Evaluation Panel: EXACT SCIENCES – Mathematics

Panel Members

Thierry Goudon (Chair)	INRIA - Institut National de Recherche en Sciences du Numérique, France
Alessandra Iozzi	ETH Zurich, Germany
Anton Wakolbinger	Institut für Mathematik, Goethe-Universtität Frankfurt, Germany
Catherine Matias	CNRS - Centre National de la Recherche Scientifique, France
Consuelo Martinez Lopez	University of Oviedo, Spain
Fabrice Bethuel	Laboratoire Jacques-Louis Lions, Sorbonne Université, France
Marc Dambrine	Université de Pau, France
Miguel Sanchez Caja	Universidad de Granada, Spain

R&D Units

Centro de Análise Funcional, Estruturas Lineares e Aplicações (CEAFEL)	Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (IST-ID)
Centro de Análise Matemática, Geometria e Sistemas Dinâmicos (CAMGSD)	Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (IST-ID)
Centro de Estatística e Aplicações (CEAUL)	FCiências.ID - Associação para a Investigação e Desenvolvimento de Ciências (Fciências.ID)
Centro de Investigação e Desenvolvimento em Matemática e Aplicações (CIDMA)	Universidade de Aveiro (UA)
Centro de Investigação em Matemática e Aplicações (CIMA)	Universidade de Évora (UE)
Centro de Matemática Computacional e Estocástica (CEMAT)	Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (IST-ID)
Centro de Matemática da Universidade de Coimbra (CMUC)	Universidade de Coimbra (UC)
Centro de Matemática da Universidade do Minho (CMAT)	Universidade do Minho (UM)
Centro de Matemática da Universidade do Porto (CMUP)	Faculdade de Ciências da Universidade do Porto (FCUP/UP)
Centro de Matemática e Aplicações (CMA/FCT/UNL)	NOVA.ID.FCT - Associação para a Inovação e Desenvolvimento da FCT (NOVA.ID.FCT/FCTUNL/UNL)
Centro de Matemática e Aplicações da Universidade da Beira Interior (CMA-UBI)	Universidade da Beira Interior (UBI)
Centro de Matemática, Aplicações Fundamentais e Investigação Operacional (CMAFCIO)	FCiências.ID - Associação para a Investigação e Desenvolvimento de Ciências (Fciências.ID)
Grupo de Física-Matemática da Universidade de Lisboa (GFMUL)	FCiências.ID - Associação para a Investigação e Desenvolvimento de Ciências (Fciências.ID)

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Análise Funcional, Estruturas Lineares e Aplicações (CEAFEL)
Coordinator: Maria Amélia Duarte Reis Bastos
Integrated PhD Researchers: 29

Overall Quality Grade: GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 3
(B) Merit of the team of Integrated Researchers: 3
(C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Base Funding for (2020-2023): 316 K€
Recommended Programmatic Support
Programmatic Funding: 5 K€.

Justification, Comments and Recommendations
The Center for Functional Analysis, Linear Structures and Applications (CEAFEL) is a R&D Unit integrated in the Instituto Superior Técnico of Lisbon. It aims to research in Functional Analysis, Representation Theory and Matrix Theory, and to explore other areas of Mathematics and applications to Physics and Engineering. It is organized into two groups: the Group for Functional Analysis (IST) and the Group for Linear, Algebraic and Combinatorial Structures (FC).

Its number of Integrated Researchers decreased strongly from 47 (2013/14) to 23 (2015) and increased to 33 (2016/2017). Such an oscillation was occasioned by the new regulations about the conditions that IR's must fulfill. Being the number of members variable, it is difficult to estimate at what extent the productivity of the researchers is sufficient.

Among the most relevant contributions by the group, two of them reach a very high level. The first one deals with variable Toeplitz matrices sequences. It involves the use of Banach algebra techniques to deal with asymptotic problems and it becomes a remarkable contribution to the topic of algebras of operator sequences. It was obtained by one of the Unit members in collaboration with a prominent usual coworker of the Unit. The second one deals with the problem of approximation in Morrey spaces over the Euclidean space. A new subspace of Morrey spaces whose elements can be approximated by infinitely differentiable compactly supported functions is introduced. These results are very valuable in the area of harmonic analysis and function spaces, and were obtained by a consolidated researcher of the Unit in collaboration with an external one. Other contributions of the Unit on Analytic Function Spaces, Completion of matrix pencils and Representation Theory of Groups are valuable in somewhat more specific areas. The collaborations between some of the authors of these contributions and the remainder of the members of the Unit should be stimulated. In general, the contributions and curricula of the members of CEAFEL show a competitive and consistent research. Nevertheless, the high level that one would expect for a Center devoted especifically to these concrete topics is not reached. Indeed, some researchers seem to have a comfortable attitude on publications restricted to journals in the area (such as Linear Alg. Appl.) where it is easier to publish.

What is more, in spite of the specialization of CEAFEL, the interactions between its two groups seem scarce. Indeed, the creation of CEAFEL does not seem to be motivated by the detection of common aims. Instead, to explore possible links between the lines seems to be an aim in its own for the applicants.

The Center cooperates with the PhD programs (IST and FC) at Lisbon, with very few PhD theses defended along the period. There are some PhD students whose theses will be finished in a short term. However, the scientific atmosphere for both predoctoral and postdoctoral students does not seem to be especially stimulating.

The Center has obtained some international recognition with the organization of the series IWOTA in 2019 (after WOTA'16 promoted by them). This is an international event whose main organizer is the Coordinator of CEAFEL, and it will involve other Centers in Portugal. However, the Unit has not attracted European projects or international funds. An important part of the researchers works in a technical Institute, but the research of the Unit is only theoretical.

They have obtained only a small quantity from private funds. No contracts nor other connections with firms or enterprises exist. Neither there is interest in true applications such as Robotics. This is especially deceiving, as CEAFEL aims to explore applications to Physics and Engineering.

Aging may be an issue for the Center, as some key Unit members are close (or have already reached) the age of retirement.

It is worth mentioning that the External Advisory Board has not been useful. In fact, the only external report consists of some lines signed by a prominent collaborator of the Unit.

CEAFEL outreach includes MOOCS and surveys on topics related to mathematics with general interest.

The plan of activities is consistent with the previous activity and, thus, no substantial improvement is expected. According to the application, CEAFEL would aim a big number of both PhD scholarships and postdoctoral fellowships with three years duration, most of them supported by the Programmatic Funding of the call. Indeed, the introduction of new topics and the addition of recent methods and techniques to the current topics are necessary for the Unit. However, the natural way to achieve this would be to explore potential relations with the other mathematical R&D Units in the Lisbon area.

Summing up, the group keeps good international contacts and it presents some highlights of quality, even though there is room to increase it. Nevertheless, the structure in two (rather unrelated) groups becomes flawed. CEAFEL aims should be re-defined in order to include also applications and to attract funds. The links with other Centers should also be re-evaluated. Indeed, the lines of research of its two groups are also developed by other groups in Lisbon, where the researchers could be integrated with renowed aims.

The Panel strongly recommends to merge the PhD programs offer in Mathematics and Statistics in Lisboa.

The Programmatic funds should be used just for participation in international newtworks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Análise Matemática, Geometria e Sistemas Dinâmicos (CAMGSD)
Coordinator: Carlos Alberto Varelas da Rocha
Integrated PhD Researchers: 65

Overall Quality Grade: EXCELLENT
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
(B) Merit of the team of Integrated Researchers: 5
(C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 1174 K€
Recommended Programmatic Support
PhD Fellowships: 6
Programmatic Funding: 678 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations
The Research Unit CMAGDS was established in 1991 and it is currently one of the largest R&D Units in Portugal. It is part of the Instituto Superior Técnico, which now constitutes a substantial portion of the recently enlarged Universidade de Lisboa. It is an internationally renowned Center in basic research that contributes substantially to the mathematical output of the country. Its main aim is high-level fundamental research. While the high qualities of some other Units come more from a breadth of themes and activities, CAMGSD goes more into the depth within two fields of mathematics that are reflected in its denomination:
1) Dynamical Systems and Differential Equations. Topics include: qualitative theory of dynamical systems; geometric mechanics and Hamiltonian systems; methods of nonlinear analysis; ergodic theory; stochastic analysis and related topics.
2) Geometry and Topology. Topics include: symplectic and Poisson geometry; algebraic geometry; algebraic topology; differential geometry; discrete geometry. The research also addresses applications to problems motivated from mathematical physics such as general relativity, quantum field theory, string theory and quantum topology.

A three-member Executive Board headed by the President coordinates the Center. The Scientific Council of the Center, composed of all the permanent members, elects the President who nominates the other two members of the Executive Board. The President, the Executive Board, and the Scientific Council supervise all programs supported by the Center. The Executive Board also prepares the annual activity reports and presents them to the Scientific Council. Despite its size, the Center is organized as a single Unit without division into thematic areas. The cooperation between members of different research areas allows this model to function in a flexible fashion.

The CAMGSD is obviously a «center of excellence» in Portugal, with outstanding record of research. The scientific production, devoted mainly to Dynamical Systems and Differential Equations and to Geometry and Topology, is of very high quality, appearing in internationally recognized mathematical journals (ARMA, CMP, JEMS, Nonlinearity, Cal Var. PDE, JDE, DCDS...). There is also a noticeable production in physics (with many papers in the J. High Energy Physics). The application mentions a total of over 550 articles, which sounds formidable (yearly more than 1.5 articles per Integrated Researcher) and represents an increase of 44% with respect to the previous period. The 15 publications selected are of outstanding quality, both in terms of the highly competitive topics and of the collaborators, who include leading consolidated international researchers.

The Center sustains since 1998/99 an ambitious international postdoctoral program in Mathematics that has been funding yearly 10 to 20 fellows, directly or through other sources. This program already accounted for the accumulated participation of 107 postdoctoral fellows and its success is measured by the high employability of its laureates. The great majority of the postdoctoral fellows (more than 80%) hold now a position in academia. Moreover, the activities include a scientific exchange program and several weekly seminars.

