

EVALUATION REPORT OF THE UNIT  
IMJ-PRG - Institut de mathématiques de Jussieu -  
Paris Rive Gauche

UNDER THE SUPERVISION OF THE  
FOLLOWING ESTABLISHMENTS AND  
ORGANISMS:

Sorbonne Université - Sorbonne U  
Centre national de la recherche scientifique -  
CNRS  
Université Paris Cité - UP Cité

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**EVALUATION CAMPAIGN 2023-2024**  
GROUP D

Report published on June, 10 2024



In the name of the expert committee :

Jean-Marc Schlenker, Chairman of the committee

For the Hcéres :

Stéphane Le Bouler, acting president

In accordance with articles R. 114-15 and R. 114-10 of the French Research Code, evaluation reports drawn up by expert committees are signed by their chairmen and countersigned by the Hcéres chairman.

To make the document easier to read, the names used in this report to designate functions, professions or responsibilities (expert, researcher, teacher-researcher, professor, lecturer, engineer, technician, director, doctoral student, etc.) are used in a generic sense and have a neutral value.

This report is the result of the unit's evaluation by the expert committee, the composition of which is specified below. The appreciations it contains are the expression of the independent and collegial deliberation of this committee. The numbers in this report are the certified exact data extracted from the deposited files by the supervising body on behalf of the unit.

## MEMBERS OF THE EXPERT COMMITTEE

### Chairperson:

Mr Jean-Marc Schlenker, Université du Luxembourg, Luxembourg.

### Experts:

Mr Tom Archibald, Simon Fraser University, Canada

Mr Alessandro Berarducci, Dipartimento di Matematica, Università di Pisa, Italy

Mr Francesco Calegari, University of Chicago, USA

Ms Caterina Consani, Johns Hopkins University, USA

Ms Céline Deleval, CNRS Grenoble (expert for administrative staff)

Ms Hélène Esnault, Freie University Berlin and Harvard, Germany and USA

Mr William Timothy Gowers, Cambridge University and Collège de France, UK

Ms Alessandra Iozzi, ETH Zürich, Switzerland (Vice-chair of the committee)

Mr Vadim Kaloshin, ISTA Vienna, Austria

Mr Vladimir Markovic, University of Oxford, UK

Mr Stéphane Nonnenmacher, Université Paris-Saclay (representative of CNU)

Mr Giorgio Maria Ottaviani, University of Florence, Italy

Mr Tanguy Rivoal, CNRS Grenoble (representative of CoNRS)

Mr Jean-Michel Roquejoffre, Université Toulouse 3 - Paul Sabatier (Vice-chair of the committee)

Ms Sarah Scherotzke, Département de Mathématique, Université du Luxembourg, Luxembourg

Mr Stefan Schwede, Mathematisches Institut, Universität Bonn, Germany

## HCÉRES REPRESENTATIVE

Mr Philippe Elbaz-Vincent

## REPRESENTATIVES OF SUPERVISING INSTITUTIONS AND BODIES

Mr Philippe Agard, Sorbonne Université

Ms Élisabeth Angel-Perez, Sorbonne Université

Mr Maximilien Cazayous, Université Paris Cité

Ms Nathalie Eisenbaum, Université Paris Cité

Ms Alessandra Sarti, CNRS

## CHARACTERISATION OF THE UNIT

Name: Institut de Mathématiques de Jussieu – Paris Rive Gauche

- Acronym: IMJ-PRG
- Label and number: UMR7586
- Composition of the executive team: M. Olivier Biquard, director, M. Laurent Desvillettes, deputy director, (replaced on September 1, 2023 by Mrs Claire Debord)

## SCIENTIFIC PANELS OF THE UNIT

ST Sciences et technologies

ST1 Mathématiques

## THEMES OF THE UNIT

Members of the unit work on most themes within "fundamental" mathematics. Referring to the twenty thematic sections defined for the ICM 2022 ([https://www.mathunion.org/fileadmin/IMU/Publications/CircularLetters/2019-2020/IMU%20AO%20CL%2012\\_2020\\_ICM2022\\_structure.pdf](https://www.mathunion.org/fileadmin/IMU/Publications/CircularLetters/2019-2020/IMU%20AO%20CL%2012_2020_ICM2022_structure.pdf)), IMJ-PRG has very active teams in most of the sections: Logic, Algebra, Number theory, Algebraic and Complex Geometry, Geometry, Topology, Lie Theory and Generalizations, Analysis, Dynamics, Partial Differential Equations, Combinatorics, and History of Mathematics. In addition, the unit also has activity relative to other sections, although larger teams can be found in other research units with the same supervising institutions: Mathematical Physics, Probability, Control Theory and Optimization, Statistics and Data Analysis.

Only a few sections are not represented, again because they are the focus of other research units with the same supervising institutions (namely "Laboratoire Jacques-Louis Lions", "Laboratoire de Probabilités, Statistique et Modélisation", "Institut de Recherche en Informatique Fondamentale"). Numerical Analysis and Scientific Computing, Stochastic and Differential Modeling, Mathematical Education and Popularization of Mathematics is actively pursued at IMJ-PRG but more as a practice than as the subject of research.

## HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

The teams of IMJ-PRG perform research in most aspects of fundamental mathematics, from dynamical systems to algebraic geometry or combinatorics. With a total of 382 members, including 193 researchers and faculties members on permanent positions, eleven staff members as well as 110 PhD candidates and dozens of postdocs. It is the largest research units in mathematics in France, and probably one of the largest in the world.

The unit has two distinct locations, one in the Jussieu Campus (Sorbonne Université), the other in the Paris Rive Gauche campus (Université Paris Cité). It was created in 1994 as the "Institut de Mathématiques de Jussieu", bringing together research teams in fundamental mathematics affiliated to two universities, Université Paris 6 (Pierre et Marie Curie) and Université Paris 7 (Université Paris Diderot) which were then both located on Campus Jussieu. In 1999, IMJ moved out to a temporary location at rue du Chevaleret because intensive work had to be done on Campus Jussieu. In 2010, the part of IMJ attached to the Université Pierre et Marie Curie (now part of Sorbonne Université) moved back to Jussieu, while in 2013 the part attached to the Université Paris Diderot (now part of the Université Paris Cité) moved to a new location on the Paris Rive Gauche campus. This explains the current name, "IMJ-PRG", as well as the two locations.

## RESEARCH ENVIRONMENT OF THE UNIT

IMJ-PRG is supervised by two large universities installed within Paris, the Sorbonne Université (which includes in particular the former teams of the Université Pierre et Marie Curie -- Paris 6) and the Université Paris Cité (with the former teams of the Université Denis Diderot -- Paris 7). The third supervising institution is the CNRS, and the members of IMJ-PRG on permanent positions are mostly affiliated with the Sorbonne Université (77 faculty, 1 support staff at the end of 2022), the Université Paris-Cité (71 and 2) and the CNRS (38 researchers, 8 support staff). In addition, IMJ-PRG benefits from a partnership with Inria, which supports one team with four Inria researchers.

Within Paris, IMJ-PRG has a clear complementarity with two large research units with the same supervising institutions: the "Laboratoire Jacques-Louis Lions (LJLL)", which focuses on fundamental, applied and numerical aspects of partial differential equations, and the "Laboratoire de Probabilités, Statistique et Modélisation (LPSM)", which covers probabilities and statistics. IMJ-PRG therefore has a somewhat restricted focus in the area of Partial Differential Equations and probabilities. The unit also has close connections with the "Institut de Recherche en Informatique Fondamentale (IRIF)", a large research unit in fundamental aspects of Computer

Science supervised by the Université Paris-Cité and the CNRS, in which several teams are working on topics close to those of IMJ-PRG.

Still within Paris, IMJ-PRG has close relations with the other research units active on fundamental aspects of mathematics, in particular with the Department of Mathematics and Applications (DMA) of the ENS-PSL, where four members of IMJ-PRG are currently detached on temporary positions (at most 10 years) following a long-standing agreement. The unit also has close connections with LAGA (at the Université Sorbonne Paris Nord). Within the larger Paris area, IMJ-PRG also has close relationships with other mathematics departments in several universities, including joint seminars and collaboration for master and doctoral education.

IMJ-PRG is a central and leading node in the highly integrated network of mathematics departments in France. It benefits regularly from incoming mobility, often from other institutions in France, both at the "junior" level (maître de conférences, chargé de recherche) and at the "senior" level (professeur, directeur de recherche). It also contributes considerably to the healthy development of mathematics departments throughout France thanks to the outward mobility of its recent PhDs, postdocs and junior researchers, who often take on junior or senior positions in France. The "mobility rule", which has been implemented since several decades in French mathematics, plays a large role. Finally, IMJ-PRG is increasingly integrated in the international mathematical community, with increasing incoming and outgoing mobility of its permanent and non-permanent members in Europe and beyond. Integration in the international mathematical community also takes the form, of course, of multiple collaborations and joint publications.

Within the Paris region, IMJ-PRG benefits from the support of the "Fondation Sciences Mathématiques de Paris (FSMP)" which in particular regularly funds PhD and postdoc positions in the unit, as well as scholarships for master students. It has also a close relationship with the "Institut Henri Poincaré (IHP)", where members of IMJ-PRG regularly co-organize programs and with which are often affiliated.

The unit is within the perimeter of two Idex projects: *Alliance Sorbonne Université* and *Idex Université Paris Cité*, centered on its two supervising universities, which provide additional support through their various programs. It is moreover related to a number of structures coordinating mathematical research or outreach to industry, such as SUMMIT (*Maison des modélisations, Ingénieries et Technologies*) or the *Domaine d'Intérêt Majeur (DIM) Math Innov (2017-2022)*.

The unit also benefits from a steady stream of external funding, which has significantly increased in the period under observation. Over the period, more than 14M€ were obtained from European programs (in particular through 10 ERC grants already active and 8 ERC grants obtained over the period), 2.8M€ from national funding sources such as ANR, and over 600k€ from regional funding or industrial collaboration (to be compared with the less than 4M€ of funding for operational expenses received from the supervising institutions over the same period).

## UNIT WORKFORCE: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	56
Maîtres de conférences et assimilés	95
Directeurs de recherche et assimilés	21
Chargés de recherche et assimilés	21
Personnels d'appui à la recherche	11
<b>Sous-total personnels permanents en activité</b>	<b>204</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	47
Personnels d'appui non permanents	1
Post-doctorants	20
Doctorants	110
<b>Sous-total personnels non permanents en activité</b>	<b>178</b>
<b>Total personnels</b>	<b>382</b>

DISTRIBUTION OF THE UNIT'S PERMANENTS BY EMPLOYER: in physical persons at 31/12/2022. Non-tutorship employers are grouped under the heading "others".

Nom de l'employeur	EC	C	PAR
SORBONNE UNIVERSITÉ	77	0	1
UNIVERSITÉ PARIS-CITÉ	71	0	2
CNRS	0	38	8
INRIA	0	4	0
<b>Total personnels</b>	<b>148</b>	<b>42</b>	<b>11</b>

## GLOBAL ASSESSMENT

IMJ-PRG is an outstanding research unit, playing a leading role in the development of mathematics at the international level. It hosts a significant number of leading researchers in mathematics. The contributions of IMJ-PRG to mathematics over the assessment period are considerable, and well above what could be expected from its size alone -- more than 5% of the articles published in the five most prestigious math journals in the period have authors at IMJ-PRG. Over the same period, IMJ-PRG researchers published hundreds of articles in other highly selective mathematics journals beyond those five. This exceptional production clearly puts IMJ-PRG among the handful of leading research centers in fundamental mathematics worldwide. Its leading role was again confirmed recently by the Crafoord prize and the Abel prize bestowed on a current and on an emeritus member of the unit.

The research activity of IMJ-PRG covers most of the main fields of fundamental mathematics, with a stronger focus on some areas, for instance Algebraic Geometry, Number Theory, Representation Theory, Complex Geometry, Dynamical Systems, Algebraic Topology, Symplectic Topology, Banach Algebras, Lie Groups and Symmetric Spaces, mathematical logic, as well as their relations. Breakthroughs have been obtained, in the evaluation period, in each of those fields, or at the interface between several of them. The unit also has a central role, at the international level, in the history of mathematics.

Any choice among those outstanding results is somewhat arbitrary. Among the many results stemming from IMJ-PRG at the frontline of international research, we quote a few articles, to show the broadness of the topics in which major advances were achieved.

- *Uniformity in Mordell–Lang for curves* improves on Mordell's conjecture (proved by Faltings) by proving a conjecture of Mazur for the number of rational points on a curve of genus at least two over a number field.
- *Topological Hochschild homology and integral p-adic Hodge theory* is a milestone in integral p-adic Hodge theory, preparing for a follow-up by two of the authors, which introduces a new cohomology theory on p-adic schemes.
- *Infinite-dimensional Polish groups and Property (T)* answers a question of Tsankov: every Roelcke precompact Polish group  $G$  possesses Kazhdan's Property (T). The proof ingeniously employs tools and concepts from continuous logic.
- *Geometrization of the local Langlands correspondence* has precipitated a paradigm shift in our understanding of the link between the arithmetic Langlands program and its more geometric analogues.
- *Cohomology of p-adic Stein spaces* is the starting point of an impressive series of papers presenting computations of p-adic étale cohomology hinting at future formulations of the p-adic Langlands program.
- *Gevrey stability of Prandtl expansions for 2-dimensional Navier-Stokes flows* addresses the long standing question of the validity of the Prandtl expansion (1904) in the boundary layer of a Navier-Stokes flow, by showing its stability with respect to a previously unexplored class of perturbations.

The development of IMJ-PRG over the period has been driven by the ambition to maintain a leading position in key areas of mathematics, such as those mentioned above, while at the same time developing expertise in well-chosen areas, e.g. Geometric Combinatorics. This policy was implemented thanks to the successful recruitment of a number of outstanding researchers, both at the "junior" (maître de conférences, CR) or "senior" (professor, DR) levels. These recruitments compensated, over the assessment period, for the departure of several high-profile researchers, who either retired or accepted positions abroad.

However, the Committee noted that the next five years will see a number of particularly outstanding researchers reach retirement age. These future departures represent a major challenge for IMJ-PRG in the

face of an increasing international competition. The supervising institutions will play an important role in supporting IMJ-PRG in this respect.

IMJ-PRG suffers from a severe gender imbalance, particularly among its senior members. The Committee however noted that significant efforts have resulted in relatively balanced recent hires. Fundamental mathematics remains one of the least balanced fields, and further efforts will be needed to progressively improve it at IMJ-PRG.

Beyond research, IMJ-PRG members displays a remarkable level of activity in doctoral training, teaching, scientific communication towards the general public -- and specifically towards secondary school students -- and even in outreach towards industry.

