasma. These studies often lead to new and deep results, among which the rotation induced transport of matter and angular momentum in stellar radiative interiors, are important progresses. Due to the reduced number of permanent researchers, some of these lean on the work of associated researchers, belonging to other research organizations.

However, the group appears to miss a shared scientific ambition. Since many members of the group have an extensive knowledge in various fields of astrophysics and theoretical tools, and as far as they are concerned with the multi-physical aspects of most astrophysical applications, it might be useful to develop new synergies, where young people could benefit from a more channeled transfer of knowledge. The JAR Group (jets astrophysiques et retroactions), a new group which has been formed, provides such an example. It presents a renewed scientific program to address a specific question, jets and their interaction with the environment, but with an enlarged scope, based on large panoply of approaches, from theory and simulations to experiments on high energy density plasmas. This is certainly a welcome initiative.





Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
B	A	A	B	B

**Noyaux Actifs de Galaxy et Milieu Inter-Stellaire (NAG-MIS) to become Phénomènes des Hautes Energies et Milieu Inter-Stellaire (PHEMIS)**

This team brings together two major activities: one on the physics and observation of Active Galactic Nuclei (NAG), the other on the Interstellar medium (MIS). It is clear though that these two groups do not have much scientific overlap and have their own logic of scientific development.

The group working on high-energy astrophysics phenomena is very active and have produced results of very high quality. Among the recent very interesting works that have been published let us mention the work on star formation in accretion disks, which adds an important element to the nature of the accretion process in AGN. Of interest is also the work with the TITAN code that allows scientists to interpret X-ray spectra with unprecedented physical insights. The involvement of the group in the HESS and CTA projects is important as it gives these collaborations an astrophysical view and knowledge about compact objects that is necessary for their development. Clearly the committee fully supports this participation. We think though that if the participation of group members to these collaborations should be secured, probably with appropriate hardware contributions, that should probably be achieved at the observatoire de Paris level rather than at the LUTH level. We also note, looking at the development of the team, that the retirement of some key staff should be compensated by arrivals at an appropriate level. The presence of continued scientific leadership in the different domains will be essential to continue to develop and exploit the available expertise in the groups. The visiting committee is convinced that a dedicated action is needed in this respect.

The second group of the NAG-MIS team focuses on the physics and chemistry of the interstellar medium. The Meudon PDR code is a world-wide acknowledged model for simulating the interstellar medium, in particular photon-dominated regions, the treatment of which is rather demanding. The Meudon code is available on the Web as was demonstrated during the visit. It allows observers to use it as an interpretation tool. In addition this team is very well renowned for its expertise in deuterium fractionation and the chemistry of dark clouds. Based on the given age distribution and on the teaching engagement of some of the staff, this group is at a turning point. In order to maintain the world-leading expertise in this group, it is strongly recommended to promote the recruitment of a young leading scientist. We will come back to this point in our recommendation sections.

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A	A+	A	A	A

**Transverse activities**

During the visit a number of transverse activities have been presented and advertised. They appear to represent a significant effort in the laboratory, to show the originality of its scientific policy through cutting edge projects.



### **Grand Challenge:**

The laboratory has a well-known expertise in intensive numerical simulations like in cosmology, galaxy formation, magneto-hydrodynamics modeling, or turbulence. During the visit a presentation of some recent simulations has been made in particular in the framework of "Grand Challenge" which gathers the most ambitious computations in terms of resolution, CPU time and technical programming with massively parallel processing. The example of the dark energy universe simulation series, that can be made at IDRIS/Orsay, illustrates well this strategic position adopted by the laboratory. Clearly the laboratory is at the cutting edge of massive numerical computations and the Committee sustains strongly the different future projects.

### **Virtual Observatory:**

The development of activities related to the Virtual Observatory (VO) appears to be one of the leading topics in LUTH. This is in direct continuation to a long tradition of developing numerical codes and/or physical libraries largely opened and distributed: the PDR code, the LORENE library for numerical relativity, etc ... This activity has recently evolved towards the recently formed "theoretical virtual observatory" environments. LUTH is actively participating in the definition of VO standards for numerical simulations (characterization of the data model, semantics, data access protocols...) and databases. Works concern all aspects that are required to open genuine and operational VO services (including on-line utilization of the codes through web interfaces) as well as the distribution of documented public codes. The projects that are more particularly supported at LUTH, are clearly ambitious. That includes the integration in the VO-Theory of the TITAN code (radiative transfer codes in diluted media), the results of large cosmological simulations like HORIZON, a database dedicated to high energy sources. These are cutting edge projects where the various expertise of the laboratory can be used to their best and the Committee clearly supports these developments. The laboratory however appears to lack human resources to fully sustain these projects. This will be commented at the end of the report.