In terms of internationalization, it is worth mentioning that the Center has been visited by around 600 visiting scientists between 2013 and 2017, more than 90 only in 2017. The Center organizes also international colloquia,

conferences and short courses, some of them integrated in European or international conference or workshop series. Moreover, it promotes thematic periods and summer schools involving PhD students and postdoctoral fellows. Perhaps independently of this, it is not uncommon that postdocs co-supervise PhD students, thus officializing a rather wide-spread and very welcome common practice.

The focus on two broadly defined directions of research is not at all restrictive and, on the contrary, it makes the Unit quite coherent and attractive for postdocs and visitors.

In terms of outreach activities, several CAMGSD members are involved in the Novos Talentos em Matemática program, consisting in research projects for undergraduates. This is quite a worthwhile program that helps breeding young new mathematicians.

The arrival of P. Gonçalves makes this R&D Unit particularly visible in probability and statistical physics (with papers published in PTRF, Stoch. Proc Appl. CMP). Her ERC grant is the first in mathematics in Portugal and got the attention of public media. This is a great opportunity for the R&D Unit (and certainly beyond) that has resulted in a research team consisting at the moment of 13 members. Likewise, it is expected that the 10 MEUR ERC Synergy grant in quantum theory that R. Schiappa in M. Mariño team obtained in collaboration with J. Andersen (Aarhus Universitet), B. Eynard (Université Paris-Saclay) and M. Kontsevich (IHES) will have a great impact on the life of the Unit. In this respect we were pleased to see that a program of identifying and coaching possible ERC applicants has been started and is available to the Unit.

The Unit, just like the majority of other R&D Units in Portugal, has a satisfactory balance in genders. However, with the internationalization of the R&D Units, one can already see also in Portugal the prodromes of a wide spread problem. It is paramount that the gender issue be identified as a potential problem well before it becomes such and the Panel was very pleased to see that a plethora of activities had already been implemented in this direction.

The Center wants to keep its identity and its fundamental research character. The configuration of the Center, its size and interactions are good, and its objectives, strategy and plan of activities are appropriate. The Centre has a sustained total budget of around 1M/year, mainly from national sources. There is a slow decrease of national funds compensated by a small increase of European ones.

The ERC grant for a young researcher in the Center has been excellent news. Indeed, the international influence of the Center should be proportional to its quality. This would mean the attraction of more international funds and other indicators such as researchers of the Center as members in the board of international journals. Perhaps the Center should identify clearly the groups and directions of research where higher visibility could be attained.

The Unit asked for funding to foster its international contacts, which are already well-established. It also requires funds for the library and the computers. It could be timely to push forward the activity in Probability and Statistical Physics.

Recommendations:

- Despite being consistent, the number of PhD students appears surprisingly low. CAMGSD has the largest budget and however, in proportion, one of the smallest number of PhD students. Instead, the R&D Unit has a strong post-doctoral activity (which is successful but somehow less risky).
- The R&D Unit is one of the most active in Portugal, but it is to be seen what is really the impact of such a R&D Unit both in Portugal and abroad. A bigger effort in the connection with society (mathematical applications, industry) is desirable in the future.
- The question remains however as to whether it would not be good to have this Center funded in a much larger percentage by international sources to the advantage of other R&D Units in Portugal.
- The Panel looks forward to a continuation of activities to prevent issues related to gender unbalance in the Unit.
- It would be desirable to have a truly independent External Advisory Committee that effectively consists of more than one person who could absolve its duty of «advising» and not just «celebrating».

The Panel strongly recommends to merge the PhD programs offer in Mathematics and Statistics in Lisboa.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Estatística e Aplicações (CEAUL)
Coordinator: Lisete Maria Ribeiro de Sousa
Integrated PhD Researchers: 43

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
(B) Merit of the team of Integrated Researchers: 3
(C) Appropriateness of objectives, strategy, plan of activities and organization: 3

Base Funding for (2020-2023): 602 K€
Recommended Programmatic Support
PhD Fellowships: 5
Programmatic Funding: 253 K€.

Justification, Comments and Recommendations
The Unit has a specific positioning as being the only R&D Unit dedicated only to statistics in the country. It has significantly contributed to other disciplines, either through new methodological developments (published in very good statistical methodology journals) and their applications in various fields or through the use of more classical statistical tools to solve concrete problems, e.g. in health science or geophysics, or from socio-economic needs. In the latter case collaborations lead either to publications in journals from various disciplines or to recommendations for decision making.

The Unit has two research areas, the first one focused on extreme value theory (EVT) and the second one gathering the statistical modeling outside 'extremes', including Bayesian methods. The first area leads mostly to methodological developments, which may or may not be applied to some specific problems. Research on Environmental and Ecological Statistics is by nature more applied than the one on EVT and the Unit has made notable contributions in this field. The Ecological Statistics group has interacted with governmental agencies, e.g. providing expertise on the monitoring of wildlife populations. The invitation made to the Unit, jointly with CEF, to produce annual fire risk maps is a typical example of the Unit commitment into putting their expertise for serving society in general.

The dialogue of this Unit with other disciplines is remarkable. The pragmatic approach taken by its members should be praised, which consists in trying to build an answer to a concrete problem whatever the difficulties encountered from the theoretical point of view, and which is opposed to the strategy that consists in trying to apply one's favorite method whatever the data are. The Panel also noted that this pragmatic approach does not happen at the cost of a loss of caution in manipulating statistical conclusion. On the contrary, the Unit is fully aware of its role in the dissemination of rigorous statistical practice, among students and also among colleagues from other disciplines.

Contracts with industry are quite numerous. However, as it is the case across Portugal, this does not bring much additional funding for the Unit. Nonetheless, the Unit was able to get fellowships for master students in that way.

The Panel has noted the presence among the PhD students of a person hired by a company that noticeably greatly values research and invests in that employee. That person was trained as a biologist, and its employers fund her to do a PhD in Statistics. That company finds here an opportunity to increase the skills of that employee and expects great benefits from that investment. This situation should be considered as a role model in the country both for companies and PhD students in mathematics.

Because of its particular positioning at the interface with other disciplines and society, it might be more difficult for this Unit to attract grants at an international level, in particular academic grants (e.g. from the EU). Considering the current low level of private funding sources in Portugal it is thus important to take into account the specificity of the Unit and programmatic funding is one way of dealing with that problem.

Considering outreach activities, the Unit is fully committed to popularization of statistics, disseminating their work for instance through TV channels.

It appears that the more methodological developments are mostly carried out by members which are about to retire or already retired, and this concerns mostly the EVT theme. While the impact of the more applied work of the team is impressive, there is a concern about the renewal of the tools and methods that are used in this more applied area. The Panel underlines that it is important that the Unit members develop and maintain collaborations with other mathematicians working for instance in probability, stochastic processes, mathematical modeling and PDEs, and also with computer scientists. This should be seen as a way to enrich their tool repertoire, increase the accuracy of their models and the efficiency of their algorithms. In the same way, PhD students and post-docs with a statistical background should be encouraged to take courses or to attend summer schools in other areas of mathematics during their training.

While the positioning of the Unit as the only one in statistics could increase its visibility, the Panel has noted that this is not effective as regarding results in terms of attraction of international students, both at the PhD and the post-doc level. This is partly explained by the international competition from the GAFAs and similar companies that highly value statisticians which are now difficult to recruit for research, combined with the lack of attractiveness of funds. Here, targeting mathematicians not specifically trained in statistics, but with good skills and highly committed to work on applications, could be a beneficial strategy for the team. Besides, this would bring into the Unit some scientific renewal and expansion of themes.

The R&D Unit is eager to develop machine learning approaches and to play its role in the training of next generation statisticians, now also called data scientists. To fully succeed in that direction, they need to unite their forces with other people working in the stochastics area in Lisbon so as to become complementary to computer scientists, both from a research and a training perspective. The Unit should increase its bonds with CEMAT - Center for Computational and Stochastic Mathematics (IST, UL) in order to foster the development of that interface. CEMAT and CEAUL have complementary skills that can fruitfully interact to address modern challenges in statistical sciences. The group on applied and numerical PDE from CEMAT certainly could bring additional skills to take part in addressing these questions.

The presentation of the Unit during the visit was very clear and dynamic, with a relevant SWOT analysis of the positioning of the Unit. Original communication tools are engaged: Facebook, Twitter accounts, and a WhatsApp group for internal purposes. The activity of the Unit naturally leads to software or packages developments; a better strategy should be set up in order to document, maintain, and promote these codes, which contribute to the scientific achievements of the Unit. The Panel appreciates the strategy of the Unit to try to pair those of its members that have less time dedicated to research with other ones that are more scientifically active. It is quite clear that the R&D Unit has established solid internal bonds – certainly due to the homogeneous scientific interests of its members. This helps them to be robust against difficulties – may those be financial, administrative, or from other source. Nonetheless, as already said earlier, opening of the Unit towards other subdisciplines of mathematics would be highly beneficial for everyone.

The awarded Programmatic Funding is partially (238 keuros) to co-fund a researcher position and, more generally, to recruit researchers, and to foster international networks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Investigação e Desenvolvimento em Matemática e Aplicações (CIDMA)
Coordinator: Luís Filipe Pinheiro de Castro
Integrated PhD Researchers: 83

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 1185 K€
Recommended Programmatic Support
PhD Fellowships: 8
Programmatic Funding: 654 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations
CIDMA is one of the largest R&D Units in mathematics in Portugal. During the evaluation period (and till today) it has been organized in 8 groups:
- (AG) Algebra and Geometry,
- (CHA) Complex and Hypercomplex Analysis,
- (FAA) Functional Analysis and Applications,
- (GGD) Gravitational Geometry and Dynamics,
- (HM) History of Mathematics,
- (OGTC) Optimization, Graph Theory and Combinatorics
- (PS) Probability and Statistics
- (SC) Systems and Control.