In addition to its research teams, the unit includes an Inria project-team, Ouragan, focused on algebraic resolution tool for geometry and its applications. The members of Ouragan are also members of one of the teams of IMJ-PRG, and their scientific interests cover different branches of mathematics.

# DETAILED EVALUATION OF THE UNIT

## A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

*"L'IMJ-PRG produit des mathématiques exceptionnelles depuis sa création. Le comité d'experts ne peut que recommander de continuer dans la même direction."*

The committee considers that IMJ-PRG has indeed continued, over the period of observation, to produce outstanding mathematics.

*"L'IMJ-PRG est une structure complexe et peut-être instable. Il faut le consolider en créant des événements transversaux et des séminaires généralistes bien visibles. De manière générale, toute action commune peut solidifier l'ensemble."*

The unit has set up an information system so that its members can be informed easily of all scientific activities. It also organizes an annual meeting day, where incoming members present their research, and a monthly colloquium. Those initiatives clearly go in the right direction.

*"L'IMJ-PRG est l'héritier d'une longue tradition d'excellence et doit prendre conscience que cette excellence « ordinaire » peut fragiliser les jeunes recrutés de l'unité. Les équipes doivent être particulièrement vigilantes sur ce point et leur apporter toute l'aide et le soutien nécessaire, en particulier pour préparer une HDR."*

During the period considered, 25 *Habilitations* have been defended, a significant number. During meetings with representatives of the "rang B", the committee was informed that significant efforts are made to support younger researchers working towards their *Habilitation*. The committee therefore considers that sufficient action was taken on this recommendation.

*"Le comité d'experts encourage l'IMJ-PRG à étudier toutes les possibilités qui pourraient lui permettre de recruter un informaticien supplémentaire."*

Currently, IMJ-PRG has a team of two IT support staff on permanent positions, and is also supported by one apprentice. Members of IMJ-PRG confirmed to the committee that this support team is sufficient to fulfill its role, although in some teams computer support seems to be also to some extent provided by mathematicians helping one another. Adding further IT support staff might not currently be a priority, given the need for additional administrative support.

*"Le comité d'experts encourage une réflexion sur le rôle du comité de prospective. Ne devrait-il pas réfléchir aux thèmes émergents ou au contraire en disparition ? Ne pourrait-il pas anticiper les départs à la retraite plusieurs années à l'avance, en cherchant activement des remplaçants potentiels ?"*

The Prospective and Recruitment Committee appears to play a large role in the recruitments at the Sorbonne Université, especially at the professor level, and also on the selection among the newly recruited CNRS staff interested in joining IMJ-PRG. The committee was convinced that the Prospective and Recruitment committee plays a significant role in actively searching for potential future recruitments.

*"L'IMJ-PRG reçoit un très grand nombre de demandes de mutations de DR qui ne peuvent bien entendu pas être toutes acceptées. Il est souhaitable que des critères objectifs soient mis en place par le comité de prospective."*

The Prospective and Recruitment committee plays a well-defined role in advising the management of IMJ-PRG on which applications are to be supported. It also appears that the number of applications of CNRS researchers willing to join IMJ-PRG has significantly decreased, a fact that can be explained by the cost of living in the center of Paris.

The following was not formally a recommendation of the previous report, but was considered as such in the SAD<sup>1</sup>.

*"La structure [du laboratoire] est complexe, satisfaisante sous de nombreux aspects, mais loin d'être optimale, parfois incohérente, et souvent impénétrable vue de l'extérieur... Le comité d'experts encourage vigoureusement l'IMJ-PRG à mettre en place une réflexion sur cette question."*

As mentioned in the SAD (p. 18) the unit has decided to not act on this recommendation. However, the committee considers that a partial re-organization would be welcome. Although the internal organization of the unit might not be particularly important for staff on permanent positions who already know the unit well

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<sup>1</sup> Self-Assessment Document



from inside, it is quite relevant for incoming PhD candidates or postdocs who would more easily and faster find the right seminars or contact points with a more logical internal structure.

## B - EVALUATION AREAS

### EVALUATION AREA 1: PROFILE, RESOURCES AND ORGANISATION OF THE UNIT

#### Assessment on the scientific objectives of the unit

The unit has a well-defined profile, with a clear focus on fundamental aspects of mathematics. There is therefore a clear complementarity between the *Laboratoire Jacques-Louis Lions* (LJLL), which is centered on pure and applied aspects of partial differential equations, and the *Laboratoire de Probabilités, Statistiques et Modélisation* (LPSM), which has a focus on probability and statistics.

Within the period considered, the unit has successfully maintained its prominent position at international level in some key areas of contemporary mathematics, while at the same time developing expertise in new topics (such as geometric combinatorics) thanks to the recruitment of leading researchers.

#### Assessment on the unit's resources

The main resources of IMJ-PRG are the positions of faculty and researchers provided by its supervising institutions. The unit is well endowed in this respect, currently with 148 faculty positions either at the Sorbonne Université or at the Université Paris-Cité (with a relative equilibrium between the two) and 42 positions of researchers (mostly CNRS, except four positions from Inria).

The administrative and IT support is quite limited, with currently eleven staff members, among whom eight only for administrative support. This level of administrative resources appears somewhat limited, in particular in view of the increasing role of externally-funded grants, which create specific needs.

Financial resources for operational expenses, between 600 and 700k€ annually appear modest but sufficient, partly thanks to the already mentioned externally-funded grants. A risk however exists since this budget will be reduced in the near future (following a reduction by the Université Paris Cité of its operational expenses) leading to restriction in travels and invitations that would be detrimental to the unit.

The committee noted positively the significant increase of external funding obtained by members of the unit in the period considered, compared to the previous period. The success in obtaining ERC and ANR grants (10 ERC grants active and 8 obtained over the period, coordination of 14 ANR projects and participation in 11 others) has led to a significant increase in the number of postdoctoral researchers, and has also funded directly or indirectly some of the scientific activities.

#### Assessment on the functioning of the unit

The unit appears to function in a rather harmonious manner, and the committee did not perceive any significant criticism from its members on the way it is organized. The main scientific orientations are decided by the management team of the unit, in coordination with the *Conseil de laboratoire* and the Prospective and Recruitment Committee, which has a specific role in identifying potential future recruitments. Many practical decisions are taken at the level of the teams, which also play a key role in the scientific activities organized at IMJ-PRG.

During the on-site visit, the committee noted significant issues within the administrative support team. The situation of administrative services must be stabilized. Departing members of the team need to be replaced. With the arrival of the new general secretary ("secrétaire général"), a reorganization seems essential.

## *1/ The unit has set itself relevant scientific objectives.*

### Strengths and possibilities linked to the context

The unit's teams cover most of the spectrum of "fundamental" mathematics, with emphasis on some topic. Its scientific objective is to contribute in a major way to the development of contemporary mathematics. This objective is highly relevant in view of the current development of fundamental mathematics. Referring to the 20 thematic sections defined for ICM 2022

([https://www.mathunion.org/fileadmin/IMU/Publications/CircularLetters/2019-](https://www.mathunion.org/fileadmin/IMU/Publications/CircularLetters/2019-2020/IMU%20AO%20CL%2012_2020_ICM2022_structure.pdf)

[2020/IMU%20AO%20CL%2012\\_2020\\_ICM2022\\_structure.pdf](https://www.mathunion.org/fileadmin/IMU/Publications/CircularLetters/2019-2020/IMU%20AO%20CL%2012_2020_ICM2022_structure.pdf)), IMJ-PRG has very active teams in most of the sections : Logic, Algebra, Number theory, Algebraic and Complex Geometry, Geometry, Topology, Lie Theory and Generalizations, Analysis, Dynamics, Partial Differential Equations, Combinatorics, and History of Mathematics. In addition, the unit also has activity relative to other sections, although larger teams can be found in other research units with the same supervising institutions: Mathematical Physics, Probability, Control Theory and Optimization, Statistics and Data Analysis.

In the period under consideration, the unit strived, quite successfully, to maintain its level of excellence in its core topics, including algebraic geometry, automorphic forms, number theory, representation theory, complex geometry, dynamical systems, algebraic topology, symplectic geometry, Banach algebras, Lie Groups and symmetric spaces. At the same time, it aimed at developing new areas of research. This was done quite successfully in some new fields, such as geometric combinatorics.

### Weaknesses and risks linked to the context

The main risk identified by the committee is the high number of retirements of outstanding or even world-leading mathematicians in the next 5-year period. It will certainly be challenging for the unit to replace them all at the same level of excellence, since positions in Paris are not, due to the cost of living, necessarily very attractive.

The internal organization of the unit in teams does not appear to be based entirely on a scientific and thematic logic -- historical development appears to be relevant, too. While some of the teams have a very clear thematic focus, others cover a number of loosely related topics, while some closely related topics appear in different teams. One team in particular (Combinatorics and Optimization) appears to have two subteams with no clear relation between the two.

## *2/ The unit has resources that are suited to its activity profile and research environment and mobilises them.*

### Strengths and possibilities linked to the context

The resources of the unit appear broadly adequate. The number of faculty and researcher positions is significant, with a relative balance between "junior" (maître de conférences, chargé de recherche) and "senior" (professor, directeur de recherche) positions. The budget for operational expenses is currently sufficient to cover the needs thanks to the additional contribution of external grants. Finally, the external funding (especially ANR, ERC) has increased significantly during the period considered and is now at a satisfactory level, with over 14 million Euros funded over the period through European and international calls, 3.335M€ through regional and national calls, and 128k€ through partnerships.

### Weaknesses and risks linked to the context

The level of administrative support is barely sufficient in view of the increasing number of externally-funded grants. It is a serious weakness and will need to be increased in the near future. This increase could be either through new administrative support positions provided by the supervising institutions, or through new positions funded by external grants. One difficulty in this case is that temporary positions (CDD) might not be attractive enough to allow for the recruitment of skilled staff.

There is a clear risk due to the reduction of the budget for operational expenses, following the decision by the Université Paris Cité to reduce by 20% the budgets of all of its units. Such a reduction will be detrimental to the activities of the unit, and should hence be compensated either by additional contributions of other supervising institutions (Sorbonne Université, CNRS, possibly Inria) or by additional externally-funded projects.

Within the unit, collective tasks and administrative responsibilities are shared in a way that does not appear well balanced, with a number of senior CNRS researchers who could assume more responsibilities pertaining to the unit.

During the on-site visit, it was noted that the allocation of CNRS and Inria researchers between the two locations was unbalanced, in particular at the level of directeurs de recherche. A better balance could be beneficial to the scientific activity of the unit. Although it could be reached naturally with the coming retirements, the committee encourage the unit to have a proactive role on it.

*3/ The unit's practices comply with the rules and directives laid down by its supervisory bodies in terms of human resources management, safety, environment, ethical protocols and protection of data and scientific heritage.*

### Strengths and possibilities linked to the context

The unit does appear to comply with all rules and directives in terms of human resources management. IMJ-PRG has a specific committee in charge of environmental issues, which has performed a broad analysis of the environmental impact of the unit, and proposed practical ways to mitigate this impact.

The unit has set up a parity committee, in charge of ensuring gender equity in all aspect of the unit's activities, and in particular in recruitments. The actions of this parity committee, as well as specific efforts made in the recruitments, have been successful in raising the proportion of women among newly recruited members of IMJ-PRG.

The other criteria here -- safety, ethical protocols, data, scientific heritage -- appear to be only tangentially applicable to a unit focused on fundamental aspects of mathematics,

### Weaknesses and risks linked to the context

As most units focused on mathematics, and specifically on fundamental aspects of mathematics, IMJ-PRG is severely unbalanced in terms of gender, with only 11% of women among professors, 18% among maîtres de conférences, 32% among directeurs de recherche, and 16% among chargés de recherche.

In spite of significant and successful efforts made in recent years, which led to much better balance among newly recruited members, it will take time and efforts to reach a relatively balanced demographics. This is underlined by the fact that only 15% of PhD candidates are women, again in spite of significant efforts made to encourage more women to start PhDs.

In 2021, a survey was organized by two PhD students to gain a better insight into sexual harassment and discrimination within the unit. The survey was an effective information tool, as it clearly defined behaviors that could be considered sexual harassment or discrimination. Among the responses, one person reported having been a victim of sexual harassment. In addition, this person and another indicated that they had witnessed sexual harassment. The three reported cases could be indicative of a more widespread problem: in many cases, with the exception of a few extremely serious cases and despite the willingness of unit governance to be proactive, such episodes go unreported for many reasons, including a sense of being able to overcome the offence on one's own or fear of reprisals. The absence of a clearly identified member (or group of members) who can assist the victim in the process and, if necessary, inform her of the steps she can take, could be a problem for the unit.

The integration of PhD candidates in their team is still limited. Some PhD candidates are during most of the time of their PhD located in a specific corridor, and therefore have only limited opportunities to interact with researchers on permanent positions beyond their adviser.

## EVALUATION AREA 2: ATTRACTIVENESS

### Assessment on the attractiveness of the unit

The unit is attractive thanks to the recognized excellence of its members and, as a consequence, through the quality of the scientific activities it offers, such as seminars, reading groups, and generally interaction with remarkable colleagues. Its dazzling international recognition is confirmed by the Crafoord and Abel prizes recently awarded to two IMJ-PRG members.

In addition, CNRS positions can be attractive to researchers who intend to avoid teaching. However it appears clearly that other aspects of the positions are far from attractive in comparison to what is offered in other European or North American (or even now Chinese) universities, such as salaries or funding opportunities. While it is completely normal that members of the unit on "junior" positions (CR, MCF) leave to take a senior position elsewhere, the unit has also seen in the assessment period a steady flow of "senior" members taking positions abroad, and this includes some of its most active researchers. Attracting and retaining excellent mathematicians is likely to be a challenge for the next five years.

- 1/ The unit has an attractive scientific reputation and is part of the European research area.*
- 2/ The unit is attractive because for the quality of its staff support policy.*
- 3/ The unit is attractive through its success in competitive calls for projects.*
- 4/ The unit is attractive for the quality of its major equipment and technical skills.*

#### Strengths and possibilities linked to the context for the four references above

The most attractive feature of the unit is clearly its scientific reputation, scientific production, as well as the level of scientific activities such as seminars, reading groups, and the possibility to interact with outstanding colleagues.

Another important element is the possibility of obtaining teaching reductions, in the form of "délégations CNRS" or "CRCT", for which members of IMJ-PRG appear to be well supported. This is particularly important for junior members when they need more time to finalize their Habilitation. Over the period, 38 members of IMJ-PRG have obtained a "délégation CNRS".

The budget available to members of IMJ-PRG, 600-700k€/year provided by the supervising institutions, appears sufficient. This budget is complemented by a much larger amount obtained by competitive funding from European sources, in particular from the ERC (10 ERC grants were active in the period, and 8 new ERC grants were obtained), with a total of over 14 million Euros obtained from European and international sources in the period. National and regional funding also contributed, with over 3.3 million Euros in the period, while the contribution of partnership, at 128k€, was more modest but still remarkable for a research unit in fundamental mathematics.