### **Laboratory experiments:**

Laboratory astrophysics using large laser is a relatively new domain of research. During the visit, a comprehensive presentation of the transverse theme of laboratory astrophysics on high energy density plasmas has outlined the various facets of the field. Not only can be measured microscopic parameters of astrophysical plasmas (opacities, EOS), but also experiments can be done on highly dynamical, interacting, plasmas, such as strong, radiative, shocks or jets. Up to now, benefiting from collaboration with the PHYDEL team at LULI, the group focused essentially on radiative shocks, with state of the art results. Within the AME/JAR group, a laudable effort is made to establish, through the development of a radiative hydrodynamic code, the links between experiments and the interpretation of astrophysical objects. It promises to bring fruitful comparisons with similar codes developed by the French and European teams working in that domain of astrophysics on large lasers. A better coordination at the French level though would improve its chance to thrive in a context of international competition to attract postdocs or even students.

## **5 • Appreciation of resources and of the life of the research unit**

### **– Management :**

The atmosphere that prevails in the Institute is clearly lively and non-conflicting. Members unanimously said they were pleased by the quality of their working conditions. The laboratory council appears to play a central part of the collective life and is associated with many of the important decisions - from the management of financial resources, the determination of a scientific policy, to the content of the presentations during this visit - that punctuate the life of the laboratory. During its visit the Committee could amply appreciate the efficiency of the management and the administration in the organization of this review, from the quality of the documents received to the smooth running of the visit. For its every day scientific life, the team structure may appear a bit artificial but it is used in a rather loose way and does not prevent the existence of collaborations between teams or with other laboratories.



- Human resources :

Since its very foundation, the LUTH has brought together researchers of various scientific background. There are currently researchers from two different sections of the CNRS in the laboratory and two different sections of the CNU. LUTH is clearly a place where interdisciplinary works are genuinely pursued. The laboratory has been very successful in the last few years in recruiting young researchers and they appear to be rather satisfied by the scientific environment they find in the laboratory. In total, the laboratory has recruited 10 new members over the last four years. This represents a remarkable partial renewal of its members. Despite those recruitments, the median age is still very large, about 55, and clearly, the age distribution of the researchers is worrisome. That threatens some activities within the labs, whether they concern theoretical works or experimental developments. Choices should probably be made in the future. Although the Committee is aware that the director has little power in his recruitment policy it nonetheless thinks that the laboratory might gain in credibility if it presented a more prioritized plan of recruitment. We will amply come back to this issue in the final section of this report.

## 6 • Recommendations and advice

- Strong points :

The scientific activities of the LUTH are at the interface between theoretical physics, astrophysics and numerical developments. It brings together researchers of recognized expertise in many domains of astrophysics in a place where interdisciplinary researches have been pursued for years with great success. It continues to be one of its main characteristics and one of its strongest assets. The overall quality of the research pursued in the LUTH is undisputable and many of its achievements are world-class.

The laboratory is also in direct contact with students thanks to the teaching that some of its members do in masters of the Paris area. This is a strong asset for attracting students and young researchers. It is to be stressed that the laboratory has indeed attracted many young and talented researchers over the last few years. They benefit from what has been unanimously described as a congenial environment. The smooth and efficient administration of the laboratory, its management, are also generally lauded.

We also note its very large opening in the domain scientific communication that has been pursued in the laboratory to an unprecedented scope. Clearly the LUTH has succeeded in finding its balance and own identity; it is a very successful laboratory within the Observatoire de Paris. It is also a recognized strong asset of the university Paris-Diderot. Although the vice-president of Paris-Diderot Sciences department, could not join the meeting, he sent a message stressing the fact that LUTH, as one of the astrophysics laboratory of the pole “deux infinis de la Physique” was fully supported, in close collaboration with the Observatoire, by the university.