This structure reflects a certain heterogeneity, which also poses a challenge for future developments of the Unit concerning collaboration and communication. There are joint interests in certain topics, e.g. in coding theory (in groups AG and SC) an in fractional analysis (in groups CHA, FAA and SC), with publications in the respective groups but so far without a visible amount of co-publications across groups.

The 15 main publications listed in the application give a good image of the wide spectrum of the Unit and correspond well to the description of the main contributions of the Unit in the application. The publications appear in respectable journals, with a certain underrepresentation of top journals. Examples from this list are a paper containing the solution of P. Cameron's "Aveiro problem" (on the highest rank of a string C-group constructed from an alternating group), a paper in shape optimization that solves a problem of minimal resistance related to the so-called Kakeya problem, and a highly cited monograph on Computational Methods in the Fractional Calculus of Variations. To advance in its quest for excellence, CIDMA should have a clear policy to increase the overall quality and reputation of the journals where its members publish their most prominent theoretical results.

The overall publication output of CIDMA is somewhat unbalanced: of the nearly 700 publications of CIDMA between 2013 and 2017, more than one half (~150+250) come from the GDD (~150) and SC (~250) groups; from the latter, about 150 have been coauthered by a single member of the Unit. This unbalance is even more pronounced as far as the number of citations are concerned, which may also be seen as a problematic feature of that kind of bibliometric indicators.

Three thematic lines (TL) have been followed in the evaluation period:
- GEOMETRIX (on educational software and games),
- MATEAS (on Teaching and Assessment in Higher Education),
- PICS on Inverse Problems and Applications in Health Sciences.

PICS is mainly carried by the CHA group and established collaborations with medical institutes and Centers in Coimbra as well as with a Bavarian network on Mathematical Methods in Biological Image Analysis.

GEOMETRIX and MATEAS are carried mainly by the AG group. The application of an existing Bayesian user model for knowledge assessment is mentioned in the application as one of the most important contributions of the AG group. As one of its outreach activities (see https://cidma.ua.pt/thematic_lines), GEOMETRIX organized the National Congress of Autism and Mathematics, according to https://cidma.ua.pt/thematic_lines. A PhD thesis on the integration of digital technologies in the teaching and learning of children's mathematics, with a focus on children with autism, won the EDF-Oracle eAccessibility Scholarship 2017/18; this was mentioned as one of the achievements of the AG group in the presentation during the site visit.

Not least with the intention to establish closer links between the groups, three new thematic lines have been created recently:
- BioMath,
- TFC: From Theory to Computational Frameworks,
- MI: Mathematics for the Industry.

TCF so far created several software packages, e.g. on Invariants Calculation and Image Representation of Lexicographic Polynomials of Graphs, on Real Object Identification and Tracking, and on Optimal Inspection Management for Reinforced Concrete Structures under Corrosion Risk.

Among other activities, MI supported a CoLAB application including 9 members from 3 different research groups.

According to https://sites.google.com/view/ltbiomath/, BioMath comprises 15 researchers from 4 research groups from CIDMA. One of its recent activities is the organization of a conference entitled Statistics on Health Decision Making at UA. The topics targeted by the TL include Mathematical Epidemiology, Biostatistics, Molecular Biology and Epigenetics. Notably, a PhD thesis of a member of the PS group (on the Analysis of Inter-Genomic word distance distributions) has been defended by the end of 2018.

CIDMA supports 4 doctoral programs. Most of the students present in the discussion with the Panel are in the Applied Mathematics programme joint with Minho and Porto (MAP-PDMA). Only a single of the students that were present in the discussion takes part in the Doctoral Programme in Mathematics, another one in that of History of Sciences and Scientific Education, another one in the International Doctorate Network in Particle Physics, Astrophysics and Cosmology. The Panel recognizes in particular the good possibilities that go along with the first year courses of MAP-PDMA, and encourages strengthening the possibilities of exchange and synergies in this programme. The Panel has the feeling that the current multiplicity of PhD programs may restrict the visibility of the Unit. Therefore the Panel suggests focusing on the joint program with Minho and Porto. The PhD fellowships granted in the programmatic funding for the period 2019-2022 should only be used for that latter programme, except one PhD fellowship which may be used for the doctoral programme in History of Sciences and Scientific Education.

Some of the participants in the Panel discussion with postdocs belonged to the group of recently contracted young researchers by CIDMA. One of them, who had studied in the Minho-Aveiro-Porto PhD programme, was the winner of the 2013 IBM Scientific Prize, see https://www.computerworld.com.pt/2014/06/04/alexandre-madeira-recebe-premio-cientifico-ibm/.

The Panel recognizes the efforts of CIDMA and UA that helped to re-integrate the former leader of the GGD group as a Coordinator Researcher starting from September 2019. This scientist has made substantial contributions not only to astrophysics but also to differential geometry as a mathematical discipline. In addition, by far most of the current project funding in CIDMA has been raised by the GGD group. It seems desirable that also the scientific links between this and the other 7 groups of CIDMA are reinforced in the future, which may materialize in joint projects, publications and co-supervisions of PhDs.

The application requests the funding of 8 researcher positions, one for each group. During the site visit the Panel encouraged the members of CIDMA to rank this request with regard to strategic planning. Such a ranking was given by the previous coordinator of CIDMA in the discussion between the Panel and the senior scientists of CIDMA, and is recognized by the Panel.

Number 1 in this ranking is the position of a researcher for analytical and numerical investigation of various models of physical interest associated with wave diffraction problems in crystals and metamaterials with cracks, with the

intention to develop a hybrid theory of crystal lattices dynamics that combines the advantages of the continuum description with the ability to reproduce some micro-structural features. Number 2 of the requests is a researcher with a background in Deep Learning, with regard to the Center's expertise in Harmonic Analysis, Optimization, Statistics, and Systems theory.

The Panel acknowledges CIDMA's outreach activities connected in particular to teaching and history of mathematics, and its efforts in strengthening the international connections, e.g. by organizing two international mathematical events of larger size in Portugal in 2019, one at UA (12th ISAAC Congress) and one at IST Lisbon (IWOTA, joint with CAMCSD-UL and with CAM-UNL).

The awarded Programmatic Funding is to partially co-fund hiring costs of researchers presently hired with costs totally or partially covered through CIDMA, to fund renewal or new Post-Doc fellowships, and for other purposes according to CIDMA's application.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Investigação em Matemática e Aplicações (CIMA)
Coordinator: Feliz Manuel Barrão Minhós
Integrated PhD Researchers: 54

Overall Quality Grade: GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 3
(B) Merit of the team of Integrated Researchers: 2
(C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Base Funding for (2020-2023): 606 K€
Recommended Programmatic Support
Programmatic Funding: 5 K€.

Justification, Comments and Recommendations
The Research Center for Mathematic and Application of the University of Évora is a rather large mathematical R&D Unit. The Center gathers 68 integrated members, 54 of them with PhD. It is a Unit with general scope in mathematics and its spectrum is very wide ranging from Logic to Statistics. The Center aims both at producing abstract results and at supporting demands of the Portuguese society. It is organized into four teams: Differential Equations and Optimization; Dynamical Systems; Logic, Algebra and Geometry; Statistics, Stochastic Processes and Applications. As a transversal structure across groups, the Center has defined two thematic lines: Complex systems; Mathematical modelling in Life Sciences and Industry Applications.

This Unit has a strong particularity: beside its main supporting institution, which is the University of Évora, there is also a far apart second pole at the University of Madeira. In the present application, the Instituto Superior de Engenharia de Lisboa is proposed as a third management institution.

These geographical constraints are a source of difficulties to maintain the cohesion of the Center: the use of modern communication tools like videoconferences allow the boards of the Unit to have the needed regular meetings. The situation is not very convenient, but the members seem to be satisfied with the videoconference system. An annual meeting of several days is also organized alternating between Évora and Madeira to insure the cohesion of the Center. The Panel has been convinced during the visit that this organization fits the needs of the Unit.

Contrary to many other Units in Portugal, the number of Integrated PhD Researchers has increased while the number of PhD students has dropped from 16 to 7. The training of PhD students is a central activity of any mathematical R&D Unit and the small number of students currently in PhD is a weakness. The Center encounters difficulties in attracting good PhD Students. A great effort is made in order to attract students from other Portuguese speaking countries and the Center is successful in this regard. The Panel is impressed by the efforts made by the Center members to organize the lectures of this PhD program even doubling the physical lectures with an e-learning version. The members of the Center have a strong commitment towards mathematics in developing countries.

None of the PhD students met by the Panel at the site visit (4 of them face-to-face, 3 through a videoconference) has a classical background in the sense of being young students coming directly from a Master degree without any work experience. Nobody has a grant. Quite a few of these students had difficulties to communicate in English. This point is extremely delicate since nowadays English is the language in which science is created and diffused. A proper strategy is mandatory in order to deal with that specific difficulty: a lecture leading to a certification in the English language must be mandatory for students not already holding such a certification. The PhD students are encouraged to participate in seminars and conferences. This is indispensable to offer them good education. However, the interest becomes questionable for students with pronounced difficulties in English.

All the young members of the Unit met by the committee (3 in person and 2 through videoconference) graduated from the PhD program of the universities supporting the Center. They have permanent or temporary teaching positions either in the mathematical departments or in Polytechnic Institutes in the vicinity or in Lisbon. The Panel

regrets the lack of independence in research visible in these young members since they kept working with their PhD advisor on topics very close of the subject of their PhD.

Despite some interesting articles in well-established mathematical journals like Journal of Differential Equations, Journal of Functional Analysis, Physica D, and some applied contributions leading to publications in journals in other disciplines like Fisheries Research, the mathematical production of the Unit does not at the moment fulfill the exigent international standards. The Panel is not convinced by the average quality of the articles produced over the period of evaluation. The references provided for 2018 which is out of the scope of this report are encouraging with some publications in very good journals.