The administrative support provided by the unit is generally considered as satisfactory by the unit members, but it will need to be strengthened, in particular in view of the increasing number of externally-funded grants that need to be administered and require reporting. Moreover during the on-site visit the committee noted a number of issues within the administrative support team, which should be resolved by an ongoing re-organization.

The IT support was also considered as satisfactory by the unit members, in spite of a small team.

IMJ-PRG appears attractive for incoming PhD candidates and postdocs thanks to the robust scientific activity and the international visibility of its members and of their results. The professional outcomes of recent PhDs and postdocs, although not entirely specified in the self-assessment report, appears to be remarkable.

#### Weaknesses and risks linked to the context for the four references above

As mentioned above, the positions offered in the unit are not competitive internationally in terms of salary or availability of research funding. It should be noted that, in the period considered, a number of senior members of the unit (including some with an exceptional level of scientific activity) took positions abroad, either in Europe, in North America, or in three cases in China. Although a certain level of outwards mobility is normal and even healthy, the number of members of IMJ-PRG who left to take positions abroad can be considered as a risk.

The administrative support team will need to be strengthened to provide a proper level of administrative support to the unit researchers, in particular for the management of large externally funded grants.

During interviews with members of the unit, it was often repeated that ongoing issues with the new tools set up by CNRS to handle travel were a constant source of frustration and irritation, and contributed negatively -- and significantly -- to the attractiveness of the unit. Let us mention that essentially the totality of the budget of the unit is managed by CNRS, so these difficulties are impacting the entire unit, not only its CNRS employees.

The problems with the new CNRS tools are only a part of a broader issue, that is the administrative burden imposed on the researchers. Several examples of travels that were not made or invitations that failed due to

the length and rigidity of administrative procedures were reported to the committee. Travel and invitations are part of the research process in mathematics, as can be seen from the list of authors in the portfolio papers. Therefore, such situations are highly problematic, and represent a risk for the scientific activity of the unit. Needless to say, they also represent a risk to its global attractiveness. The PhD candidates in the unit appear well informed of the possibilities -- and challenges -- of professional development in the academic sector, but much less of possible non-academic directions.

### EVALUATION AREA 3: SCIENTIFIC PRODUCTION

#### Assessment on the scientific production of the unit

The unit has obtained during the period under consideration a remarkable number of truly excellent results in various areas of mathematics. Over the assessment period, members of IMJ-PRG have solved long-standing questions in key areas of mathematics, explored new directions of research, invented new paradigms that appear very promising.

The quality of those results can be seen through a number of indicators that are well-established in mathematics. For instance, members of the unit have published in the reference period over 50 articles in the five leading journals in mathematics (Acta mathematica, Annals of Mathematics, Inventiones Math., Journal of the Amer. Math. Soc., Publications IHES). Over the same period, those very selective journals published a total of 916 articles. A simple count shows that the role of IMJ-PRG in the production of outstanding results in fundamental results is considerable: well over 5% of articles in fundamental mathematics in those top journals (which also publish articles outside the scope of IMJ-PRG) have at least one author from IMJ-PRG. Moreover, hundreds of articles were published in the same period by IMJ-PRG members in leading mathematics journals beyond those "top 5". This share of international research is far greater than could be expected given the size of the unit.

- 1/ The scientific production of the unit meets quality criteria.*
- 2/ The unit's scientific production is proportionate to its research potential and properly shared out between its personnel.*
- 3/ The scientific production of the unit complies with the principles of research integrity, ethics and open science. It complies with the directives applicable in this field.*

#### Strengths and possibilities linked to the context for the three references above

The scientific production of the unit over the assessment period is outstanding. In total, more than 1200 articles have been published by IMJ-PRG members, a sufficient number in the field of fundamental mathematics. Hundreds of those articles were published in some of the highly selective journals in mathematics, and over 50 were published in the five most selective journals in the field. Over the same period, those five journals published a total of 916 articles, so the share of IMJ-PRG is quite remarkable.

Moreover, hundreds of articles were published in the same period by IMJ-PRG members in leading mathematics journals beyond those "top 5".

Most of the members of IMJ-PRG contribute to this scientific production, and even the publications in the most selective journals are split among a fairly large number of members of the unit.

The vast majority of the scientific production of the unit appears first on the arXiv platform, as it is customary in mathematics.

Since the unit is focused primarily on fundamental mathematics, the committee could not identify any issue related to the data availability or any research integrity or ethical issue.

#### Weaknesses and risks linked to the context for the three references above

As in almost any mathematics department, a very small minority of IMJ-PRG members had no publication activity in the period. A more detailed analysis shows that some of those members have a regular research activity and contribute to the scientific life of the unit, while very few have no apparent research activity.

IMJ-PRG and its team have set up a number of activities designed specifically to encourage the non-publishing members of the unit either to re-start a research activity, or to orient their existing research activity in

a way that can lead to publications. In a number of cases, those activities were successful and some members of the unit resumed research or publishing over the period.

## EVALUATION AREA 4: CONTRIBUTION OF RESEARCH ACTIVITIES TO SOCIETY

### Assessment on the inclusion of the unit's research in society

The unit has very significant activities, of different types, towards society.

Although its focus is on fundamental mathematics, it had during the evaluation period a number of partnerships with industry. A central role is played in this partnership activity by the Ouragan team. In addition to two industrial contracts, two PhD theses in co-supervision with private companies (CryptoExperts and Safran) were funded by Cifre contracts.

Members of IMJ-PRG were also active participants in ongoing societal debates on important topics. They took an active part in communicating science to the general public, and in particular to elementary and secondary school students.

- 1/ The unit stands out for the quality and the amount of its interactions with the non-academic world.*
- 2/ The unit develops products for the cultural, economic and social world.*
- 3/ The unit shares its knowledge with the general public and takes part in debates in society.*

Strengths and possibilities linked to the context for the three references above

The unit has, given its focus on fundamental mathematics, a significant number of partnerships with companies, including through the supervision of PhDs funded by Cifre contracts. Some of its members are actively participating in societal debates in questions involving mathematics in one way or another.

The Ouragan team is clearly an asset for the partnership activity of the unit, and most relations with industrial partners goes through Ouragan.

Many members of IMJ-PRG are regularly taking part in many science communication towards the general public, thus contributing to increase awareness of the importance of mathematics research in the general public, as well as interest in mathematics, including among high-school students. One can mention for instance science communication events such as the *Fête de la science*, *MathPark*, *Animath*, *Math.en.Jeans*, and many others. One member is particularly active as the president of *Animath*, an association that plays a central role in mathematics education in France through the organization of math competition to which 100 000 students participate each year.

Weaknesses and risks linked to the context for the three references above

The Committee did not identify any weaknesses in these areas.

## ANALYSIS OF THE UNIT'S TRAJECTORY

IMJ-PRG has been, since its creation in 1994 as *Institut de Mathématiques de Jussieu*, one of the largest and strongest research units in mathematics in France and worldwide. During the assessment period, it has managed to maintain its level of scientific excellence and continues to play a leading role in research on fundamental aspects of mathematics at the international level, as evidenced by the large number of articles published by its members in the most selective mathematical journals.

While IMJ-PRG has maintained its prominence in a number of key research areas in fundamental mathematics, it has also managed to open new directions of research in some fields such as geometric combinatorics.

Over the evaluation period, a number of particularly active members of IMJ-PRG have left the unit, either to retire or to take positions in other institutions. Those departures have been compensated by high-level recruitments. Moreover, the new recruitments have better gender balance than the members of IMJ-PRG as a whole.

In the next five years, a very significant number of highly active members of IMJ-PRG will retire. The main challenge for the unit will be to attract enough outstanding mathematicians to replace them at the same level of excellence.



## RECOMMENDATIONS TO THE UNIT

### Recommendations regarding the Evaluation Area 1: Profile, Resources and Organisation of the Unit

The internal organization of the unit in teams is partly outdated and should be reconsidered, possibly on a regular basis. Although some teams have a very clear and well-identified focus, other teams appear to merge topics without clear connection, while some topics are spread between different teams.

The unit should continue the effort already started to better integrate PhD candidates in their teams, in particular by having their offices within the same physical space as the rest of the team, but also by including them more systematically in informal social activities (such as lunch with team members), so as to foster scientific exchanges between PhD candidates and more senior IMJ-PRG members, beyond their supervisors.

During the assessment period the unit has considerably increased its external funding. It should continue and extend this effort, both towards European funding (such as those of the ERC) and national ones (such as ANR). A high level of administrative support for grant application and grant management should be provided.

Specific efforts should be made to prevent and address the issue of sexual harassment and discrimination. The governance of the unit has signaled their willingness to act upon it, an attitude that the committee favorably acknowledges. While victims of sexual harassment and discrimination should be addressed to the relevant teams within the supervising universities, the governance of the unit is encouraged to bring to the Conseil de Laboratoire the issue of information and prevention of sexual harassment and discrimination, and to come up with concrete measures. In particular, a member of the laboratory (or a group of members) should be appointed to assist with these issues.

In addition to informing about sexual harassment and discrimination, it would be informative and useful -- and in fact expected by many of the PhD candidates and postdocs -- to repeat the 2021 poll, so as to assess the current situation with respect to sexual harassment and discrimination within the unit.

The unit should take advantage that SU, UPC and CNRS have identified instances and have defined actions to tackle the problem. It should coordinate with them to take the most appropriate steps in order to obtain maximum efficiency. It could also take an inspiration from what is done abroad, such as online modules (possibly mandatory for all members of the unit) presenting different situations of sexual harassment and discrimination, or awareness speeches given at the beginning of the year in a course followed by most students. Parallel to that, in order to increase awareness of this issue, and to grasp the full measure of the problem, the unit should organize regularly a poll on this topic, similar to the poll organized by PhD candidates. We believe that such actions will significantly increase the global awareness of the unit in order to create a better working environment for women, which in turn will increase the attractiveness of the IMJ-PRG for young female students and early-stage researchers.

The unit should continue its efforts towards a relative gender balance in its recruitments, by identifying and attracting outstanding female candidates whenever possible on all positions, from PhD to professor/DR, with a particular emphasis on professor positions, where the imbalance is greatest. Specific efforts should also be made to attract outstanding students, PhD candidates and postdocs. IMJ-PRG is in a better position to succeed in this respect than other research units, thanks to its reputation for excellence.

Administrative responsibilities should be shared in a more balanced manner among members of the unit, and in particular among those who are at a later stage of their career.

### Recommendations regarding the Evaluation Area 2: Attractiveness

The Prospective and recruitment committee should consult the active members of the unit, and in particular the team coordinators, so as to make the best use of the expertise within IMJ-PRG and to be able to best identify important directions of development and potential candidates for future positions.

The Prospective and Recruitment Committee should have a well-defined role also in the definition of profiles and the identification of outstanding candidates for positions opened at U. Paris-Cité.

The unit should make sure that its PhD candidates are well informed of possible non-academic career directions. In addition to information, it could provide them with networking opportunities, for instance with former PhDs working outside academia.

### Recommendations regarding Evaluation Area 3: Scientific Production

The unit should continue, and possibly extend to all teams, the ongoing efforts to help and encourage the small minority of non-publishing members to resume publishing and if necessary, a research activity.

### Recommendations regarding Evaluation Area 4: Contribution of Research Activities to Society

Outreach activities towards the general public, and specifically towards high-school students, should (even more) strongly take into account gender issues. In particular they should aim at counterbalancing gender stereotypes related to mathematics and attract more excellent female students towards the study of mathematics.

## TEAM-BY-TEAM OR THEME ASSESSMENT

**Team 1:** Analyse algébrique (AA)

Name of the supervisor: Mr François Loeser

### THEMES OF THE TEAM

The research activities of the "Analyse algébrique" team are organized around five thematic areas: dynamical systems; enumerative, tropical and symplectic geometry; microlocal geometry, homotopic methods and motivic geometry; algebra and Lie theory; geometry and groups.

### CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

Overall, the recommendations have been well taken in consideration. The team started a general seminar "Géométrie et topologie" with the team "Analyse complexe et géométrie" replacing the specialized one "Analyse algébrique" and "Géométrie hamiltonienne". New hirings moreover reinforced the link with the team "Géométrie et dynamique" and new collaborations started with the team "Topologie et géométrie algébrique".

### WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	8
Maîtres de conférences et assimilés	15
Directeurs de recherche et assimilés	3
Chargés de recherche et assimilés	3
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>29</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	2
Personnels d'appui non permanents	0
Post-doctorants	7
Doctorants	13
<b>Sous-total personnels non permanents en activité</b>	<b>22</b>
<b>Total personnels</b>	<b>51</b>

### EVALUATION

#### Overall assessment of the team

The scientific production of the team is of excellent quality. Among the many results obtained within the team, some of which have already been mentioned in the general assessment, we recall here just a few. First, the remarkable work on real Gromov-Witten theory, some orientability issues to extend Gromov-Witten theory have been overcome, in order to get applications to real enumerative geometry. We mention also the examples showing how the Arnold conjecture concerning fixed points of Hamiltonian diffeomorphisms cannot be extended naively to the continuous setting, and the proposals for new meaningful extensions.

We mention also the proof of the Fried conjecture in dimension 3, relating Reidemeister torsion and the value of the Ruelle zeta function at 0.

A further indication is the remarkable scientific output, with five preprints and 188 article publishes in research journals, among which ten published in the five best regarded ones. The research output is not equally distributed among team members, but there is only one of them whose scientific output in the evaluation period seems negligible.

The team is also very active in thesis supervision, with 21 theses defended during the assessment period and thirteen theses in progress. It has also welcomed thirteen post-docs.

Among the team members, five of them will be 65 years old in the next assessment period.

## Strengths and possibilities linked to the context

Several team members were recipients of important prizes and recognition such as the election at the Academia Europea, Bronze medal CNRS, Silver medal CNRS, Clay Senior Scholar, Fellow of the Institut d'Études Avancées of the Université de Strasbourg. Many team members are editors or chief editors of scientific journals, some of which excellent. We mention also that in the team there are four ERC grants, two ANR grants as PI, as well as three IUF laureates.

Finally, we feel it is important to emphasize that members of the team are very actively involved in scientific dissemination and mediation activities. Not only many of them reach out to the general public (for example with organisation of a seminar for the general public, where ecological issues are considered from a point of view combining the humanities and natural sciences), but also with their activities they have been able to show the importance of mathematics in real life (in particular in the judicial system) and to raise public awareness of the importance of the proper use of mathematics and statistics in criminal proceedings. We mention in addition several teaching aids that have been developed by the team.