- Weak points :

The LUTH is however facing a major threat with the imminent retirement of many of its key members that will cause the disappearance of some of its activities. This is bound to induce some reorganization of the scientific themes, for which the laboratory does not seem to be fully prepared. We have the feeling that too much of wait and see policy might compromise the future of the laboratory and the survival of some of its know-how. In other words, the laboratory needs to define better focused perspectives in its recruitment plans for the next years. We think for instance that a hiring in the MIS team should be prioritized by the laboratory management and the observatory management. It is not however only a matter of topic prioritization but also of identifying the most appropriate level of recruitment in each case.

It also appears that though the Laboratory is involved in many world-class projects – whether it is for gravity, high-energy astrophysics, astrophysical plasmas – it is not necessarily identified as a leading partner in either of these projects. The Laboratory needs to take on more PI-ships through ANR or international projects.



– Recommendations :

Let us now make some specific recommendations,

(i) The MIS team is making large efforts to include surface chemistry into their chemical modeling including the PDR code. This is a route which is followed by several other groups worldwide. International collaborations, for instance with Israeli teams, could help the team to be state-of-the-art in the treatment of realistic grain chemistry. The committee notes that one such collaboration has started. In addition, the LERMA team on the experimental investigation of molecule formation on grains is among the world leading teams. Large investments have been made in the past and the prospects of the FORMOLISM instrument are very good. A stronger connection to astrophysical use of their data has been recommended. We believe that both laboratories, LUTH and LERMA would benefit from a regular scientific exchange. This could be done by a bi-monthly half a day symposium. Combining contributions from outside guests and from team members could generate a lively environment visiting all laboratories over time. As a result the French efforts along these lines may take a more leading role in the field, combining experimental, theoretical and observational work.

(ii) Cross fertilization between the atomic and molecular group at LERMA and the rich knowledge of the ISM chemistry at LUTH could lead to similar synergies. Given the historical developments of the specific teams, making the effort to join forces in selected parts might be a more realistic and fruitful way of collaboration than restructuring the laboratories which appears as the second choice to improve the strengths of both laboratories.

(iii) The development of VO is perceived as a major strength of the laboratory. It is a joint effort undertaken at the Observatoire de Paris. It will be the responsibility of the management of the observatory to join the forces of all contributing laboratories to the VO. The French part in this effort is substantial, acknowledged by the community and will also be funded by EU via the FP7 program in the “Virtual Atomic and Molecular Data Centre” coordinated by a French team. We feel that the development of those efforts in the LUTH should be supported by its 'tutelles' as much as possible. Recruitment of a software engineer with expertise in data bases and virtual observatory appears in particular to be crucial to ensure a perennial existence of this activity in the laboratory.

(iv) With the next coming of the large, and demanding, lasers LIL and PETAL, the “laboratory astrophysics” transverse activity should take advantage in getting closer to other teams engaged in laboratory astrophysics (Observatory and CEA/DSM). There would be a great advantage to mutualize, with discernment, the efforts among these groups, regarding (i) the preparation of the experiments (integrated simulations, laser-target-plasma-diagnostics), (ii) the design and realization of targets and the associated diagnostics.

(v) Participation in HESS and CTA is perceived by the Committee as very positive for both the LUTH and these collaborations as it reinforces their astrophysics expertise. The Committee clearly recommends that the LUTH, jointly with the Observatoire de Paris, ensure a continued participation of LUTH members in those collaborations. We understand that it requires contributions at the hardware level and also to the observing shifts. We think though that this is the responsibility of the Observatoire de Paris to reach a viable solution, not necessarily of the LUTH, the latter, we think, being not appropriate for hardware developments in the long run.

Note de l'unité	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A	A	A	A+	A

Meudon, le 20 Avril 2009,

Chère Madame Martine Michel

Je remercie le comité de visite de l'AERES pour son rapport. J'espère que les efforts et résultats remarquables obtenus par le laboratoire et soulignés par ce rapport permettront les recrutements en personnel scientifique et technique, évoqués par le comité.

Bien Cordialement

Jean-Michel ALIMY



Directeur de Recherche au CNRS,  
Directeur du Laboratoire Univers et Théories,