The Panel has the impression that the Unit at the moment is more a collection of individuals without a collective strategy and the benefit of being gathered together in this Unit is not entirely clear from the scientific point of view. Indeed, the Panel feels that there is not a clear scientific strategy defined by the Unit. Such a strategy should be defined. More than one strategy is possible, and the Center should take into account the interaction with the local society that is a very important issue for such a Unit.

Among the weakness detected, the committee wants to emphasize that some are easy to improve, like for example the organization of regular seminars within the thematic lines. The choice of developing extremely specialized topics, like flexible optimization, increases the feeling of isolation of young researchers.

Other weaknesses are more difficult to deal with: typically, those regarding PhD students and young researchers that are in a difficult daily situation of work. The production is unbalanced between some members having an extremely large volume production and some members at the limit of the criteria defined to belong to the Unit. A research in pairs gathering a member with high production and a member with a lower one could be organized inside the Unit. Working groups on a dedicated subject inside the Unit can be organized at a larger scale.

Much more important than quantity is quality. Concerning the theoretical contributions, the Panel encourages the Unit to make an effort to publish more articles in well established mathematical journals and not to disperse them in publishing in journal with less visibility.

The Panel has also detected strengths and opportunities for the Center: the geographical situation makes daily scientific life difficult but also provides opportunities of applied subjects that can be very useful for the south of Portugal. The Unit has already a good record in applied and interdisciplinary work as attested e.g. by the contributions on forest fires and fisheries. The Panel strongly encourages the Unit to develop strongly and structuring collaborations in subjects of that kind. As far as the interdisciplinary activities of the Unit are concerned, their impact for the society is more important than the number of publications.

Many members of the Unit are experts in topics also covered in Lisbon: we encourage them to increase the level of collaboration with colleagues in Lisbon. Another notable point is that some members have already developed an important international network for example in stochastic analysis leading to important contributions. The Panel believe these collaborations are crucial to this Center.

In conclusion, the Center hardly satisfies the requirements for what the committee considers to be ranked as Good. It is mandatory that the Unit strongly reacts and increases its interactions with others researchers abroad and in Lisbon. We suggest to abandon topics far from the main stream of the current mathematical activities. The Unit should focus on some strengths already present in the Unit, like probability and stochastic processes. The hiring of some permanent positions in a near future for the mathematical department of the University of Évora will be crucial for this Unit. The committee believes it is very important to hire new members coming from another Unit or another country.

It is important that the Unit makes effort to enter international networks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática Computacional e Estocástica (CEMAT)
Coordinator: Adélia da Costa Sequeira dos Ramos Silva
Integrated PhD Researchers: 35

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 4

Base Funding for (2020-2023): 503 K€
Recommended Programmatic Support
PhD Fellowships: 5
Programmatic Funding: 371 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations
CEMAT - Center for Computational and Stochastic Mathematics is a Research Unit of the Universidade de Lisboa, whose host institution is Instituto Superior Técnico, Universidade de Lisboa (IST-UL). It gathers 35 PhD researchers from a large number of different academic institutions and approximately 20 PhD students.

The Unit develops interdisciplinary research achieving a very good quality publication record. Its main areas of research are: algebra and computing, applied and numerical analysis, mathematical modeling in biomedicine, statistics and stochastic processes. The present structure results from the merging of two previous Units. The Panel acknowledges that the merging was successful and that the Unit has a good visibility, with a central position in the landscape of Applied Mathematics in Lisbon. It has a clearly defined and accepted governance.

The line of research in algebra and computation has a high visibility and a very good production. It connects abstract algebra, computational algebra and theoretical computing. The group produces both theoretical results and software packages. It has natural connections with the group on algebra of the Universidade Nova de Lisboa.

The Mathematical modelling in biomedicine group possesses an international scientific leader in the modeling of human physiology. She was an invited plenary speaker at the European conference on Mathematical and Theoretical Biology (ECMTB) in 2016 and has developed this topic with success as assessed by the publication of books and articles in peer-reviewed journals. However, the weakness of this group, which interacts at the best international level and is among the leaders of the field, is that it is very small and its contributions heavily rely on its scientific leader who is almost ubiquitous in the group publications. This raises concerns regarding the future of the group.

The Applied and numerical PDE group gathers the remaining members working in numerical analysis in a broad sense. They develop numerical methods for the resolution of partial differential equations with a large scope of methods ranging from integral equations to mesh less method. Some of their results obtained in collaboration with colleagues from other mathematical R&D Units in Lisbon are very original and raised much attention for applications in numerical methods in inverse problems and shape optimization. A small weakness of the two groups working on numerical analysis is the lack of a common software policy, and more generally a lack of interactions on close topics (finite elements methods for fluid mechanics).

The statistics and stochastics group has organized the Data Science, Statistics and Visualization (DSSV) conference in 2017, which was an interesting opportunity in the context of the development of data science in Portugal, at the interface between Mathematics/Statistics and Computer Science. Recent developments in Extreme Value Theory are promising. This group should increase its bonds with the CEAUL in order to foster the development of that interface. CEMAT and CEAUL have complementary skills that can fruitfully interact to address modern challenges in statistical sciences. The group on Applied and numerical PDE certainly could bring additional skills to take part in addressing these questions. The group has a specifici activity in financial mathematics in particular through the FCT funded project SANAF that led to a collaboration with the Norvegian government.

Like many other R&D Units in Portugal, the ageing of certain charismatic members of the Unit could be critical for its future. Nonetheless, it seems that the younger members of the Unit are also very good quality researchers and the renewal of the team leaders might be overcome. A vast majority of the members publish their results in high quality international journals, have already supervised many students (including PhD students) and have been involved in projects/grants applications. In fact, the quality level of the Unit members is surprisingly homogeneous and rather high.

The members of the Unit stand in editorial boards of journals and societies and benefit from an international network of collaborators. They obtained grants both from FCT and at an international level during the period under evaluation: one EU FP7 project (Neurostochism), Cost Actions and had a collaboration with the University of Texas at Austin.

The Unit has many projects with industry, but each project does not involve adequate amounts of funds to be obtained by the Unit. This is a general situation all across the country. Nonetheless the Unit benefits from these synergies, serves the socio-economic world and gains contacts for its students. During the visit, the Panel has been informed that the Unit has increased its funding from industry. The strategy in this direction is convincing and the Unit can certainly play an incentive role in the country for the transfer of knowledge towards industry. The Panel strongly encourage the Unit to continue to go in that direction and to continue to send PhD students to Modelling weeks.

The Unit has encountered funding problems in the last period. As a consequence, the level of invitation of foreign researchers has decreased during the period under evaluation. The Center has an international recruitment of PhD students which is certainly very positive. They also value international exchange and an important proportion of its members have international experience.

The Unit supports or benefits from 5 different PhD programs which seems to be quite a lot and does not contribute to the visibility of the offer in Lisbon. The students might certainly get confused by this. This is particularly the case for the 3 PhD programs LisMath, the one by FCT-UL and the one by IST-UL, respectively. The online PhD program from Universidade Aberta on computational algebra is attractive and it represents an innovative opportunity. The PhD program in Statistics and Operation Research might be biased towards Operation Research. The students are well prepared for the (worldwide) job market, and many have been able to get a job in the private sector. The Unit has been successful into spreading PhD students and post-docs in academia.

The Unit would certainly benefit of an increase of scientific exchange between its members, in particular in sharing codes, software usage and good practices with respect to numerical experiments. This is particularly relevant for PhD students and post-docs who could gain in efficiency and increase their knowledge by organizing regular students meetings on these issues. The Panel observed that students use different software tools to tackle the same type of things without being aware of this situation (e.g. finite element methods through the use of LifeV). Another weakness of the Unit is the lack of human support for computation in relation to its ambitions.

The Unit has started thinking about a strategy to have ERC grants proposals, which is certainly a positive initiative. They get some help from IST-UL in this direction.

The Panel strongly recommends to merge the PhD programs offer in Mathematics and Statistics in Lisboa.

The Programmatic Funding should be partially to contract researchers with PhD in the research lines of the Unit.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática da Universidade de Coimbra (CMUC)
Coordinator: Maria Manuel Pinto Lopes Ribeiro Clementino
Integrated PhD Researchers: 66

Overall Quality Grade: EXCELLENT
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 1183 K€
Recommended Programmatic Support
PhD Fellowships: 8
Programmatic Funding: 722 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations
The Center for Mathematic of the University of Coimbra (CMUC) is one of the largest mathematical R&D Units in Portugal. CMUC gathers 66 Integrated Researchers with a PhD. It aims at the same time at producing abstract results and at supporting some demands of the Portuguese society. To that end, CMUC is a Unit with a general mathematical scope and its spectrum is very wide ranging from fundamental mathematical subjects, like category theory, to more applied and numerical mathematics. The Unit has a clear organization with six groups of relatively the same size: Algebra and Combinatorics; Algebra, Logic and Topology; Analysis; Geometry; Numerical Analysis and Optimization; Probability and Statistics. These groups interact through three thematic lines: the laboratory of computational mathematics, the outreach activities and history of mathematics.

The mathematical production of the Unit fulfills a very good international standard with some particular high level results. Some of the team members have acquired national and international recognition as attested by the remarkable fact that the prestigious Lagrange prize in continuous optimization 2015 was awarded by the American SIAM (Society for Industrial and Applied Mathematics) to one of the Unit members. The papers selected in the proposal appeared in top journals either of general scope (Adv. Math, Crelle's Journal...) either specialized (J. Differential Equations, J Funct. Anal., SIAM Num. Anal., …). The overall production of the Unit is also very satisfactory.