## Weaknesses and risks linked to the context

Since eight people of the team have left the Department and only six new members entered the team, the global balance is numerically negative. A gender problem exists, even if not dramatic. Among the eight researchers who authored papers for the portfolio of the team, only one is a female.

## Analysis of the team's trajectory

The team has lost eight of its members since the beginning of the evaluation period. The arrival of six new members brought in new expertise opening up possibilities of developing new interactions within the team and new connections with other teams.

These new connections already showed up in the organization of seminars. The team explores a huge variety of different research topics, although the themes of fixed points and dynamic of maps remain central and are considered by new and different perspectives.

## RECOMMENDATIONS TO THE TEAM

The team is expected to maintain its excellent scientific quality in the research, the high number of prestigious grants, the original connections with other areas, the open dissemination activities, the high attraction for young students. A stronger attention to gender balance is important from the very beginning.

**Team 2:** Géométrie et dynamique (GD)

Name of the supervisor: Mrs Marie-Claude Arnaud

## THEMES OF THE TEAM

The Geometry and Dynamics team has focused on dynamical systems, geometry and singularity theory. On the dynamics side this includes: symplectic and Hamiltonian dynamics, complex dynamics, ergodic theory, and Teichmüller dynamics. Geometry is mainly focused on geometric analysis which in particular includes: minimal surfaces and harmonic maps, spectral geometry, geometric measure theory, and gauge theory and supersymmetries.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The previous evaluation committee wondered whether it would not be useful to redefine the team's composition and perimeter, which are currently very vague. It also noted that the team included a number of CNRS research directors whose involvement in the life of the laboratory needed to be stepped up.

It does not appear that these recommendations were seriously taken on board. The group composition is still very vague. Three senior researchers (DR) have left the group in recent years, depleting even further the team's senior leadership pool.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	6
Maîtres de conférences et assimilés	9
Directeurs de recherche et assimilés	1
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>18</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	5
Personnels d'appui non permanents	0
Post-doctorants	1
Doctorants	10
<b>Sous-total personnels non permanents en activité</b>	<b>16</b>
<b>Total personnels</b>	<b>34</b>

## EVALUATION

### Overall assessment of the team

The team has obtained several internationally leading results within the assessment period. This includes the first examples of analytic Hamiltonians of Euclidean spaces of sufficiently large dimension which exhibit unstable elliptic equilibria in the Lyapunov sense, as well as the first examples of polynomial automorphisms of the two-dimensional complex space with a wandering Fatou component. In sub-Riemannian geometry,

we single out the proof of the Sard's strong conjecture for analytic sub-Riemannian structures in analytic 3-varieties. Other truly excellent results were obtained. Among them are theorems concerning the effort, pursued by top teams in the field, of assessing the Willmore functional as a Morse function on the Teichmüller space. Others concerns the Teichmüller dynamics of large surfaces, or the existence of extremal metrics for the Laplacian eigenvalues.

Overall, the team has produced numerous publications, including a dozen or so published in the very best mathematics journals (*Inventiones Mathematicae*, *J. Amer. Math. Soc.*). Another 30 papers were published in other leading journals, *Duke Math.* or *Memoirs of the American Math. Soc.*

The team is also very active in thesis supervision, with 21 theses defended and 10 theses in progress. In addition, team members serve on the editorial boards of fifteen international journals.

## Strengths and possibilities linked to the context

The team has obtained funds through national competitions which includes two ANR, and three IUF laureates. Although the team does not have an ERC grant, it would have the means to do so.

The team is involved in a wide range of activities to promote scientific culture. Some team members write articles which aim at popularizing mathematics. Likewise, they produce podcasts and other video formats explaining and visualizing mathematical research. What makes the team special in this respect is that one team member has developed an expertise in cryptocurrencies, is part of the Labex ReFi (European Laboratory on Financial Regulation) and has participated in the production of parliamentary reports on the subject.

## Weaknesses and risks linked to the context

Two leading dynamicists have left the IMG-PRG for laboratories abroad. In addition, two high profile researchers have retired over the period. Over the next period, between two and four retirements may occur, among them leading scholars in their field.

At least in the short term, this will impact the quality of the team's output and probably decrease the number of PhD students in the group. It is to be hoped that the new appointments that were made will help maintain the team's high standards.

The team suffers from a severe gender imbalance, as it comprises only two women, with one female professor among eleven.

## Analysis of the team's trajectory

As mentioned above, new appointments were made to replace people who left. While it is hard to replace leading senior mathematicians who left, the most recent appointments pursue new research directions, and bring another type of expertise to the team. This opens up new possibilities for growth and strengthening connections with other teams in the unit.

## RECOMMENDATIONS TO THE TEAM

The team is expected to maintain its excellent scientific quality in research. Efforts should be made towards ERC applications. Attention should be paid to gender balance in recruitments.

**Team 3:** Analyse complexe et géométrie (ACG)

Name of the supervisor: Mr. Andrés Sambarino

## THEMES OF THE TEAM

The team's research activities can be generally summarised as the study of the geometry of locally symmetric spaces, geometric structures on manifolds and their moduli spaces, geometry of singular spaces, Kähler and Kähler-Einstein metrics, resolution of singularities, geometry of non-positively curved spaces, Higgs bundles and Anosov representations.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

Overall, the recommendations of the previous evaluation have been taken into consideration and addressed. With the three new hiring and the return of a professor from the ENS-PSL the proportion between personnel of rang A and rang B is now more balanced. As a consequence, themes so-called "historic" in the team have also been reinforced. Finally, a new series of seminars and an informal series of weekly talks at lunch time "Café de maths" has been established also with the intention of encouraging communication among the team members and even extending a hand to the colleagues with a more modest research record. It is however not clear to which extent this had the intended effect.

On the other hand, while we see on the last three years of the evaluation period successful efforts in obtaining funds through national calls for projects (more specifically ANR and IUF), this is not the case for funds through international calls such as ERC.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	6
Maîtres de conférences et assimilés	11
Directeurs de recherche et assimilés	2
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>21</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	1
Personnels d'appui non permanents	0
Post-doctorants	1
Doctorants	8
<b>Sous-total personnels non permanents en activité</b>	<b>10</b>
<b>Total personnels</b>	<b>31</b>

## EVALUATION

### Overall assessment of the team

The team covers a very broad thematic spectrum and it has been able to make some superb hiring in the evaluation period, which is a clear indication of its attractiveness.

Equally striking are many of the results obtained within the team, some of which have already been

mentioned in the general evaluation. We recall here the proof that the action of the mapping class group on the connected component with Euler class 1 or -1 of the character variety of representations of a surface group of genus 2 into  $PSL(2, \mathbb{R})$  is ergodic, thus proving an old conjecture of Goldman's. An equally striking result obtained in this group concerns the complex analogue of Thurston's Dehn filling theorem for hyperbolic three manifolds. Given a noncompact arithmetic quotient  $X$  of the complex  $n$ -ball, there is a sequence of orbifold Kähler-Einstein metrics on a toroidal compactification  $Y$  of  $X$  converging to the hyperbolic metric on  $X$ . In fact, these KE metrics lift to smooth metrics on finite ramified covers of  $Y$ , the cover getting larger as the sequence approaches the hyperbolic metric on  $X$ . Such results require rather deep analytic insights. Equally notable is a result according to which a finitely generated group embeds into the group of  $r$ -diffeomorphisms of an interval or a circle, but not into the group of  $s$ -diffeomorphisms for any  $s > r$ . This algebraic feature of the group of diffeomorphisms is particularly striking since the group is not particularly well-behaves (for example is not locally compact).

A further indication is the remarkable scientific output, with fifteen preprints and 127 articles, among which five published in the five best regarded research journals. However, the team seems to have almost 15% of members with a negligible research output in the evaluation period.

The team is also very active in thesis supervision, with twelve theses defended over the evaluation period and eight theses in progress. It has also welcomed five post-docs.

Six team members are part of the editorial boards of ten very good research journals. Overall, the team organises several international conferences and summer schools. Three team members are members of the IUF, two are PI of an ANR project and an ANR project Tremplin, one has received the Price Brin.

## Strengths and possibilities linked to the context

The team started a general seminar "Géométrie et topologie" with the team "Analyse algébrique" and has strengthened the link with that team further by having a member of "Analyse algébrique" among the organisers of the team seminar "Analyse et géométrie".

Despite being a team involved in research in pure mathematics, the team has been able to assure some industrial contracts. They are equally involved in activities of dissemination to the general public at several levels.

## Weaknesses and risks linked to the context

This team suffers from an important gender imbalance. Among the 21 members present at the moment, there are only two women, among which one professor out of eight. One is a recent hire, but the other is close to retirement. Among the doctor's students in the evaluation period we can see only three women out of 20.

## Analysis of the team's trajectory

This is a very well-balanced team. In particular, the team contains a number of very productive mid-career researchers who are pursuing new research directions. This will attract even more PhD students, and increase the quality of the research output even further.

## RECOMMENDATIONS TO THE TEAM

The team should maintain his excellent scientific quality in the research. It is paramount that the team continues the superb hirings keeping close attention to gender balance, The same attention should be devoted to the hiring of women doctoral students, perhaps with the help of increased outreach activities.



**Team 4:** Groupe, représentations et géométrie (GRG)  
 Name of the supervisor: Mr. Emmanuel Letellier

## THEMES OF THE TEAM

The team was formed at the beginning of 2009 by merging the "Group theory, representations and applications" and "Finite and algebraic groups". The team studies mainly problems arising from Lie theory and representation theory of finite groups using geometric, topological and algebraic methods. More concretely the themes covered by the team include representations of p-adic groups and categorification, quantum affine algebras, homological algebra, representations of algebras, cluster algebras and categorification with connections to quantum groups, moduli spaces of representations such as quiver varieties and character varieties.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The previous recommendation emphasized the insufficient involvement of the team in graduate studies and the training of PhD students. Most of the points have been positively addressed by the team; the number of PhD students has been significantly increased (with currently thirteen PhD students and twelve defended PhD theses). Moreover, the two-part seminar, with the first 45mn focused on graduate students, is also a welcome change. In addition, the recruitment of young researchers has compensated for some of the retirements that occurred during the evaluation period.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	6
Maîtres de conférences et assimilés	6
Directeurs de recherche et assimilés	1
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>15</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	6
Personnels d'appui non permanents	0
Post-doctorants	2
Doctorants	13
<b>Sous-total personnels non permanents en activité</b>	<b>21</b>
<b>Total personnels</b>	<b>36</b>

## EVALUATION

### Overall assessment of the team

The team's research themes are wide but coherent and there are many collaborations between its members as documented in the publication list. The team is based on the Sophie Germain building (UPC

site), but some of the group members have offices at the Jussieu site and group members meet regularly there as well. The professors and directeur de recherche of the group are world's leading experts in representation theory. By a recent hiring at the junior level, the research methods have been further widened to higher algebra and derived algebraic geometry methods, remaining consistent with the research themes.

The research strength of the group is also reflected by many awards and distinctions. Amongst these we mention one IUF junior member and one IUF senior member, one winner of the Académie des sciences' Fondé par l'État 2019 prize, one winner of the 2017 Gabrielle Sand Prize of the French Academy of sciences, two speakers at the ICM 2022 Satellite conference on Geometric Representation Theory.

The team holds one ERC consolidator grant, furthermore two members are ANR coordinators, and two members are ANR participants jointly with other IMJ-PRG members.

## Strengths and possibilities linked to the context

The results obtained by the GRG team are of great importance, with publications in the most prestigious journals in fundamental mathematics. There is at least one publication in the following journals: Annals of Mathematics, Duke Mathematics Journal, Annales Scientifiques de l'ENS, Compositio Mathematica, Acta Mathematica, and six publications in Crelle. Also, the quantitative scientific output is very high: 110 published articles in internationally recognised specialised journals, fourteen conferences proceedings and six book publications.

Among the team's most notable results is the proof of an important conjecture on the unitriangularity of unipotent block decomposition matrices for finite reductive groups which also leads to the proof of a Kawanaka conjecture stated 30 years ago. Another very important result is the positivity conjecture of Kazhdan-Lusztig polynomials for non-simply laced quantum affine algebras. Determining the Kazhdan-Lusztig polynomials is a step forward to the important problem of determining the dimension and  $q$ -characters of simple modules from the standard modules. Hence, they bring us closer to understanding the representation theory of the quantum affine algebra in the general case.

Due to its wide research interests and methods, the team can interact with other IMJ-PRG teams such as TGA, FA and AA.

A great strength of the GRG group is also its inclusion of master 2 students and young PhD students into the team. This is for instance achieved by the team's seminar whose first 45 minutes are accessible to students.

In the reference period twelve PhD theses have been completed and two HDR. Also, to be noted very positively, is the number of current PhD students which has now increased to thirteen compared to seven in the previous reference period. There are two ongoing postdocs.

The team has a strong editorial activity and has editors in more than twelve journals. The most prestigious of these journals is Astérisque and the team has an editor-in-chief at Compositio Mathematica. The team is also very active in the popularization of mathematics mostly by presentations for the general public.

The members of the team are also involved in administrative responsibilities of great prestige. For instance, the team has a vice-president of CNU and a member of CoNRS. Many members are part of Scientific Committees at internationally renowned research centres, such as [Mathematisches Forschungsinstitut Oberwolfach](#) (Germany) and the Bernoulli centre (Switzerland). Many have been organising research semesters at prestigious research centres such as the Isaac Newton Institute (Cambridge, UK)

## Weaknesses and risks linked to the context

It has been mentioned during the interviews by PhD students and team members that after the Covid-19 pandemic, there were notably fewer social activities such as joint lunch and dinners related to seminar activities also involving PhD students. It would be good to make sure PhD-students feel integrated.

As also noted by the team, the recent departures of two very dynamic young CRs are affecting the strength of the team. The number of CRs have dropped from five to two but one new DR has been hired in the evaluation period. There is however some imbalance between permanent members of rank A (PR and DR) and of rank B (MCF and CR).

Another risk mentioned by the team during the interviews is the bad reimbursement procedure of the CNRS which makes travelling difficult. The constant renovation and construction work at Sophie Germain building has also been mentioned as a factor which makes joint activities difficult.

## Analysis of the team's trajectory

The team's permanent staff has decreased slightly from eighteen to fifteen members. At the same time, its scientific production remains very impressive. Thanks to new hirings, the team's research methods and themes have widened and make the research group more modern and attractive.

In the next evaluation period, several members (among them one of the pillars of the team) will reach the age of 65.

## RECOMMENDATIONS TO THE TEAM

As mentioned above, it is essential for the team to attract new CRs or DRs of high calibre which fit well into the team's research profile but bring new methods to the team.

It is also important to keep up the seminar geared towards young students, and encourage PhD students to participate to the seminar. At the same time, it is also good to make them also feel involved socially by giving them the possibility to meet speakers in joint lunches.

It would be very good to keep offering many master 2 classes, attracting thereby a high number of PhD students. This seems to have worked very well so far. The many working groups also offer a very stimulating environment for young students.

The team should pay particular attention to gender issues, as in the next evaluation period the already small percentage of women (approximately 13%) will likely be further reduced. In addition, a better balance between permanent members of rank A and of rank B could be envisaged.

**Team 5:** Analyse fonctionnelle (AF)

Name of the supervisor: Mr. Frédéric Klopp

## THEMES OF THE TEAM

The main themes are the study of Banach spaces (proper Functional Analysis), pursued at Jussieu site, and the theory of PDE, which is the main area of research for the members based at Sophie Germain site, and also concerns some of the members located at Jussieu. The study of Banach spaces should be broadly understood -- it encompasses areas such as metric geometry, high-dimensional convexity and geometric inequalities, in addition to the global study of Banach spaces. The research topics in PDEs revolve around the mathematical analysis of linear or nonlinear models in mathematical physics, fluid dynamics or the kinetic theory of gases, but also in more applied fields such as multiphase fluids or applications of PDE to ecology.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The recommendation of keeping the research activity at the highest level has clearly been followed. However, the recommendation of promoting a stronger interaction between the Functional Analysis group and the PDE group bears repeating, as does that of improving the ratio between female and male researchers (among the seven new recruits over the evaluation period, only one is a woman).

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	5
Maîtres de conférences et assimilés	9
Directeurs de recherche et assimilés	0
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>16</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	6
Personnels d'appui non permanents	0
Post-doctorants	1
Doctorants	6
<b>Sous-total personnels non permanents en activité</b>	<b>13</b>
<b>Total personnels</b>	<b>29</b>

## EVALUATION

### Overall assessment of the team

Initially centred on the theory of Banach spaces, on which it has consistently been a leader, the scientific activity of the team has broadened so as to encompass, over the evaluation period, an important activity in linear and nonlinear PDEs, on which it has also achieved international leadership. Its best works have been recognised by prestigious distinctions.

Among the issues that deserve attention are the several outstanding departures or retirements over the review period, the seemingly minimal interaction between the two subgroups (a matter of fact that is enhanced by the separate location of the two groups, the Banach space one being located at Jussieu,

while most of the PDE one is located at Sophie Germain), possibly resulting in missed scientific opportunities, and the skewed gender balance, that has not improved in the recent years.

## Strengths and possibilities linked to the context

Some team members have been recognised by international distinctions, sometimes of the most distinguished type. Among them one lists a Banach medal and a Sierpinski medal. Most prominently, a Shaw Prize and, quite recently (2024), an Abel Prize were awarded to the same emeritus. This amply demonstrates the attractiveness and international recognition of the team.

The best work of the team continues to be outstanding. Two PR have been appointed at the IUF, and one has been awarded an IDEX Excellence Chair. One PR is on temporary leave at the ENS-PSL. Over the evaluation period, one MCF and one PR have left for positions in France or abroad, and one of them for a full professor position in Italy. Additional proofs of attractiveness are the three ANR projects, active over the evaluation period, led by team members. This shows a good ability of the team to access competitive funding.

Many people who began their careers working in traditional Banach space theory have branched out into other areas. This is reflected in some of the recent appointments at Jussieu, who are people with wide mathematical interests. It is also reflected by a lively weekly seminar that covers a very broad set of themes, going well beyond the confines of Banach space theory. In particular, there are strong links with people working in probability. There are also connections with researchers from other institutions in Paris. One important theme is high-dimensional convexity and geometric inequalities. Two papers by members of the group (together with international collaborators) illustrate this very well. One concerns a question from 2010 about whether the Brunn-Minkowski inequality holds for convex sets that contain the origin if Lebesgue measure is replaced by Gaussian measure. The answer is no, but members of this group showed that it is true if the convex sets are centrally symmetric. The other, involving a different member of the group (which suggests fruitful interactions within the group) is a striking generalization from Gaussian measure to a wide class of rotationally invariant measures. In general, the group has produced several high-quality papers, including publications in highly regarded journals such as *Acta Math.*, *Invent. Math.*, *J. Funct. Anal.*, *Adv. Math.*, *Ann. Probab.*, and *Math. Ann.*

The activity on the PDE group spans an important, yet consistent spectrum. It covers the theoretical aspects of linear PDEs originating from quantum mechanics (microlocal and semiclassical analysis, dispersive estimates), the mathematical analysis of fundamental nonlinear PDEs from kinetic theory to fluid mechanics (Boltzmann, Landau, resp. Navier-Stokes equations), and the analytical investigations of nonlinear models oriented towards physical and biological applications (multiphase flows, reaction-diffusion equations from the life sciences). It is structured by a monthly seminar of high visibility at ENS-PSL, two of the three researchers in charge of which being from the IMJ-PRG (one from the AF team, the other from the GD team); members of the team also contribute to the organization of the Paris-London Analysis seminar, taking place once every trimester at IHP. The research output is of the best international level; it is published either in high profile specialised journals (e.g. *Arch. Rat. Mech. Anal.*, *Ann. IHP C*, *Ann. PDEs*, *Comm. PDE*, *J. Funct. Anal.*, *J. Diff. Eq.*, *Comm. Math. Phys.*...) or highly regarded generalist journals (*J. Eur. Math. Soc.*, *Duke Math. J.*).

Among the most notable contributions, one can single out the analysis of the stability of boundary layers for the Navier-Stokes (NS) equation, an important and difficult topic on which the team has been an international leader over the last decade. The solutions of the 2D NS equations in a bounded domain with small viscosity are indeed well approximated by those of the Euler equations, except in a thin vicinity of the boundary where they are, at least formally, described by the Prandtl equations. Whether or not the solutions of the Prandtl equations are good approximations of those of the NS equations in the boundary layer is a delicate issue, one aspect being the class of stability of these solutions. In particular, they are stable to analytic perturbations but unstable to Sobolev perturbations. The team has achieved important progress on this question by the discovery of a new class of stability, the Gevrey class, as admissible perturbations.

## Weaknesses and risks linked to the context

Over the evaluation period, three PRs and two DRs have retired, while one PR has left to the ENS-PSL on a long term leave. Most of them are outstanding driving forces. There have been some excellent new hires, but these have mostly been at a more junior level. As a result, there are for example only three senior members at Jussieu, and therefore not many who can take on PhD students. This is reflected in the relatively small number of PhD students currently in the team: there are four, of whom two are at Sophie Germain site and two at Jussieu site. The number of postdocs in the team during the period is also rather low (presently there is only one).

The localization of one branch of the team at the Jussieu site, and of the other branch mainly at the Sophie Germain site, reinforces the impression that the team is actually made up of two separate sub-teams; whereas some natural thematic intersections do exist between these two branches (e.g. functional or spectral inequalities play decisive roles in the study of convexity and in PDEs). We noticed some collaboration, on a

mathematical physics project, between two junior members of the two branches. Yet, there does not seem to be any periodic joint event between the two branches (seminar, working group). This separation, already pointed out in the preceding report, may represent, in the long run, the risk of missing scientific opportunities. The self-assessment report of the team advances its capacity to interact with the two other large size mathematics laboratories, the LJLL and LPSM. The self-assessment report does not suggest an important ongoing activity in this direction at the moment.

Out of the seven new permanent members, six are male. Given the fact that the team is highly attractive, and already features an unbalanced gender ratio, this small figure is difficult to understand.

### Analysis of the team's trajectory

The fairly large number of retirements over the last five to ten years has changed the profile of the team, leading to an imbalance, and in particular a small number of researchers at a senior level.

## RECOMMENDATIONS TO THE TEAM

The imbalance between senior and junior researchers should be addressed. A reconfiguration of the teams (for instance by transferring some "Optimization" members of the CO team towards AF) could be useful to increase the number of senior team members, allowed to supervise students. Such a transfer would make sense thematically.

Gender parity should be addressed, possibly by prospectively identifying potential promising candidates, especially at the PR level.

The team should endeavour to develop, a stronger interface between the Banach Space (in the broad sense) branch and its PDE branch, for instance by organizing a joint working group on topics of shared interest.

Outside IMJ-PRG, setting up regular and formalized interactions with colleagues at LJLL or LPSM would also be a positive direction.

**Team 6:** Histoire des sciences mathématiques (HSM)

Name of the supervisor: Mrs Catherine Goldstein

## THEMES OF THE TEAM

The principal themes interact subtly and mostly involve several members of the team.

1. Editions and digital humanities in history of mathematics, including the ENCCRE project and the d'Alembert edition.
2. The study (and edition) of scientific correspondence, including the relevant parts of the d'Alembert edition and the work of other researchers in the unit.
3. The cultural and social history of the mathematical sciences broadly understood, which includes the study of women and other under-represented groups in mathematical science, the involvement of the mathematical sciences and community in warfare.
4. The involvement of mathematics in the pursuit of other scientific studies, for example in physics, biology, and other aspects of modelling, considered historically.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The main comment in the previous review was that links with other groups in the human sciences as well as with the mathematical community should be developed still further. The self-evaluation points to many areas in which such contacts continue to be developed. These include, most notably, the ENCCRE project and the D'Alembert edition, and the HSM team is involved in these in a central way. Similarly, the involvement with the digital humanities group of the Institute of Computing and Data Sciences (ICSD) at Sorbonne Université deepens such contacts. The existence of a jointly supervised PhD with members of the Centre Koyré (EHESS) reflects further such outreach. Further partnerships with the Centre F. Viète at the Université de Nantes, and with the Centre Jean Pepin of the ENS-PSL, show additional involvement both locally and nationally. This is already a great deal for a small team to be taking on.

As for the mathematics community, the team participates in many mathematical events, ranging from the ICM 2022 (where a team member gave a plenary talk) to national and local colloquia, summer schools, and so forth. The organization of a colloquium in the context of a recent SMF-AMS joint meeting is further indication of such involvement at an international level.

Thus, it seems that this comment has been more than fully addressed.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	1
Maîtres de conférences et assimilés	1
Directeurs de recherche et assimilés	2
Chargés de recherche et assimilés	0
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>4</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	1
Personnels d'appui non permanents	0
Post-doctorants	0
Doctorants	0
<b>Sous-total personnels non permanents en activité</b>	<b>1</b>
<b>Total personnels</b>	<b>5</b>

## EVALUATION

### Overall assessment of the team

This cohesive team is producing outstanding work with impressive reach. This overall unity does much to give the unit a central place in history of mathematics internationally. Recent and forthcoming retirements severely threaten this status.

The breadth and quality of publication activity is amply demonstrated. There is highly significant activity in both technical and social history. The activities associated with the digital humanities are healthy but need more technical support.

There is room for additional PhD supervision; quality in the past has been outstanding.

### Strengths and possibilities linked to the context

The context of IMJ-PRG for a history of mathematics unit provides a unique attractiveness to a certain kind of future researcher, one who seeks to combine technical competence and involvement in the mathematics community with broader attachment to the history of science community in the ways so well demonstrated by the present unit. For the researchers involved in the unit, the geographic local provides a unique and immediate access to archival and other materials that has been exploited with great effectiveness by the present team, and should continue to be in the future. This is a source of attractiveness for excellent researchers to fill the coming (and past) retirements. The same holds true for the location of the unit within a network of well-established connections both in the history of science and in the mathematical communities centred in Paris.

The existing strengths of the individual team members are augmented by what appears to be a remarkable coherence of the unit. While methods and focal points vary, the investigations of social historical questions from the seventeenth to the twentieth centuries show significant shared participation by the researchers of the team. The members of the team produce outstanding works that leads the field. The topics of mathematics and warfare, as well as on women's participation in the history of ideas and scientific culture, have led to remarkable contributions.

There is a shared interest in the methods of digital humanities, overlapping with work on mathematical correspondences. This is an area attracting great interest internationally among historians (and historians of science), and this existing strength could be built on with minimal additional technical support. A further point of unity is the broad view taken of mathematical activity, likewise consistent with developments both in the field of history and in mathematics itself. This team is unusual internationally precisely because of its successful integration of many kinds of mathematical activity into historical analysis. This leadership could be enhanced in future hires.

In addition to this unity, there are singular points of remarkable significance for the field. One of these in the portfolio is the ICM 2022 plenary address concerning the relationship between long-term history of mathematics and the ephemeral configurations in which all producing mathematicians function. This analysis not only addresses a set of problems of long standing, it also does so in a way that is of interest historically, philosophically, and mathematically. The deep involvement with technical mathematics as well as with the ways in which the mathematical community is embedded in broader society argues powerfully for the importance of IMJ-PRG as a context for history of mathematics, and for the continued strengthening of history inside the IMJ-PRG.

### Weaknesses and risks linked to the context

A very clear risk is presented by the imminent retirement of two team member, both female, one a key senior researcher and one MCF highly involved in several aspects of the projects. Despite a key retirement a few years ago of a Rank A researcher (who continues as emeritus), no new positions have been allotted to the unit since 2009. While many of the units in this assessment face similar difficulties, for this team this poses an existential threat.

The lack of PhDs funded within the unit is likewise a difficulty, though this has been circumvented by various means in the past, for example by joint supervisions. The team also did not obtain any externally funded project in the period, in spite of significant efforts.



## Analysis of the team's trajectory

The ENCCRE project and the D'Alembert works will continue to bear fruit, the latter with several volumes expected in the next two years, the former not only via the regular seminar but through a diversification of the commentary. The ENCCRE project likewise has recent initiatives (a colloquium and an exhibition) as well as new initiatives involving the integration of computer vision tools. The latter has involved the creation of an Emergence project jointly with the ICDS at Sorbonne Univ. These projects have good momentum and are certainly long-term for the members of the team involved.

The specific trajectories proposed by the senior members of the team continue the pattern of integrating the overall historical approaches of the team with specific aspects of the history of the mathematical sciences. The ANR proposal concerning Hermite, the special issue planned on mathematical and personal trajectories around the Great War, and the overall theme of looking at numerical experiment and observation, all promise to continue the effectiveness of the group as such, while also reaching in many directions to other laboratories and in method and areas of interest. All of the proposed projects are of high current interest and will likewise contribute to the continued international relevance of the team's work among historians of mathematics and science.

Once again it is worth pointing out that these trajectories will be interrupted without the arrival of additional personnel.

## RECOMMENDATIONS TO THE TEAM

With four members, two of whom will soon retire, the team has a vast ambit of activity, and should strive to maintain the admirable cohesion that has been achieved.

The team needs to recruit for positions of both rank A and B, while maintaining gender balance. Given rapid changes of focus in the history of science world, if recruitment is possible, the greatest care should be taken to maintain the team's international strength through the scientific relevance of the appointees' work.

The technical side of the digital humanities projects seems to be rather a time-sink for some members. This should be better supported by the relevant institutions.