The training of PhD students is an important and central activity of the Unit. A large proportion of them came from abroad attracted by the researchers of the Unit: 21 of the 28 students that defended their thesis in the period under evaluation. Their countries of origin are well spread over the whole world (China, Iran, Turkey, France, Spain, Brazil, Mexico, …) proving the international visibility of the Unit. These students were enrolled through the joint PhD program run by the universities of Coimbra and Porto. From our point of view, the high quality and the visibility of this program is a keystone in the success of this Unit. It is well advertised, but the interviews with the PhD students show that they mainly came attracted thanks to the network and the recognition of the members of the Unit. The PhD students have good conditions of work, having easy access to their supervisors and to conferences and summer schools. The only notable thing to be improved is about the payment of the grants that could take some months to start. The Unit can hardly be blamed for that. The PhD students have also the possibility to take part in Modelling Weeks. During these weeks, they meet companies setting practical problems. Since they are usually very focused on their academic work and not always thinking that they could leave the academic world after presenting the theses, this Committee deeply encourages the Unit to provide PhD Students this opportunity to realize that their knowledge is valuable outside academic research.

Postdocs positions are very important for CMUC since the age pyramid of the Unit is not satisfactory: it is a weakness and may, in a close future, threaten the capacity of the Unit for maintaining the quality of its research. Post-doc fellows are indeed involved in many important projects; some of them participate to the supervision of some PhD students. Their situations are very diverse: some having just finished their thesis while some can be considered as almost confirmed researchers with a rather large experience. Notice that, as the PhD students, they come from abroad (USA, France, Italy, …), for a vast majority of them mainly attracted by the scientific reputation of their

supervisor. They are given good work condition and a large scientific autonomy allowing them to develop their ideas. They are encouraged to collaborate with other R&D Units and most of them get a position abroad.

The Unit organized many international conferences and some of its members have editorial activities. CMUC has been active and successful in applying for proposals, and its researchers manage to obtain fourteen projects funded by FCT, including three in collaboration of the University of Texas at Austin.

The members of CMUC have also a strong commitment for developing research projects with other disciplines and in particular medicine as well as with industry. No less than nine of these projects were conducted involving mainly the groups of Probability and Statistics and of Numerical Analysis and Optimization, but not only these. These activities are gathered in a Thematic Line called the Laboratory on Computational Mathematics whose aim is to promote research in computational mathematics and scientific computing, as techniques for the solution of challenging quantitative problems arising in science, engineering, finance and management. At the moment, the amount of funding obtained by CMUC this way is not so important, but it already provides some grants for Master students and the Panel strongly encourage the Unit to continue its efforts towards these interactions. CMUC, as many other national Units of Mathematics, also takes part in the recently created network PT.Math.IN devoted to favor the interactions with companies at the national level.

Like many R&D Units in Portugal, CMUC has a large activity towards the society, and in particular high school students, in order to promote mathematics. The particularity of CMUC in that direction is the organization of the Portuguese Olympiads of Mathematics. This very time consuming activity may not be the most visible at the national level, but this Committee wants to emphasize how the detection and the early training of brilliant students is important for the whole mathematical community.

The Panel appreciates the atmosphere in the Unit, sign of a dynamic management. The organization of CMUC is well adapted to their mathematical geography and allows it to be efficient. The decisions are made collectively with well-established rules for the funding of missions and invitations that is a crucial point for a Unit like CMUC with many international relationships.

Currently, CMUC has to face two structural difficulties. The most important one is a consequence of the dramatic economic crisis: the absence of any new position and promotion for a very long time. In a first time, this national problem has been attenuated by the hiring of many post-doctoral researchers, but it becomes critical in Coimbra. The second threat is increased by this fact: one of the most visible members of the Unit has been hired by a USA University, weakening the group of Numerical Analysis and Optimization, while at the same time his activity was crucial to the Laboratory of Computational Mathematics. The departure of very active researchers is something normal in the academic world, but it is important to deal with the void left by hiring young researchers. The Panel has no doubts that CMUC could attract very good candidates from the whole world and strongly encourage the University of Coimbra to open some positions in this department.

The Programmatic Funding should be partially used to hiring some researchers under contract at the Unit discretion and for sending PhD students to Modelling weeks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática da Universidade do Minho (CMAT)
Coordinator: José Pedro Miranda Mourão Patrício
Integrated PhD Researchers: 41

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 3
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 615 K€
Recommended Programmatic Support
PhD Fellowships: 5
Programmatic Funding: 381 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations
The CMAT, Centre of Mathematics of the University of Minho has 41 Integrated PhD Researchers, 12 PhD students and 11 collaborators. This Unit has a pole at the University of Minho (UM) and another at the University of Trás-os-Montes e Alto Douro (UTAD). The pole of Minho University is itself divided in two Campuses, one in Braga and the other in Guimarães. In order to manage the distance, the Unit plans to invest in video conference devices, which seems certainly relevant.

This Unit, created in 1991, modified the conditions required for a researcher to be an Integrated Researcher according to the indications of the External Advisory Board; so, the number of Integrated PhD Researchers went down from 58 in 2014 to 42 in 2018. The decrease in the number of members is also consequence of the departure of half of the members of the group of Statistics, Applied Probability and Operational Research (SAPOR), including the Coordinator of the Unit. This departure is in part a reaction after the previous round of evaluation of the Unit corresponding to the period 2008-2013. During the last 3 years, the Unit ran with limited funding. However, the remaining members were still able to find some other sources of funding to continue the research lines and produced a significant number of papers in good journals, some of them even very good.

During the last period, the hiring of postdocs and the initiation grants awarded to PhD students were rather limited. Still the Unit has created the CMAT Junior Group as a motivation for undergraduate students to start research. This is an original initiative, which has been successful. And indeed, PhD students show a relaxed attitude and declare to have a nice environment for their activity. Recently, the Unit has been able to recover some former post-doc that has got a contract.

The CEMAT is organized in four research groups:
- Algebra, Logic and Computation (ALC),
- Analysis and Applications (ANAP),
- Geometry, Topology and Applications (GTA),
- The already mentioned SAPOR.

All the groups show significant records of publications, both in terms of volume and quality.

The University of Minho participates in a joined program in Applied Mathematics with the Universities of Aveiro and Porto. During the period under evaluation they have advised 28 PhD students, 14 theses have been defended and they have had 64 master students in the Master of Mathematics and Computation and the one of Statistics. Participating in such a joint program with highly visible R&D Units is certainly a source of motivation, which plays a very positive role on the activity of the Unit.

The members of the group act as an organized team, showing a nice solidarity to cope with the difficulties. They have several inner collaborations as well as collaborations with other national or foreign researchers.

The Unit has participated or participates in several European Projects:

- CNRS PICS project (2018-2021),
- H2020 project NEWEX (2017-2020),
- Cost Actions EUT types (2016-2020),
- Marie Curie Initial Training Network,
- ESF network (2011-2015).

They also had 6 projects funded by FCT whose Principal Investigator belongs either to the University of Minho or to UTAD.

Several members of the Unit have participated in other externally financed projects. The significant contribution of the Unit in a project of Bosch with researchers of the University of Minho deserves special mention. The Panel recommends strengthening this effort towards industrial subjects, which should be a source both of funding and new questions.

Members of the Unit, especially in the research group ALC, have stablished a relevant collaboration with Computer Science researchers and have developed software that is available free.

Members of the group of Dynamic Field Theory have been able to apply the research of the group to get interesting application in Robotics and Mathematical Neurosciences. There is a group working in theoretical physics, which finds a decisive advantage in being exposed to experts in mathematics. Finally, it is fair to say that the outreach activity of the Unit, without special financial support for it, is quite impressive.

This Panel considers that the group has made a huge effort to pass over a difficult situation in funding and has been successful! And this fact deserves recognition.

The Unit needs some stable funding that allows their members to travel, attend and organize conferences, give talks and reinforce its international recognition, as well as to be able to hire postdocs, that may bring new impulse to the activity of the group, and to offer grants to students for the doctoral program.

PhD fellowships should be awarded only to students of the Doctoral Program in Applied Mathematics, MAP, shared by the Universities of Minho, Aveiro and Porto.

According to the application, 6K euros are assigned to the Unit to cover the expenses linked to the fact that CMAT is linked to PT-MATHS-IN, the Portuguese participating organization of EU-MATHS-IN and that CMAT has been a long term associate of CIM (International Center for Mathematics, a not-for-profit, privately-run association that aims at developing and promoting research in Mathematics).

CMAT is a participant of the project "Dynamics of complex ODEs and Geometry", submitted in 2017, and hosted by Université Toulouse III Paul Sabatier, to the International Programs for Scientific Cooperation (PICS) financed by CNRS.

Programmatic Funds are meant to be used in the organization and/or participation in Congresses or Conferences, Long term visits and Outreach activities.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática da Universidade do Porto (CMUP)
Coordinator: Jorge Miguel Milhazes de Freitas
Integrated PhD Researchers: 61

Overall Quality Grade: EXCELLENT
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
(B) Merit of the team of Integrated Researchers: 5
(C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 1101 K€
Recommended Programmatic Support
PhD Fellowships: 9
Programmatic Funding: 682 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations
The research of the Unit, which counts about 61 integrated PhD Researchers for the reference period, covers a large spectrum of mathematics. The most notable contributions are concentrated on fundamental aspects, but important efforts are made to catch up with applications too.

This Committee is very impressed by some exceptional achievements, especially in the areas of dynamical systems and their connections to probability theory, geometry and semi-groups, which are historically very strong. These fields count several world leading experts. The papers selected in the proposal appeared in top journals (JEMS, Adv. Math...), and more recently a paper was even accepted in “Inventiones Mathematicae”, quite unanimously considered as one of the three best journals in mathematics. The overall total number of papers is also very satisfactory (374), in particular given the subjects.

The training of PhD students is a central activity of the Unit. The group has trained in the last period over 40 PhD students, who have contributed in a significant way to the high value of the scientific production. It takes part into three different joint PhD programs, two in mathematics and one in computer science. The two joint programs in mathematics (one with Coimbra, the other with Minho and Aveiro) are managed in a very efficient way and cover a period of four years. Students begin with a first curricular year, where, besides the courses (which take place in the different sites mentioned, with an annual rotation), they have the opportunity to choose (rather freely) their respective fields and advisers, and hence also their host huniversity. This Committee wishes to emphasize the quality of these programs, in particular the care in selecting the students. The PhD programs are well advertised abroad, through standard website advertisements, but also thanks to the large network of collaborations and exchanges that the Unit and its partners have built during the years. It follows that almost half of the students are foreigners (Egypt, Netherlands, Greece, Brazil, …) or Portuguese students which have studied abroad, or come from other institutions in Portugal.