Efforts should be continued to have PhD students within the unit, fully involved in its activities. Co-supervision with members of laboratories outside the IMJ-PRG must continue to be explored.

Members of the team should also continue their efforts to obtain externally-funded projects. Such projects could even provide some for the PhD positions and/or technical support positions which are currently lacking in the team.

**Team 7:** Algèbres d'opérateurs (AO)

Name of the supervisor: Mr. Romain Tessera

## THEMES OF THE TEAM

Despite maintaining its original name of 'Operator Algebras', the team has significantly expanded its scientific interests, showing a remarkable breadth of knowledge and interactions with several mathematical areas. This team is currently developing five primary research topics: 1) Geometric and measured group theory; 2) Baum-Connes conjecture, operator algebras, and quantum groups; 3) K-theory, cyclic cohomology, pseudo-differential calculus, and index theory on singular spaces; 4) Global analysis of varieties; 5) Important arithmetic applications such as trace formulas on foliated spaces.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

In line with the recommendations of the prior report, the team has effectively recruited two 'Directeurs de Recherche' (DR) and one female 'Professeur des Universités' (PR), bolstering the group with two additional A-level ranks. This strategic addition anticipates the future retirement of two active A-level members. Notably, one of the newly onboarded A-level members is an internationally acclaimed expert in K-theory and operator algebras, who is also diversifying into researching new materials for green energy.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	4
Maîtres de conférences et assimilés	6
Directeurs de recherche et assimilés	3
Chargés de recherche et assimilés	0
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>13</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	2
Personnels d'appui non permanents	0
Post-doctorants	0
Doctorants	9
<b>Sous-total personnels non permanents en activité</b>	<b>11</b>
<b>Total personnels</b>	<b>24</b>

## EVALUATION

### Overall assessment of the team

The team is made of thirteen permanent members, including three CNRS researchers and a key female professor, and also includes nine doctoral candidates, showing a commitment to research-based training. This dedication extends to offering structured master 2 course packages annually. Over the evaluation period, the team's achievements include the successful defence of eleven theses, the acceptance of two post-docs, and the offering of numerous post-doctoral courses at summer schools. The emerging career paths of the young doctors span diverse roles from research fellow to secondary school teacher, indicating a promising future. Significantly, the team's scientific prowess has been enhanced by hiring internationally

recognized new members. The global recognition of the team's work is evident through the several invitations its members have received. Notable among these are a plenary speaker invitation at ICM 2018 and at the joint AMS-EMS-SMF congress in 2022. Additionally, the team's esteemed achievements include the election of a member to the Académie des Sciences in 2022, the honor of receiving two Sophie Germain Prizes, and the prestigious Gay-Lussac Humboldt Prize. Team members are members of the editorial boards of nine mathematical journals of excellent quality.

A notable accomplishment at the junior level is the thesis defended by a doctoral candidate from this team (October 2018). This thesis led to three first-rate subsequent publications (in the Journal of Functional Analysis, Journal of the London Mathematical Society, and Advances in Mathematics). This thesis and its developments resolve a longstanding conjecture on hypoelliptic operators, employing non-commutative geometry's foundational concepts (using the  $C^*$ -algebra of smooth groupoid to elucidate the pseudo-differential calculus). The influential role of the thesis advisor in this achievement and his continued involvement in the team's renowned weekly seminar is critical. The team has demonstrated exceptional scientific productivity in quality and quantity, as evidenced by the publication (or pending publication) of over 70 articles in prestigious journals. This level of scientific output is commensurate with the team's research capabilities. The weekly Thursday seminar has an international reputation and is a hub for leading experts in operator algebras and non-commutative geometry.

The team's research scope has significantly expanded to include index theory, groupoids, ergodic theory, quantum groups, and geometric group theory within the broader field of non-commutative geometry. This evolution marks a gradual shift from traditional operator algebras to more geometrically oriented research while preserving team unity. Integrating studies on measured equivalence relations and geometric-oriented subjects aligns well with the team's expertise, fostering growth and coherence in research. Furthermore, the team researches connections with number theory, mainly through arithmetic geometry and its links to non-commutative geometry and the Riemann zeta function. Introducing new themes, especially in emerging areas like quantum chemistry mathematics, reflects the team's evolving profile. This evolution is significantly influenced by a newly recruited and internationally recognized member whose focus on ecology and climate change applications underscores the team's potential in cutting-edge mathematical research.

The overall evaluation of the team is highly positive. Despite the extended period of confinement due to the pandemic, the team has not only maintained its strong international standing but has also initiated a dynamic process of renewal.

The team seems to have no outside grants.

## Strengths and possibilities linked to the context

A particularly novel approach, aligned with the current context, involves deepening the relationship with number theory, in particular the applications using the adèle class space rather than following purely conjectural frameworks. Another innovative direction is to enhance the link with non-commutative geometry, especially the application of cyclic theory. Lastly, a less apparent but equally promising avenue is the exploration of mathematical applications in ecology and climate change. For this endeavor, maintaining an open and patient mindset is essential.

## Weaknesses and risks linked to the context

A clear and present risk is the potential reduction in active involvement from a prominent team member approaching retirement, particularly in contributing to the weekly seminar and mentoring young researchers. The team seems to have no outside grants.

## Analysis of the team's trajectory

As the report outlines, the team is progressively shifting its focus towards geometric aspects, gradually moving away from a purely algebraic and operator-theoretic approach.

## RECOMMENDATIONS TO THE TEAM

The primary recommendation for the team emphasizes the importance of meticulously managing the Thursday seminar and the insistence of the presence of the members at this event. The team is advised to focus on nurturing scholars from student to postdoctoral levels, particularly in the innovative convergence of operator theory, foliations, and arithmetic geometry. This approach will cultivate a distinctive amalgamation of skills and knowledge within these interrelated disciplines.

Given the very small presence of women in the team, particular attention should be paid to gender issues in the next hirings.

The team should also be more active insuring third party financing, both in France and abroad.

## THEMES OF THE TEAM

### Team 8: Logique mathématique

Name of the supervisor: Mr. Arnaud Durand

The research of the team revolves around set theory, model theory, and computability. These subfields are well integrated and enrich each other by sharing common methods and perspectives.

A unifying aspect lies in the exploration of definability within diverse structures or formal systems, along with the advancement of techniques for constructing or classifying structures that meet certain specifications.

In addition to progress within the discipline, increasingly sophisticated tools and techniques find applications in other areas of mathematics and computer science, with bi-directional interactions requiring expertise in different areas including: functional analysis, operator algebras, topological dynamics, topological groups (especially in connection with set theory and model theory); valuation theory, number theory, arithmetic geometry, real geometry, singularity theory (model theory); complexity theory, automata, formal languages (computability); Ramsey theory (all subfields).

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

In the last evaluation, the following recommendations were made:

1. Deepen scientific relations with other IMJ-PRG teams working on similar themes (model theory in the AA and AF teams, and set theory in the AF team), perhaps by organizing joint seminars.
2. Concentrate research themes to match the size of the team.
3. Free young researchers as much as possible from administrative and teaching responsibilities.
4. Seek to attract A-ranked researchers in model theory and B-ranked researchers in set theory.

Overall, the recommendations have been followed, within the limits imposed by the workforce and the recruitment dynamics.

Regarding items 1 and 4, connections with other IMG-PRG teams have been strengthened through the recruitment of MCFs and one CR, one of which has further enhanced scientific collaborations with members of IRIF, the fundamental computer science laboratory. The model theory group's activities focus on the interface with other mathematical fields, contributing to the strengthening of connections. Overall, the level of collaborations within IMG-PRG and the Parisian area is very satisfactory.

Regarding item 2, the scientific cohesion of the team remains strong despite the diverse directions in which the applications are oriented. This can be attributed to the use of common methods and perspectives, as outlined in the section 'Themes of the Team.' A common master program in Logic and Computer Science, relying also on collaboration with members of IRIF and other teams in the Parisian area, is evidence of this cohesion. Further concentration would be challenging to achieve without compromising the team's international appeal.

Regarding item 3, given the limited number of A-level positions and a high level of scientific activities, it is inevitable that numerous administrative tasks are delegated to B-level personnel.

Regarding item 4, it was not possible to recruit on a rank A position, and this remains a risk factor for the team.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	2
Maîtres de conférences et assimilés	10
Directeurs de recherche et assimilés	0
Chargés de recherche et assimilés	3

Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>15</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	3
Personnels d'appui non permanents	0
Post-doctorants	0
Doctorants	12
<b>Sous-total personnels non permanents en activité</b>	<b>15</b>
<b>Total personnels</b>	<b>30</b>

## EVALUATION

### Overall assessment of the team

The team's scientific output is at an outstanding level and spans the entire spectrum of mathematical logic, including applications to theoretical computer science. The team has a robust tradition of training through research and attracts many doctoral and post-doctoral students. It also runs a master program in Logic and Computer Science. Its members actively participate in numerous seminars and scientific activities. Team members are consistently successful in ANR and other project calls (although no ERC project was obtained). The team's engagement with society is substantial, distributed well among team members and taking many different forms. A potential risk factor for the team is the limited number of members holding Rank A positions.

The team has published over the period 75 articles in peer review journals, seventeen in conference proceedings, and two books. Three papers were published in a leading journal (*Invent. math.*) and many others in other highly selective venues (*Duke Math.*, *Ann. Sci. ENS*, *TAMS*, *Adv. Math.*, etc.). Other publications appear in prestigious computer science journals and conference proceedings.

Important advances within the core subjects of the discipline have been obtained, focusing in particular on forcing constructions, descriptive set theory, infinite combinatorics, infinite automata, algebraic complexity, model-theoretic tameness phenomena ( $\omega$ -minimality,  $C$ -minimality, etc.). One can highlight, for example, the proof that there is no finite or countable basis for Borel graphs with infinite Borel chromatic number.

The team also obtained significant applications to algebra, geometry and analysis (valued field, Borel-Laplace summability, etc.). Other applications were obtained by young MCFs and collaborators and are of outstanding level.

We can highlight on two notable contributions: The one on "Infinite-dimensional Polish groups and Property (T)" ingeniously employs tools and concepts from continuous logic to show that every Roelcke precompact Polish group  $G$  possesses Kazhdan's Property (T), meaning that every unitary representation of  $G$  with 'almost invariant' unit vectors also has invariant unit vectors. The work on "Uniform Roe algebras of uniformly locally finite metric spaces are rigid" applies  $C^*$ -algebras (also connected to continuous logic) to the study of the large-scale geometry of metric spaces. It is shown that the large-scale geometry is captured by the uniform Roe algebra associated to the space.

On the interface between logic and computer science, one publication was awarded the best paper award at the conference on Petri nets 2020. Numerous other publications showcase substantial advancements in diverse measures of computational complexity and establish strong connections with other subjects in the discipline. For instance, the study of infinite automata is linked to descriptive set theory, team semantics is associated with model theory, and reverse mathematics with computability and infinite combinatorics. The numerous interconnections contribute to the cohesiveness of the team and the attractiveness of the master in logic and foundations of computing.

### Strengths and possibilities linked to the context

Despite its small size, the team plays a very active role in scientific activities and has a high international profile.

The team has a strong tradition in doctoral training, drawing in a considerable number of both French and international students (12 throughout the period). Additionally, the team has hosted a substantial number of post-doctoral researchers (5 during the period) and administers a master's program in Logic and Foundations of Computer Science, enhanced by collaborations with members of the IRIF and other teams within the Parisian area.

The team has a weekly seminar "Séminaire Général de Logique de Paris" which has been running for over 40 years. It features talks by guest speakers from all over the world and presentations by doctoral students and young researchers. Other regular seminars are also organized (Model theory and groups, Ordered Algebraic Structures, Séminaire itinérant de catégories, Computability theory and Applications). During the pandemic a joint online seminar with Lyon was organized.

The team has been involved in six ANR projects. The members of the team are involved in various responsibilities beyond the IMJ-PRG.

The team's involvement with society is significant, well distributed among all team members, and takes many different forms. One notes the interdisciplinary program "Mathematics and Social Sciences" in partnership with Science Po; various activities in collaboration with the IREM (Institut de Recherche sur l'Enseignement des Mathématiques), talks at the "Cité des Sciences et de l'Industrie", web-content, shows, seminars, science popularization activities (Math.en.Jean, Fête de la Science, Rencontre Déclics), courses for secondary school teachers (PAF courses), visits to high-school classes, etc.

## Weaknesses and risks linked to the context

The team has consistently faced a decline in its workforce over the years, primarily due to retirements or promotions to professor positions in other universities. Presently, the team comprises only two members in Rank A positions (as of 06/30/2012, there were sixteen tenured professor and similar positions). Specifically, there are no Rank A members in model theory, one PR in set theory, and one PR in logic and foundations of computability. While there is a noteworthy presence of dynamic MCFs in the early stages of their careers, there are few members with HDR. The situation is particularly acute in set theory (only one member with HDR) and model theory (two MCFs with HDR, including one nearing retirement).

Despite these challenges, the team has thus far managed to maintain an admirably high level of scientific and supervisory activity, as well as engagement with the non-academic world.

Nevertheless, if the issue of the current staffing composition is not addressed, particularly in anticipation of upcoming retirements, there is the potential for long-term impacts on supervisory capabilities and the team's ability to undertake administrative tasks, which are already shared by members who are relatively young or in mid-career.

## Analysis of the team's trajectory

The LM team was established in 1982 and became part of IMJ-PRG in 2010. Historically, it has been a globally prominent center for logic. Over the years, the team has consistently experienced a decline in its workforce, but it has successfully maintained a very high international standing and excellent integration among its subthemes.

The recruitment of highly dynamic MCFs has strengthened ties with other IMJ-PRG teams. A significant development in the model-theoretical landscape over the last two decades is the emergence of continuous logic, allowing the tools and ideas of model theory to be applied to the study of structures typical of functional analysis and operator algebras. The logic team has actively participated and continues to contribute significantly to this advancement.

The theme of calculability, especially in connection with proof theory and reverse mathematics, has been bolstered with the addition of a CR in December 2021.

## RECOMMENDATIONS TO THE TEAM

After several years of fostering collaboration with other areas of mathematics, reinforcing the inter-theme coherence within the team and maintaining equilibrium and integration among its subthemes holds significant scientific interest.

The team should strive to sustain a diverse spectrum of research without compromising its cohesion, which is a hallmark of its scientific identity and is vital for the enduring success of research-oriented training.

The team needs to recruit for both teaching-research positions (Rank A) and research positions (Ranks A and B). The deficiencies in model theory (lacking Rank A) and set theory are apparent. Depending on the opportunities available, the team could explore the creation of Junior Professor Chairs (CPJ) and aim to rebalance gender representation.

It is imperative to formulate strategies to address these challenges, ensuring the team's enduring success and efficacy while safeguarding its distinctive position in the international academic landscape.