The discussion with the students has convinced the Panel that they have good working conditions, regular discussions with their advisers, and satisfactory support for travel and conferences. They also benefit from regular summer schools (lasting about one week, with short courses by well-known experts). There is however no regular seminar run by them, which might be an idea to be studied by the Unit. Besides this, they have no teaching duty. This allows them to concentrate fully on their research; nevertheless, some light teaching might prepare them better for the teaching duties involved in their possible future Professor positions. As a matter of fact, most of the interviewed students wish to stay in the academics. It is also worth pointing out that some of the theses are joint work with other departments, for instance the Faculty of Economics or the Faculty of Medicine.

Hiring of good post-doctoral fellows in another priority of the Unit, which is also vital for keeping the quality of the Unit at a high level. Post-doc fellows are indeed involved in many important projects. This is also a way to compensate for the negative effect of the age pyramid. However, this has its limits, as will be discussed below.

Most, if not all, post-docs come from outside the Unit, and a fair number from abroad. The Unit has decided to push its own students to seek fellowships outside the Unit, which can be considered a good practice. As above for the PhD students, the high level of the fellows with is certainly related to the good network of the Unit as well as of its excellent reputation. The post-docs feel well-treated in the Unit and enjoy their stay. They work in collaboration with their mentors, but have a large freedom to work on their own projects. They do not stay for unreasonably long periods stuck in the Unit, a situation observed in some other Units. Many of the fellows who left the Unit recently found permanent research positions throughout the world, sometimes in prestigious institutions.

A peculiarity of the Unit, is that it has also offered rather short post-doctoral stays (half a year for instance). It uses this as a way to test fellows (or fellows to test the Unit), and to see whether their background matches the needs of Unit. These short-term visits are quite original and seem to be very positive for both sides. Perhaps, this possibility should be considered by other Units.

One of the post-docs regrets the absence of a colloquium, he experienced in another university. The possibility of running such a colloquium should be considered by the Unit.

The group organized an important number of events or conference, and is very dynamic in that activity too. The most important event was held in 2015 and hosted over then 1100 participants: it was a joint AMS/EMS/SPM meeting, which enhanced of course the prestige of the Unit. It is involved in several major scientific networks, in particular it is a major node of the European-Brazilian network BREUDS.

Several members are also in distinguished editorial boards of journals, such as “Portugaliae Mathematica” or ”Semigroup Forum”, or have given lectures in outstanding conferences.

The activities in statistics, modeling, and computational mathematics are made more visible through GEMAC, a specific consulting office concerned with the interactions with industry and public institutions. It is already involved in several projects, and it is successful to set up collaborations and transfer, which brings substantial funding to the Unit and a fruitful motivation to address new mathematical questions and to design new algorithms. This Committee recommends that the Unit continue its efforts in that promising activity. Compared to most advanced countries, interactions between mathematicians and companies is rather limited in Portugal; CMUP has a rather advanced position on this aspect, and it might play a leading role for the development of such activities.

The Unit has been very active and successful in applying for proposals, and has now an impressive number of projects (10 FCT projects). These, sometimes substantial, projects contribute to the funding of an ambitious scientific policy, in particular the large variety of Post-doc or short term visiting positions.

The committee wishes to point out the very dynamic and innovative management of the Unit, which might serve as a model for other Units. The visit has permitted to clarify the organisation of the Unit: the four groups and four transverse lines which, at first sight, might be suspected to over-divide the Unit, are actually fully relevant, and appropriate. It appears that decisions are taking in a democratic, but also in a very reactive way. The general impression is that the Unit lives in a friendly atmosphere, without visible tensions.

Currently the most important threat to the Unit is the dramatic aging of its permanent members. This observation is of course not unique in Portugal, it is actually shared by all Units. However, it seems to be extremely accurate in the mathematics department of the University of Porto, which nevertheless is highly visible by its reseach. As a matter of fact, the last hiring of a permanent member goes back to 2001 (the Department might be penalized by the fact that its members have limited access to lecturing in engineering degree programs). As mentioned above, a smart post-doc and PhD student fellowship policy has allowed to keep the scientific production at a high level. However, this policy has its limits, and needs to be backed up by a reasonable number of permanent members (and promotions). We fear that the Unit will run to a breakdown of its research force if nothing changes in the next period. The management is negotiating with the University of having two tenure-track positions: this might be possible with the help of FCT support to new researchers positions. The Panel strongly supports this demand, as well as the choice (reinforcement in analysis and PDE) of the fields for these positions.

The Programmatic Funding is to partially serve for various purpose presented in the Unit proposal, in particular the top mentioned priority, namely financial support to cover part of the salaries of two wished tenure-track positions, for 2019-2022, but also PhD grants, or other possible expenses (travel, conferences, etc...), as well as to strengthen connections with European networks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática e Aplicações (CMA/FCT/UNL)
Coordinator: Fabio Augusto da Costa Carvalho Chalub
Integrated PhD Researchers: 82

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
(B) Merit of the team of Integrated Researchers: 5
(C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 1170 K€
Recommended Programmatic Support
PhD Fellowships: 8
Programmatic Funding: 729 K€, including for 2 (Junior) New PhD Researchers Contracts.

Justification, Comments and Recommendations
The Faculty of Science and Technology of the New University of Lisbon (Nova University) FCT/UNL was founded in 1977, dedicated to research and higher education in Science, Technology, and Engineering. Its Center of Mathematics included at the moment of the application 82 Integrated PhD Researchers and 22 collaborators. It has grown up to 97 at this moment, due to the recent incorporation of 10 new Integrated Researchers and thanks to the hiring policy at Nova University. Integrated Researchers must satisfy some conditions to belong to the Unit: they must have three articles classified in the Web of Science in the last five years or four scientific articles, two of them in the Web of Science. The group has collaborations with the Bank of Portugal and the Portuguese Navy. It also has members from Mozambique, Cabo Verde, Institute of Engineering of Lisbon and the Polytechnics of Setúbal, Beira Interior, Tomar, Portalegre and Beja.

This Unit is one of the largest and youngest in Portugal. It is structured in 4 groups:
- Algebra and Logic,
- Analysis,
- Operations Research,
- Statistics and Risk Management.

It also developed two thematic lines which are "Mathematical Modeling in Ecology, Evolution, and Genetics" and "Mathematical Modeling for the Independent Living of Elderly, Disabled, and Chronic Patients".

The first and the last groups are the biggest ones, with 30 and 38 members, respectively. Analysis with 13 members is the smallest one and Operations Research has 16 Integrated Researchers. The previous Coordinator has been able to construct a Unit with a strong activity, good cooperation within its members and international collaborations.

The productivity of Unit members, according to the acceptance rules, is rather high.

The list of selected publications contains some published in journals of very high quality, including other disciplines than mathematics. More precisely, the Unit members significantly contributed to nonlinear optimization problems, the 24th Hilbert problem and the proof that every plactic monoid is automatic. Within the first thematic line, their results have important impact, e.g. in epidemiology (dengue) and ecology (species distribution). The project and strategy with respect to at least the second thematic line (about ageing people) remains unclear, maybe due to the lack of manpower available among the Integrated Researchers. If possible, the Panel encourages the Unit to pursue that thematic line, which is both timely at the international level and presents a potential source of contracts with insurance companies. The existence of the doctoral program in Statistics and Risk Management certainly puts the Unit in a good position to tackle the challenges in this area.

The strong policy from Nova Universidade demanding that their faculty members belong to the R&D Units they lead (whenever there exists such a Unit in their research area) is seen as a constraint by some of the members. While the Panel understands the limitations of such a policy, it also sees the advantages of it. Indeed, this induces a fight against

the Portuguese tendency to gather with one's former PhD advisor. This promotes scientific independence of researchers and renewal of ideas. Nonetheless, this should not hinder the possibility to construct research projects and apply for grants between different units. The host institutions should be aware that this is their interest to promote such external collaborations and thus should provide administrative support in this direction (for instance decreasing the delays for signing agreements between different institutions).

The Unit funding is pretty well balanced between basis and programmatic funding. Indeed, members of the group have been able to be granted a significant amount of projects since 2013 and continue doing so, as for instance:

- Hilbert's 24th problem, (FCT, 2016-19),
- Semigroups: Conjugacy, Computation, Crystals and Combinatorics, (FCT, 2018-21),
- BoostDFO: Improving the performance and moving to newer dimensions in Derivative-Free Optimization, (FCT, 2018--).

Nonetheless, up to the moment, most of the funding of the Unit comes from FCT and a small part from international sources other national funding.

Members of the group have many international collaboration and international recognition as is assessed by the number of positions in Scientific Societies (Applied Mathematics Committee of EMS, Eurogroup of continuous optimization, European Soc. for Math and Theoretical).

The general policy of the Unit seems to be working well. Each member is free to define his or her research group. Each group has its own Coordinator, who is elected by the respective Integrated Researchers. Group coordinators have broad autonomy to decide, within the group budget, the precise activities that will be funded, including equipment (for individual use), missions, and visitors; often small events are also funded.

The Panel appreciated the good level of internationalization of the students, both at the level of PhD and post-docs (they came from Iran, Ghana, Italy, Ukrain, Switzerland, etc.), which is very positive. It also appreciated that the majority of the post-docs were not former PhD students in the Unit. These are good indicators that the Unit is both attractive, integrated into an international network and promotes scientific exchanges.

During the meetings with the students they praised how they were taken care of by their advisors in particular and the rest of the Unit in general. They have easy and fluid contacts with their advisors. They benefit from a good support from the Unit, both from the financial and the administrative points of view.