**Team 9:** Combinatoire et optimisation (CO)

Name of the supervisor: Mr. Jimmy Lamboley

## THEMES OF THE TEAM

Two seemingly disconnected topics are addressed in this team. One touches discrete combinatorics, with two of the main areas of activity being classical problems additive combinatorics, such as generalizations of the Erdos-Ginzburg-Ziv theorem, and combinatorial geometry and convexity.

The other focuses on optimisation, mainly continuous: shape optimisation, that is, the problem of finding a set that minimises, or maximises, a bunch of functional constraints; stochastic optimal control, that is, finding the best way to bring a random process to a pre-defined set in minimal time. Related issues on game theory are also part of the research activity.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The previous report recommended an evolution of the team, due to the forthcoming retirements of PRs and DRs. This recommendation was not taken into account, so that it is repeated here.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	1
Maîtres de conférences et assimilés	2
Directeurs de recherche et assimilés	0
Chargés de recherche et assimilés	1
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>4</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	3
Personnels d'appui non permanents	0
Post-doctorants	2
Doctorants	5
<b>Sous-total personnels non permanents en activité</b>	<b>10</b>
<b>Total personnels</b>	<b>14</b>

## EVALUATION

### Overall assessment of the team

The team activity has, over the period, been of very good level, with some remarkable results. A steady drop in its permanent work force raises the question keeping it as it is over the next period.

### Strengths and possibilities linked to the context

Over the evaluation period, three post-docs have left the team for permanent, sometimes quite senior positions, in France and abroad. One MCF has left for a professor position abroad. In 2023, the team was able to attract a high profile DR in discrete mathematics, a scientific operation that Sorbonne Université has



accepted to assist by the hiring of a PR in the area. This is an excellent sign of the attractiveness of the team. Three ANR projects, and one 300keuros contract with the Air Force Office of Scientific Researches were active over the period. This is remarkable for such a small size team.

Results obtained during the evaluation period include an asymptotic resolution of a conjecture concerning Davenport constants, and a result concerning simplicial depth, which resolves a conjecture of Deza from 2008 and a conjecture of Burton from 2003.

Over the period, the part of the team working in the continuous optimisation part has obtained results of international level on deterministic or stochastic optimal control, related issues about Hamilton-Jacobi equations, and, as a more recent topic allowed by the hiring of a new PR in 2017, the calculus of variations pertaining to geometrical quantities such as Laplacian eigenvalues or perimeter functionals. The results are published in visible specialised (SIAM J. Math. Anal., SIAM J. Control Optim, J. Diff. Eq...) or generalist (J. Math. Pures Appl., Trans. AMS) journals. One may single out, over the period, the general study of the relation, in a given functional of shape optimisation (such as the perimeter), between minimality, and the stability of a solution of the Euler-Lagrange equation related to it (a quadratic form in infinite dimensions is positive). This result should have interesting consequences in many applications.

### Weaknesses and risks linked to the context

The number of permanent members has steadily decreased over the period 2012-22. Three PRs have retired over the evaluation period. Despite the recent 2023 hirings, the overall workforce of the team may be considered as below critical level. This is especially true of the optimisation part, which is left with just one PR in activity. This situation has the potential to become problematic to PhD students and young researchers, who may find themselves isolated from researchers of other teams working on similar topics. It is also a potential problem on the combinatorics side: while in some areas, such as combinatorial geometry, there are interactions between members of the group, in other areas the members are more isolated.

### Analysis of the team's trajectory

Both topics addressed in the team are healthy, productive and competitive at international level. What is, however, problematic, is how the union of the two can make a team.

There are, on the other hand, many common points between the optimisation part and the researchers of the GD team dealing with the analysis of the Willmore functional/the optimisation of eigenvalues, or combinations of eigenvalues, or with the researchers of the AF team dealing with PDEs.

On the combinatorics side, there would seem to be the potential for fruitful interactions between those working on combinatorial geometry and convexity and people in the functional analysis group who work on convexity and geometric inequalities. While the two topics are not identical, they are a great deal closer to each other both in subject matter and in mathematical style than they are to optimisation.

Therefore, it does not seem opportune that the team continues as it is.

## RECOMMENDATIONS TO THE TEAM

The general recommendation is that the team is reconfigured, taking into account the above assessment and, most importantly, the interests of the researchers that are in activity.

**Team 10:** Topologie et Géométrie Algébriques (TGA)  
 Name of the supervisor: Mrs Muriel Livernet

## THEMES OF THE TEAM

The research of this team covers a relatively broad range of themes. These include topics in algebraic topology, specifically within the areas of topological quantum field theories, homotopy theory, and higher categories. For example, operadic techniques are successfully applied to promote the understanding of configuration spaces of manifolds. Another major research strand is complex geometry, where the focuses comprise Hodge theory, algebraic cycles, moduli spaces in algebraic geometry, enumerative geometry, and mirror symmetry. A strong expertise exists in the study of complex manifolds via their deformations, allowing to deduce geometric information from data which only depends on the diffeomorphism type. A further center of activity is arithmetic geometry, where team member work on archimedean and non-archimedean analytic geometry, the theory of Berkovich spaces and local-to-global principles.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The previous report's recommendation to get involved in setting up national and international projects has been met with success. Several members of the TGA team are members in current third-party funded projects. An outstanding example is an ERC Synergy Grant, in which two team members are co-leaders. Another team member recently secured an ANR project.

The previous report encouraged the team to continue to attract new CNRS researchers, in particular young ones. This was partially achieved with the hire of one new DR, leaving the total number of CNRS researchers unchanged. Finally, the previous report raised the question of thematic balance within the team. While the topology section of the team has been strengthened by the hiring of a MCF, a slight imbalance towards complex and arithmetic geometry continues.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	6
Maîtres de conférences et assimilés	12
Directeurs de recherche et assimilés	3
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>23</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	5
Personnels d'appui non permanents	0
Post-doctorants	3
Doctorants	11
<b>Sous-total personnels non permanents en activité</b>	<b>19</b>
<b>Total personnels</b>	<b>42</b>

## EVALUATION

### Overall assessment of the team

A large part of the members of the TGA team continue to exhibit a strong research profile and a high level of international visibility, as detailed in the following paragraph. Witnesses to this are an impressive publication record, and various awards and prizes. The level of excellence is not entirely uniform, with some team members sticking out more than others. This unit also displays a certain lack of mathematical cohesiveness, in the sense that few connections between the subgroups of the team are clearly visible.

### Strengths and possibilities linked to the context

The TGA team has continued to produce exciting research output at the highest international level. One indicator of this success is the publication of over 100 research articles in peer reviewed journals, including the very top mathematics journals such as *Inventiones Mathematicae*, *Journal of the AMS*, *Duke Mathematical Journal* and *Forum of Mathematics Pi*. Members of the group also published six books, and completed two habilitation theses and seventeen PhD theses. The list of prizes and distinctions awarded to team members is impressive, too, and includes a L'Oréal-Unesco prize in 2019, the Prix Thérèse Gautier in 2019, the Ferran Sunyer y Balaguer Prize in 2017, as well as elections of a team member as a Fellow of the Royal Society, to the American Academy of Arts and Science and a member of the Abel Prize committee. A high level of international visibility of various team members is attested by invited addresses at major international conferences, long term invitations to renowned universities worldwide, and numerous editorships in high standing peer reviewed journals. For example, team members serve on the editorial boards of *Duke Mathematical Journal*, *Comptes Rendus Académie des Sciences*, *Mathematische Zeitschrift*, *Annales scientifiques de l'ENS*, and *Annales de l'Institut Fourier*. Two team members are managing editors at *Publications Mathématiques de l'IHES* and *Algebra & Number Theory*, respectively.

Among the results obtained by the members of the TGA team, some are particularly outstanding. One example is the proof of a conjecture of O'Grady, affirming that -- under specific topological assumptions -- hyper-Kähler four-manifolds are of K3 deformation type. Another major theorem concerns the question to which extent the rational homotopy type of a manifold determines that of its configuration spaces. The result affirms a conjecture of Lambrechts and Stanley: for simply connected, smooth closed manifolds, any Poincaré duality model determines the real homotopy type of the configurations spaces in a functorial way. Another remarkable paper concerns non-archimedean integrals and shows how these occur naturally in asymptotics of families of complex integrals. The authors establish a natural morphism between bicomplexes of archimedean and non-archimedean forms that is moreover compatible with integration.

During the assessment period, the team was rejuvenated through the hiring of one CNRS DR and three MCF, distributed over all thematic areas within the group. Overall, the team has a healthy balance of members at different career stages, and a respectable gender balance (30% female members in the team, 26% among the permanent members). During the review period, two HDR and a total of seventeen PhD theses were completed, bearing witness to the strong success in educating the future generation of mathematicians.

### Weaknesses and risks linked to the context

A certain amount of mathematical incohesiveness exists within the TGA team, possibly due to the genesis and history of the unit. The existence of two separate seminars, one for complex geometry and one focused on topology, resonates with the impression that the subgroups within the TGA team are only loosely linked. A slight imbalance with respect to visibility and research output remains within the group, favouring the complex and arithmetic geometry themes. The attractiveness of the TGA team for young CNRS researchers and postdocs is still not commensurate with its excellent scientific standing. The full potential for tapping third party funding, in particular ERC and ANR grants, might still not be exhausted.

### Analysis of the team's trajectory

A substantial number of team members continue to produce excellent or strong scientific results, and the future perspective of the team as a whole looks bright, in particularly in the algebraic geometry themes. This is despite the fact that four very active members of the team will be 65 years old in the next evaluation period. A certain thematic imbalance and a danger of developing into a fragmented group, connected mostly for historical reasons, remains.

## RECOMMENDATIONS TO THE TEAM

The structure of the IMJ-PRG laboratory in general, and of the TGA team in particular, appears to largely be a result of a historical development, and it serves the practical needs of organizing the allocation of resources. From the outside, the scientific rationale for the present layout of the various teams is not immediately obvious. For example, questions in arithmetic geometry are investigated in teams FA, TGA, and TN; enumerate algebraic geometry is a topic in teams AA and TGA; and different aspects of complex geometry are studied in teams ACG and TGA. At the same time, it is not clear how strong the interaction between the different subgroups of the TGA team is; additional measures to foster scientific collaboration within the team might be useful.

The team should be vigilant in the next evaluation period for possible departures that could potentially weaken the team.

**Team 11:** Formes Automorphes (FA)  
 Name of the supervisor: Mrs Anne-Marie Aubert

## THEMES OF THE TEAM

The general theme of the team is the Langlands program, both in its original formulation and its variants. Particular interests include the trace formula and its applications, p-adic Hodge theory, Galois representations, and the representation theory of p-adic groups. There is a natural cohesiveness between these topics even though they cover a wide spectrum of mathematics.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The recommendations of the previous report highlighted the need to maintain the focus and excellence of the automorphic Forms seminar, and there appears to be every indication that this has been done.

The other issue was to address (particularly among early career members) the male/female ratio. During the last five years cycle, a CR CNRS has been hired.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	4
Maîtres de conférences et assimilés	5
Directeurs de recherche et assimilés	2
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>13</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	3
Personnels d'appui non permanents	0
Post-doctorants	0
Doctorants	8
<b>Sous-total personnels non permanents en activité</b>	<b>11</b>
<b>Total personnels</b>	<b>24</b>

## EVALUATION

### Overall assessment of the team

The IMJ-PRG automorphic forms team has, historically, been hugely influential in shaping the modern theory of automorphic forms and its interactions and applications to neighbouring subjects. Recent work on the geometrization of the local Langlands correspondence has precipitated a paradigm shift in our understanding of the links between the arithmetic Langlands program and its more geometric analogues. The research produced by the team has been at the highest international level, with a number of publications not only appearing in the very top journals but (perhaps more importantly) being influential in the subject as a whole. The group has helped to maintain Paris as a world center for the theory of automorphic forms. One slight blemish is that the division of this production is not optimally distributed among its staff.

## Strengths and possibilities linked to the context

The automorphic forms team has produced exceptional work of the highest quality. It is particularly worth noting here the work on the geometrization of the local Langlands correspondence. The changing nature of the field (and its evolution towards more categorical and geometric methods) is both a challenge and an opportunity. Given the expertise of the group, there is the possibility of building the group in a direction to take advantage of how the subject is evolving.

Other significant papers produced by the team include a paper on the finiteness for Hecke algebras of  $p$ -adic groups and work around the Gross-Gan-Prasad conjecture.

The Langlands program (broadly construed) remains a very active area (or collection of areas) in mathematics internationally. Members of the team have played a role in running international conferences to help propel the discipline in new directions, including a widely attended summer school (at IHÉS) organized in part by members of the team, and numerous other specialized conferences throughout the world.

Members of the team are active with many collaborations throughout France and throughout the world, with a number of collaborations attracting funding from the American Institute of Mathematics (AIM), ERC grants, the Indo-French Centre for the Promotion of Advanced Research, and elsewhere.

## Weaknesses and risks linked to the context

One challenge facing the team is to maintain the high historic quality of its members, a number of whom have recently or will soon be retired. A number of members of the team close to retirement have impressively continued to maintain a world class publication record, but this cannot be expected to continue, and the current scientific output of the team is not entirely balanced. As highlighted in the paragraph describing "possibilities", the changing nature of certain aspects of the subject requires effort by the team (in terms of hiring and research) in order to stay relevant and vital on the international scene.

## Analysis of the team's trajectory

For a group which has traditionally been one of the crown jewels of the Paris mathematical firmament, there is always the danger of a "reversion to the mean" due to the passage of time and retirements. However, the work of the group remains exceptional, and with continual efforts to hire and retain the best people has every expectation of remaining so.

## RECOMMENDATIONS TO THE TEAM

The "Groupes Réductifs et Formes Automorphes" seminar plays a key role on a number of levels. First, it helps to unify the team both geographically and mathematically. Second, it helps bridge connections to other teams such as Number Theory. For this reason, it is imperative to maintain efforts to keep the seminar running effectively. Possibly some extra resources should be allocated (for example, to continue to be able to invite outside speakers), and efforts should always be maintained to make talks accessible to graduate students.

There is a strong overlap between the FA team and a number of other teams, including TN and TGA. These groups work symbiotically, both coordinating seminars (both with respect to time and location), and with a number of cross-group collaborations. Taking this into account, there is no apparent need for any reorganization of structure.

As always, to maintain the quality of the faculty, continual efforts towards recruitment at the top level should be maintained.

There are a number of mid-career scientists in the team whose rate of publication was not that high. As senior faculty retire, there will be an onus on many of the mid-career scientists to step up their role in leading the team throughout the next cycle, either through their own research or through other forms of academic leadership.