The low number of students is a general problem in all Mathematical PhD programs in Portugal and this Unit in particular suffers from the lack of a unique and unified PhD program in Mathematics in Lisbon. Nonetheless, the PhD program on computational algebra from the Universidade Aberta has attracted a fair number of students to this Unit and appears to be quite successful.

The activity of this Unit goes along three directions: social impact, look out for solutions to real-word problems and cutting-edge research. The Unit is nicely evolving along those lines, though there is still room for improvement.

The Unit has participated in very original outreach activities. One of the members of the Unit is responsible (creator, writer, and presenter) of the TV show "Isto é Matemática", broadcasted by SIC Notícias, a generalist TV channel. The program shows the connections of mathematics using real life examples and received several prizes, including one international (Ver Ciência 2013, Brazil) and two nominations for The European Science TV & Media Awards. This is certainly an international reference in this area.

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urthermore, many other members target general and wide audiences with their writing, or participate in outreach events. The Unit partially funds activities directed to high school students (MatNova, MathIngenious, Ciência Viva no Laboratório, ClubeMath).

In conclusion, we consider that this Unit is of high quality and should get a strong support to consolidate. This Unit could become one of the engines of the Mathematical research in Portugal.

Recommendations:

- The Unit aims to promote a research that provides solutions to real-world problems and to have a strong and fluid relation with Industry. Even if members of the Unit have contributions in other disciplines and socio-economic questions (as for instance a project to solve frequency compatibility problems in the underground), the income from this activity is still very small.

- The Unit should continue its efforts to spread connections and collaborations with companies and industry.
- One of the main problems of the Unit is the difficulty to attract PhD students. This problem is shared by all Units in Portugal, especially those based in Lisbon. Some new and imaginative outreach action, targeted to students of masters in Mathematics could help.
- Members in this Unit are trying to establish a unique PhD Program in Mathematics in Lisbon. This Panel believes that a unique PhD program in Mathematics would benefit both students and R&D Units from Universidade de Lisboa (FCT and IST) and Universidade Nova. First, a unique PhD program in Mathematics in Lisbon would increase the visibility and the strength and would give more freedom to students, since they would be able to choose among a wider rank of subjects and do it with more information and knowledge. Second, this would be in favor of obtaining a critical mass of PhD students and promote inter-relations and cooperation between them. This is something that all students are looking forward, according to what they have expressed in their meeting with this Panel.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática e Aplicações da Universidade da Beira Interior (CMA-UBI)
Coordinator: Rui Miguel Nobre Martins Pacheco
Integrated PhD Researchers: 28

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 3
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 5

Base Funding for (2020-2023): 420 K€
Recommended Programmatic Support
PhD Fellowships: 5
Programmatic Funding: 332 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations
The University of Beira Interior is the only mathematical R&D Unit located in the interior of the center-northern Portugal. At its onset in 1988 it was created with the purpose of overcoming the geographical isolation of the region from which it serves as a cultural and intellectual reference point. The goal of the administration is to create a campus comparable to Cornell in the United States or to Marburg in Germany. Efforts in this direction have been made for example by keeping the library open 24 hours a day, seven days a week, all holidays included.

It is in this context that the CMA-UBI operates. It is one of the smallest mathematics R&D Units in Portugal, despite the fact that its number of Integrated Researches has increased from 25 in 2014 to 30 in 2017. In contrast with several other Units, most researchers (with the exception of only one) are located in the same place, the UBI.

The Unit is composed of two groups, of approximately equivalent size: a group in mathematical physics, including 5 theoretical physicists, who work on various topics as probability theory, statistics, numerical analysis, PDEs and theoretical physics, and a group in fundamental research in mathematics (differential geometry, dynamical systems, ODEs, linear algebra, rings). The R&D Unit has adopted an eligibility criterion, according to which any integrated researcher must have at least one publication every two years or a record of publications of outstanding quality. As a result, the general productivity of the researchers in the R&D Unit is at a very reasonable level, although the journals have been of varying quality, and not equally distributed among research fields.

The strength of the scientific production of the Unit is in geometry and dynamical systems. Notable examples are the generalization of a theorem of Hopf on the rigidity of a constant mean curvature immersion of the sphere in 3-space and of a conjecture of Viana on the positivity of the Lyapounov exponents in the symplectic context. The group has also a strong expertise on extreme value theory on spatial random fields. This work includes important results with deep consequences in accurate modeling of extreme events.

Although the main core of the research is of fundamental nature, CMA members, especially in statistics, collaborate with R&D Units in others research areas such as nuclear engineering, health sciences or sport, as well as didactics.

The Unit has been able to host also postdoctoral researchers of international stature from abroad. The postdoctoral program, despite the limited resources, can be deemed to be successful and worthy of further financial support.

Following the general trend in Portugal, greatly enhanced in this case by its isolated location, the number of students has been decreasing and the UBI has been unable to maintain a Bachelor program in Mathematics and in Physics. In the attempt to shape itself to the need and requirements of outside world, a proposal to open a first cycle in Mathematics and Applications has been submitted to Agência de Avaliação e Acreditação do Ensino Superior and is waiting for certification. The Unit has within itself the expertise for making this a very successful BSc program. In turn the development of this new course of study could have two effects: on the one hand to allow CMA to feed its Master

and PhD programs with well-prepared students; on the other it could have an interesting impact on the research themes for example in the dynamical system and statistics group.

However, quite remarkably without the input of a Bachelor program in Mathematics and Physics, the R&D Unit is able to run two successful PhD programs with a number of PhD supervised in the reference period in reasonable proportion with the other Research Units. This is even more commendable, as it is done by actively targeting and recruiting students in Portuguese speaking countries across the world. Some of the PhD students, for example those from Angola, teach already at universities in their home country and come to UBI as part of a government program. They view it as their social duty, after completion of their PhD, to go back to their country importing their expertise and their renewed life experience. From this point of view, the UBI has a role of absolute prominence in intellectual outreach in Portuguese speaking countries.

In the spirit of seeing itself as a cultural reference point in the area, the Unit takes very seriously its responsibilities in developing also local outreach activities, such as for example the mathematical contest for high school students "Carpemath", teacher training short courses, a science academy for high school students and a first meeting Mathematics for Teaching.

The Unit participates in the Brazilian—European Partnership in Dynamical Systems. It has also been quite active in organizing conferences (7 in the reference period) and running seminars. Nevertheless, there seems not to be much contact with mathematicians and mathematics outside Portugal and the international impact of the group (projects, funds, participation in editorial committees of journals) should be improved.

The Unit faces some serious budgetary problems that influence severely their possibility to function at the top level. The overall impression is that there is a very constructive and pleasant feeling of cohesion and cooperation. The Integrated Researchers are conscious of their role and of the importance of using at best the scarce resources at their disposal.

The R&D Unit proposes:

- to strengthen their international contacts, in particular with Brazil, from where they expect to receive PhD students.
- to increase the number of postdocs, which at the moment is on the low side; for this it requires support from FCT as well as from external sources such as Santander.
- to hire PhD students (in Mathematics and, in reduced proportion, in Physics).
- to hire PhD holders with no specific profile, but who will be integrated in the main areas of research of CMA.

Recommendations:

- To enhance the visibility of the R&D Unit, we suggest starting a series of international conferences "University of Beira International Workshops" to be held on a biannual basis, so as to exploit the geographical isolation of the Unit and transform the feeling of mountainous retreat into an asset, fostering the interaction among participants.
- To help the positive influx of novel mathematical ideas the R&D Unit could envision to engage into a series of seminars (for example once a semester), to be held in cooperation with R&D Units in Porto, Aveiro, Minho and Coimbra with an alternation of the hosting venue.
- The R&D Unit could envision negotiating with the administration to transform an FCT postdoctoral position into a tenure-track position to be used within the thematic lines of CMA-UBI.
- We find auspicious that the University gets actively involved in helping out the academic environment of the countries of origin of their PhD students, as to profit as much as possible of the initial investment.
- Outreach activities should be encouraged and supported.
- Cooperation with industry (facilitated for example by the presence of statistics) should result in more funding from companies.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Centro de Matemática, Aplicações Fundamentais e Investigação Operacional (CMAFCIO)
Coordinator: Luis Eduardo Neves Gouveia
Integrated PhD Researchers: 59

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 4
(B) Merit of the team of Integrated Researchers: 3
(C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Base Funding for (2020-2023): 843 K€
Recommended Programmatic Support
PhD Fellowships: 3
Programmatic Funding: 410 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations
The Unit CMAFCIO is one of the six Units of mathematics of the University of Lisboa. It belongs to the Faculty of Sciences and counts 59 PhD Integrated PhD Researchers. It is the result of the merger of two separate R&D Units of the faculty in 2015, the CMAF on one hand, and the CIO on the other, the latter Unit being essentially focused on optimization and operations research. This merger was strongly suggested by previous evaluations. A little before that time, the University of Lisbon and the Universidade Técnica de Lisboa, which included the Instituto Superior Técnico (IST), merged as well, implying a reorganization of CMAF, so that the Unit has had to face several crucial changes during the reference period. As a resulting effect, the Unit now covers a quite large, but not exhaustive, spectrum of mathematics. The members come from several institutions, mainly from the Faculty of Sciences at the University of Lisboa, but also from various schools in Faro, Setúbal, Leiria and Coimbra.

An important decision taken in the reference period concerns the requirements for being an integrated PhD member of the Unit. This decision was suggested by the latest report of the External Advisory Board. The adopted precise rules concerning the intensity of research activities are applied in a strict way. As a result, several members had to leave the Unit, which is one of the explanations for the fluctuations in the number of members.

The Unit has no groups in the formal sense. However, as clearly appears in the project, there are three main areas of research: first “Logic, geometry and dynamical systems”(LGDS), then “nonlinear analysis and differential equations ”(NADE), finally “optimisation and operation research” (OR&0). This decomposition corresponds somewhat to groups already existing before the merger, and are still the entities where research is organized. The groups are of rather different sizes, the first (LGDS) being currently the smallest with 11 integrated PhD members, the second (NADE) the largest with 25 integrated members.