**Team 12:** Théorie des nombres (TN)

Name of the supervisor: Mrs Anna Cadoret

## THEMES OF THE TEAM

The Number Theory team deals with essentially all aspects of number theory: Arithmetic geometry, Arakelov geometry, Diophantine geometry; Analytic number theory; Effective aspects, cryptography; Cohomological theories; Galois representations, L-functions, modular forms.

## CONSIDERATION OF THE RECOMMENDATIONS OF THE PREVIOUS REPORT

The team was able to follow the recommendations of the previous report by recruiting a PR in 2017 at SU (Arithmetic geometry), and a MCF at UPC in 2020 (Analytic number theory). Interactions with the transversal team OURAGAN are also visible, for instance a Ph. D thesis is co-directed since 2023 by two MCF in both teams.

## WORKFORCE OF THE TEAM: in physical persons at 31/12/2022

Catégories de personnel	Effectifs
Professeurs et assimilés	7
Maîtres de conférences et assimilés	8
Directeurs de recherche et assimilés	4
Chargés de recherche et assimilés	2
Personnels d'appui à la recherche	0
<b>Sous-total personnels permanents en activité</b>	<b>21</b>
Enseignants-chercheurs et chercheurs non permanents et assimilés	9
Personnels d'appui non permanents	0
Post-doctorants	3
Doctorants	20
<b>Sous-total personnels non permanents en activité</b>	<b>32</b>
<b>Total personnels</b>	<b>53</b>

## EVALUATION

### Overall assessment of the team

The Number Theory team continues to exhibit an exceptional research profile, with an impressive number of publications in the best journals, various prizes, prestigious invitations and grants. The scientific production is however not entirely uniform amongst members of the team. Many shall soon retire, all of them with a highly visible and recognized activity. The team has to quickly renew itself to maintain this high level of excellence.

## Strengths and possibilities linked to the context

The scientific production of the team is exceptional from the point of view of quality and quantity, with around 200 articles published in journals with editorial board. Many papers have appeared in excellent generalist journals (Advances, Annales ENS, Annals of Math, Compositio, Crelle, IMRN, Inventiones, JEMS, JEP, JAMS, PIHES, PLMS, etc) as well as in the best journals in Number Theory and Cryptography. Members of the team participate to editorial boards of journals, have been awarded prizes, ICM invitation, IUF position or ERC grants. Two CR of the team have been promoted DR and PR.

There are many important results obtained by members of the team, including a proof of Mazur's conjecture that the number of rational points on a suitable curve  $C$  of genus  $g \geq 2$  over a number field of degree  $d$  is bounded in terms of  $g$ ,  $d$  and the Mordell-Weil rank of the Jacobian of  $C$ , a proof (under natural assumptions) that, given a  $g$ -dimensional complex abelian scheme  $A$  and a section not entirely contained in the torsion points of  $A$ , the torsion points on that section are dense. Fundamental results in integral  $p$ -adic Hodge theory which help lay the foundations for prismatic cohomology (Bhatt-Scholze 2022), computation of  $p$ -adic étale cohomology hinting at future formulations of the  $p$ -adic Langlands program. Improved lower bounds for localized extreme values of the Riemann zeta function using Gal's sums. Proof of a conjecture of Sczech for  $GL(N)$  over imaginary quadratic fields. In addition, in thesis work produced under the supervision of the team there is the development of a new theory of higher Eisenstein elements.

Members of the team had many long-term invitations abroad. They participate to/lead Emergence (SU) and ANR projects; two CR obtained ERC starting grants and one PR an Advanced ERC grant. They teach master 2 courses, supervise internships of students, organize a weekly number theory seminar and the "preprint seminar". They organized twenty international conferences, including in 2021 the summer school of IMJ-PRG in Analytic number theory and the Young researchers days of GDR JC2A. Three CR defended their HDR. Sixteen students defended their Ph. D Thesis; four of them now hold permanent academic positions in France or abroad. Fourteen post-doctoral students visited the team.

Members of the team participate to the life of the laboratory: direction of IMJ-PRG till 2020, direction adjointe of FSMP till 2018, participation to the laboratory council, foresight and recruitment council, Comité développement durable, editor-in-chief of Journal IMJ-PRG. They are active in outreach: direction of the "Fête de la Science", activities towards high-school students and society (Animath, Math.en.Jeans, IHP).

Some of the team members have received prestigious prizes, such as the David Goss Prize, the ICCM Best Paper Award, the Neuron Foundation Prize, the Prix Fulbright for the future, the Cours Peccot, the Prix Kevin Henriot and two are member of the Academia Europaea.

## Weaknesses and risks linked to the context

The team had 28 permanent members in 2017 and was the largest number theory group of any university in France. It had 21 members in 2022, due to retirements, mobility, promotions of many of its members (MCF, CR, PR, DR) as well as the death of a professor. In the period 2017-2022, one PR (recruitment), one CR (mobility) and one MCF (recruitment) arrived; in 2023, one PR was recruited, one DR came back and one CR will arrive in 2024, for a total of 24 permanent members. On the other hand, 8 members of the team, either PR or DR, are over 60 years old and shall probably retire in the next period 2023-2027.

The subject of Diophantine theory (geometry, transcendence) is at risk at very short term because of recent and future mobility, promotion and retirements of many active researchers. At medium term, this could also happen to the Cohomological theories theme for the same reasons. The Analytic number theory group is not very large: it was composed of only two members in 2022 after the recruitment of a MCF in 2020, but it seems less at risk with the return of a DR in 2023.

## Analysis of the team's trajectory

In the last five-year period, the team has consistently produced fundamental and significant work in number theory, continuing a long history of exceptional research. Some of the most influential work by members of the Number Theory team was produced by senior members who are close to retirement. If the group can replace some of these imminent departures with junior or senior mathematicians with high potential there is every expectation that this excellence can be maintained.



## RECOMMENDATIONS TO THE TEAM

The team is split (almost) in half between the Jussieu and Sophie Germain sites. The team runs a weekly seminar that alternates between the two sites and it is important that the program remains of broad interest to everybody to ensure a large participation each week, in spite of the distance. Alternance could also be the rule for other seminars or groupes de travail organized within the perimeter of the team. The team should continue to run seminars (such as the preprint seminar) which covers breaking research in a way accessible to graduate students.

The articles production is not optimally distributed amongst members of the team. It is important to ensure that other scientific activities/administrative tasks remain evenly spread so that enough time can be dedicated to research by each member.

The team's scientific directions cover almost all the number theory spectrum but this may change with promotions and retirements in the next cycle, in particular of members working in Diophantine theory and in Cohomology theories. The team have to think about how to maintain and expand these themes, and quickly identify and attract in excellent potential candidates, mainly at senior level. The possibility of applying for CPJ positions (at University or CNRS levels) could also be assessed.

# CONDUCT OF THE INTERVIEWS

## Dates

**Start:** 18 December 2023 at 12:00 (Paris time)

**End:** 20 December 2023 at 18:30 (Paris time)

**Interview conducted: online for teams and unit presentations on 18 and 19 December. On-site on 20 December for the remaining interviews (for only a part of the committee)**

## INTERVIEW SCHEDULE (ALL TIMES GIVEN IN PARIS LOCAL TIME)

### Monday 18/12/2023:

- **12:00-13:00 Team GD** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30mn interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **13:00-14:00 lunch break**

- **14:00-15:30 presentation of the IMJ-PRG (its scientific environment, scientific and administrative review for the past 5 years, project for the next 5 years) by the executive team (1h15 talk, 15 minutes questions)**  
**This session is open to everyone.**

- **15:30-16:30 Team TN** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **16:30-16:45 short break for the committee**

- **16:45-17:45 Team TGA** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **17:45-18:45 Team FA** : 25mn scientific presentations (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **18:45-19:00 committee camera session for debrief**

- **19:00-19:20 interviews with team leaders GD, TN, TGA and FA.**

- **19:20-20:00 committee camera session for debrief**

### Tuesday 19/12/2023:

- **09:30-10:30 Team LM** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **10:30-11:30 Team GRG** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **5mn break for the committee**

- **11:35-12:35 Team AO** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

- **12:35-12:50 committee camera session for debrief**

- **12:50-13:05 interviews with team leaders LM, GRG, AO**

**- 13:05-14:00 lunch break**

**- 14:00-14:35 Team CO** : 15mn scientific talks (based on portfolio), 5mn short questions from the committee, 15mn interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

**- 14:35-15:00 meeting with INRIA project-team OURAGAN** : 10mn short presentation on specific and transversal activities and contribution to IMJ-PRG, 15mn interviews with the committee.

**nb: as it is not an assessment of the INRIA team within the unit, team's leaders are allowed to be present.**

**- 15:00-16:00 Team ACG** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

**- 16:00-17:00 Team AA** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

**- 17:00-17:15 committee camera session for debrief**

**- 17:15-17:30 interviews with team leaders CO, ACG, AA**

**- 17:30-18:30 Team AF** : 25mn scientific talks (based on portfolio), 5mn short questions from the committee, 30m interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

**- 18:30-19:05 Team HSM** : 15mn scientific talks (based on portfolio), 5mn short questions from the committee, 15mn interviews with the members of the team (excluded team leaders and members of executive team of IMJ-PRG)

**- 19:05-19:15 committee camera session for debrief**

**- 19:15-19:25 interviews with team leaders AF, HSM**

**- 19:25-20:00 committee camera session for final debrief**

**Wednesday 20/12/2023: On-site, at Institut Mathématique de Jussieu - Paris Rive Gauche , 4 place Jussieu (Paris 5)**

**10:15 - Welcoming the expert committee**

10:30 - Interview with research support staff (ITA/BIATSS), 30mn

11:00 - Interview with the Parity Committee, 25mn

11:25 - Interview with the Sustainable Development Committee, 15mn

11:40 - Interview with the Project Managers Council, 20mn

12:00 - Meeting with representatives of B level scientific staff, 30mn

**12:30 - Committee lunch in camera**

13:30 - Interview with representatives of doctoral and post-doctoral students, 30mn

14:00 - Interview with the heads of doctoral and masters programs, 20mn

14:20 - Interview with the Foresight and Recruitment Council, 30mn

14:50 - *In camera committee meeting (20mn)*

15:10 - Interview with the Laboratory Council, 30mn

15:40 - Interview with the management and executive team of the unit, 40mn

16:20 - *In camera meeting of the committee (25mn)*

**16:45 - Interview with the supervisory bodies (CNRS, Sorbonne Université and Université Paris Cité), 60mn**

~~17:45 - Interview with INRIA, 20mn~~

**18:05 - Committee's final in camera session (visit)**

**18:30 - End of the day**

**PARTICULAR POINT TO BE MENTIONED**

**- On 20 December 2023, as the on-site committee members were fluent french speakers, most of the interviews were conducted in french, except when other members were presents online.**

- Due to scheduling problem, the interview with the INRIA representative had to be canceled on 20 December 2023. This interview has been rescheduled and conducted online on 8 January 2024 at 17:00 with the Chair and Vice-chairs of the committee.

## GENERAL OBSERVATIONS OF THE SUPERVISORS

Marie-Aude Vitrani  
Vice-Présidente Vie institutionnelle et démarche  
participative  
Sorbonne Université

à

Monsieur Eric Saint-Aman  
Directeur du Département d'évaluation de la recherche  
HCERES – Haut conseil de l'évaluation de la recherche  
et de l'enseignement supérieur  
2 rue Albert Einstein  
75013 Paris

Paris, le 9 mai 2024

Objet : Rapport d'évaluation **DER-PUR250024402 - IMJ-PRG - Institut de mathématiques de Jussieu - Paris Rive Gauche**.

Cher Collègue,

Sorbonne Université vous remercie ainsi que tous les membres du comité HCERES pour le travail d'expertise réalisé sur l'unité de recherche « IMJ-PRG ».

Sorbonne Université n'a aucune observation de portée générale à formuler sur le rapport d'évaluation transmis.

Je vous prie d'agréer, Cher Collègue, l'expression de mes cordiales salutations.

**Marie-Aude Vitrani**  
Vice-Présidente Vie institutionnelle  
et démarche participative



Le Président

Paris, le 30 avril 2024

HCERES  
2 rue Albert Einstein  
75013 Paris

**Objet : Rapport d'évaluation de l'unité DER-PUR250024402 - IMJ-PRG - Institut de mathématiques de Jussieu - Paris Rive Gauche.**

Madame, Monsieur,

L'Université Paris Cité (UPCité) a pris connaissance du rapport d'évaluation de l'Unité de Recherche IMJ-PRG - Institut de mathématiques de Jussieu - Paris Rive Gauche.

Ce rapport a été lu avec attention par la direction de l'unité, par la vice-doyenne recherche et le doyen de la Faculté des Sciences d'UPCité (cf courrier du Doyen Cazayous), par la vice-présidente recherche d'UPCité et par moi-même.

**Présidence**

**Référence**

Pr/DGDRIVE/2023

**Affaire suivie par**

Christine Debydeal -  
DGDRIVE

**Adresse**

85 boulevard St-Germain  
75006 - Paris

Je remercie le comité pour la qualité de son évaluation et vous indique, qu'en dehors de la modification demandée par le doyen de la Faculté des Sciences, ne pas avoir d'observations complémentaires.

Je vous prie d'agréer, Madame, Monsieur, l'expression de ma considération distinguée.

[www.u-paris.fr](http://www.u-paris.fr)

Édouard Kaminski



Référence  
MC/NE/EB/2024-030

**Faculté des Sciences**  
**Université Paris Cité**  
5 rue Thomas Mann  
75013 Paris

Objet : DER-PUR250024402 - Évaluation HCERES de l'UMR 7586 IMJ-PRG – Retour Tutelle Université Paris Cité

Chères et Chers Collègues,

Nous souhaitons par ce courrier remercier les membres du comité de visite pour le temps qu'ils ont consacré à l'évaluation de l'IMJ-PRG, ainsi que pour leur écoute et le travail considérable qu'ils ont accompli.

La Faculté des Sciences est fière de compter l'IMJ-PRG parmi ses unités de recherche et rappelle la grande qualité de la recherche menée par tous les membres du laboratoire.

Après lecture du rapport provisoire d'évaluation de l'UMR 7586 IMJ-PRG, la Faculté des Sciences souhaite ajouter la remarque suivante concernant la page 16 : *Le comité suggère de traiter les cas de harcèlement relevés à l'IMJ-PRG, en Conseil de laboratoire. Nous pensons que le Conseil de laboratoire n'est pas le lieu approprié pour cela et conseillons d'orienter les victimes vers la cellule dédiée de la tutelle appropriée (CNRS, SU ou UPCité)*

En vous priant, chères et chers collègues, d'accepter nos chaleureuses salutations.

Maximilien CAZAYOUS  
Doyen  
Faculté des Sciences  
Université Paris Cité

Nathalie EISENBAUM  
Vice-Doyenne recherche Faculté  
des Sciences  
Université Paris Cité





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