The Unit has produced several scientific results of outstanding value, for instance in Logic, with a paper in “Advances in Math”, in Dynamical systems, with a paper in “Comm.Math.Phys”, in partial differential equations, with a paper in“Arch. Rational. Mech. Anal.”, in operations research with papers in “Math. Programm” and “European. J. Oper. Res “. The total number of publications lies between 70 and 102 a year, which is a satisfactory, but not exceptional, number. As already observed by the advisory board in 2017, a large majority of these papers is published in respectable, but not top level, journals. Given the quality of the researchers, this Committee joins the opinion of the External Advisory Board and urges the Unit to work to improve this point.

Several members of the team are editor or Editors-in-chief of known journals, as “Interfaces and free boundaries”, “Computer and Operations research”, or “Portugaliae Mathematica”, or associate editors, or involved in international networks. Several others, in particular in Logic and Operations Research got international prizes or recognitions. Members of the Unit devote important efforts in outreach of mathematics, through exhibitions, books and software. Some members are also working to support the application of Lisboa to the organization of the European Congress 2024, an initiative which would obviously boost mathematics in Portugal, and hence is extremely important. Whereas the Unit was moderately active in the organization of conferences on the reference period, it hosted and co-organized

an important event in Mathematical Biology 2018 (more then 700 participants) and plans to organize others in its main areas of research in the near future, following once more the suggestion of the External Advisory Board.

The Unit takes part on the PhD program “Lismath”, joint with the other math Units of the university. This program offers a first year of curricular studies where students have the opportunity to choose their subject and adviser. The overall number of PhD students in the Unit is fluctuating in time, with a current low of 8 students, plus 3 Chinese exchange students. This low number is somewhat worrisome, much below the training capacity of the Unit. This Committee noticed, in particular, that there is only one student in PDEs, which is even rather alarming. Most of the students the Panel met came from the University of Lisboa, in contrast to some of the other Units where important efforts are devoted to hire PhD students from other universities, in particular outside of Portugal. Many of them wish to stay in academia, mainly in Lisboa or Portugal. Very few intend to go abroad after their theses. Besides this, this Committee regrets that there is no regular PhD student seminar and also the lack of a regular seminar in the OR&O group, in contrast with the Logic group which has a weekly seminar. However, the students feel globally well treated in the Unit, appreciate the high level of the research, and may obtain satisfactory funds for travels.

The Unit also counts with 5 Post-doc fellows or FCT researchers, several of them from Portugal.

As for the PhD students, this Committee found that a good part of the Portuguese post-docs in the Unit are reluctant to go abroad, or even far from Lisboa.

The Unit has an impressive list of collaborations with companies. A large part of these projects rely on the group OR&R, which has partnerships with the Portuguese Navy (for Harbor protection), companies like Emel (mobility and parking in Lisbon), Unilever and several others. These collaborations sometimes involve a PhD student, working half-time in the company and half-time on a PhD Thesis: one of these students the Panel met worked for the Navy (and is still collaborating with the Unit after the defense of the thesis), another for a transportation company. Another outstanding project, held in the NADE group, deals with models for dengue vaccinations (jointly with SANOFI), combining nonlinear dynamics with data analysis. This project involves other R&D Units in Lisboa and, unfortunately, one of the project leaders has recently left the Unit.

The Unit has been rather successful concerning FCT projects, since its members won six projects as Principal Investigators (and to others as researchers), providing the Unit with important funding for its research, travel and post-doc positions. The groups RO&R and LGDS have been particularly successful in their applications.

Whereas a good level of research has been maintained in each of the groups, the committee has not been convinced that significant scientific interactions between the three groups have taken place since the merger of two Units in 2015. The same observation applies to the governance of the Unit, where no common project seems to have been elaborated or emerged since then. It is even possible, if not likely, that some tensions have been created instead. This raises of course the question of the relevance of the merger.

In the course of the evaluation of all six Units of the university, this Committee made the observation that many scientific topics appear simultaneously in various Units, with only rather subtle differences. The Committee was led to the conclusion that the the Units and their scientific fields of expertise are overall the effect of their (long) history, and that perhaps, with the advent of new generations of researchers, one might leave the past behind and possibly consider performing changes in the form and number of the Units. This would lead to more consistent and efficient Units. It is difficult to give precise indications how these changes should be carried out, and anyway, the precise form of these changes should be left to the researchers and the University. However, the Committee urges the R&D Units and the University to take this possibility seriously into account.

The Panel strongly recommends to merge the PhD programs offer in Mathematics and Statistics in Lisboa.

The Unit is already active in several networks and intend to do so for the next period.

The Programmating Funding should be partially used for the various demands of the Unit, for instance the grants for students at different levels (from undergraduate to PhD) and for post-docs, as well as the other demands in the applications, including for strengthening international networks.

Evaluation Panel: EXACT SCIENCES – Mathematics

R&D Unit: Grupo de Física-Matemática da Universidade de Lisboa (GFMUL)
Coordinator: Jean-Claude Zambrini
Integrated PhD Researchers: 18

Overall Quality Grade: VERY GOOD
Evaluation Criteria Ratings
(A) Quality, merit, relevance and internationalization of the R&D activities of the Integrated Researchers in the R&D Unit Application: 5
(B) Merit of the team of Integrated Researchers: 4
(C) Appropriateness of objectives, strategy, plan of activities and organization: 2

Base Funding for (2020-2023): 270 K€
Recommended Programmatic Support
PhD Fellowships: 4
Programmatic Funding: 278 K€, including for 1 (Junior) New PhD Researcher Contract.

Justification, Comments and Recommendations
Since 1995 GFMUL is a dynamic and highly internationalized group in Mathematical Physics, composed by a small number of researchers with common interests. It is indeed the smallest mathematics R&D Unit in Portugal, as it involves 18 Integrated PhD Researchers coming from five academic institutions in Portugal and some PhD students from different nationalities: they fit in the four lines of the project.

It is the unique Center devoted specifically to Mathematical Physics and the applicants claim a unique position in Portugal. Nevertheless, there are other Centers in Portugal that develop high quality lines of research in this area, and interactions with them should be promoted at all the levels.

The group highlights five very high-level contributions. The GFMUL Coordinator has been one of the pioneers of Stochastic Mechanics, following its founder Edward Nelson from Princeton University, and the heritage of this field has been cultivated at GMFUL by other members. Indeed, one of the five most important contributions deals with this topic and such a line includes also especially interesting lines of collaboration with prominent researchers at EPFL (Lausanne, Switzerland). The other three lines of research are also well represented in the selected five contributions, as well as in GFMUL main publications, which include top journals. Collaborations on numerical topics with CEMAT is of the highest level, and has led to striking publications. The scientific output of the group, available at its webpage, shows an internationally highly competitive research.

Being a small group, it is enough for them a soft organization structure. They present a natural plan of activities, even though some of the information about the project and the budget is somewhat unclear.

As a continuation of the structure maintained until now, the project is based on a high turn-over of PhDs and post-docs, recruited internationally. This strengthens the research network of GFMUL and becomes a highly interesting bet.

Consistently, they ask for a very large number of PhD positions, which would be a strong responsibility for the small number of researchers who can be advisers (currently, 10 permanent and, eventually, 7 FCT postdocs). PhD students attend a PhD program in Mathematics where Mathematical Physics is under-represented. Apart from PhD students, the Unit concentrates mainly in hiring post-docs (8 postdocs for 2 years each), but no hiring of researchers is planned. This will stimulate the strenuous behavior of the group. However, some difficulties appear. On the one hand, PhD students would require a bigger group in order to interact with more people, including their peers. On the other hand, the Unit Coordinator explains that the ratio Researchers/Permanent is unusually high in this Unit (a datum kept in mind by the postdocs), while the median age of the Unit is ten years lower than the median age at the Universidade de Lisboa. Even though this contributes to the dynamism of the Unit, it can be a problem for its renewal. Indeed, taking into account the age of the researchers with nuclear CV (the Coordinator is over the age of retirement in Portugal), the absence of hirings might be a drawback for the future.

Some activity by one of its members about study groups with industry is reported. However, its fruits are not clear, and the group had not obtained private funds. However, they have been very successful obtaining research projects, including international ones.

The applicants include an original proposal of public talks by prestigious scientists (such as Fields Medals or Nobel prizes). It might be questionable to put so much effort on the organization of such an event for a large public audience, especially for a Unit that seems to treasure its isolation. The proposal might be very fruitful if the group is capable of taking advantage of this activity in order to find top new lines of research and contacts. However the ratio cost/true benefits of this proposal should be tracked very carefully.

The applicants claim that a long-term strategy would include the creation of a bigger national Center in Portugal; indeed, they mentioned the stellar moment when they organized the ICMP, sixteen years ago. Nevertheless, to this aim, they should be more ambitious and explore interactions and synergies between the group and other Portuguese groups in Mathematical Physics, starting at CAMGSD in Lisbon and including lines not directly developed by the four ones at GFMUL, such as Mathematical Relativity. Once again, the claimed aim does not seem to be in tune with the general attitude within the Unit.

Of concern to the Panel is the unawareness of the Unit of their gender unbalance. While it is true that representation of women is not uniform throughout fields, there does not seem to be any concern leading to activities that would result in an open and encouraging atmosphere.

Summing up, the Unit is dynamic and highly internationalized. It has achieved high quality publications, including some top highlights, and, clearly, it deserves to be supported by FCT. However, some issues should be taken into account:

- Being internationally competitive, the group should try to attract international funds, as well as to detect lines with potential applications to industry or society.
- Concrete steps for the definition of the role of the Unit in the Portuguese system, and the long-term sustainability of the project and its staff, should be taken.
- The issue of gender balance should be taken into account by the applicant.
- The self-evaluation of its activity and projects is a bit problematic: the advisory board reports dates back to 2013 and some data of the application are not consistently well explained.

The Panel strongly recommends to merge the PhD programs offer in Mathematics and Statistics in Lisboa.