

Institution: Queen Mary University of London
Unit of Assessment: 10

1. Unit context and structure, research and impact strategy

1.1 Highlights

Queen Mary's School of Mathematical Sciences has experienced a period of exceptional growth and major transformation since 2014. In this REF period:

- Of the current complement of permanent research-active staff, 27 (representing 26.2 FTEs) were appointed since the previous REF, a strong demonstration of Queen Mary's commitment to investing in our discipline. The number of research-active academic staff has increased from 41 to 60 (40 to 58.2 FTEs).
- The School successfully applied for £17.7M (fEC) of research funding during this REF period, with 40 EPSRC grants (5 of which are over 0.5M) and 18 research fellowships (including 2 EPSRC, 7 ERC and 4 Royal Society). Our research income during the current REF period averaged £1,630k per year. This compares with an average of £755k per year in the previous REF period. (Source: HESA. → *Section 3.*)
- The Mathematical Sciences Building was recently extended, remodelled and completely transformed in a £18M project which has provided the School with an excellent environment for research collaboration. (→ *Section 3.*)
- PhD completions have averaged 10.0 per year in the current REF period compared to 7.2 in the previous, an increase of nearly 40%. (Source: HESA.) This metric is set to grow strongly, as annual enrolments have increased to around 20 in recent years. (→ *Section 2.*)
- In 2018, Queen Mary became a partner of the *Alan Turing Institute* (ATI), opening up a new channel for interdisciplinary work. With **Farber** as *Turing University Lead*, the School played a critical role in initiating and developing this University-wide enterprise. Currently, four members of the School benefit from substantial support (grants and fellowships) from the ATI, and five more are Turing Fellows.
- The School's visibility has been enhanced through hosting major conferences, including the British Mathematical Colloquium (2014) and the Conference on Formal Power Series and Algebraic Combinatorics (2017).

Since REF2014, the School's activity has been divided into six – increased to seven in September 2020 – new Research Groups. As explained in Section 1.2, this restructuring has enhanced the School's inter- and intradisciplinary research by narrowing the cultural divide between pure and applied mathematics. The School plays a leading role in the Institute for Applied Data Science (IADS), with Farber holding the Directorship since the Institute's inception in 2018. The IADS supports wide-ranging collaboration across Queen Mary and coordinates the University's activity in data science with the Alan Turing Institute, maximising the potential for scientific cooperation with the institute's other university and industry partners. Across all Queen Mary faculties, a total of £37.5M in grants has been awarded to IADS members since 2018.

1.2 Structure

One of the School's key aims for REF2014 and beyond was “*to sustain our traditional strengths in core mathematics and strengthen where necessary, whilst also identifying and securing investment for emerging areas*”. It is within this context that we have expanded the School substantially, with

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the number of research-active academic staff rising by about 50% (→ *Section 1.3*). This aligns with the School's Research Strategy for this REF period, which in 2014 envisaged increasing academic staff numbers to 62 in 2018–19 (close to our achieved figure of 60). Our carefully managed growth has paid off, evidenced through significantly increased grant income and a rising level of interdisciplinary and impactful research. This reflects our strategic understanding that a successful mathematics department needs to have breadth as well as depth in order to promote intradisciplinary research and respond effectively to funding initiatives. Such an academic unit also needs a certain critical mass to provide a stimulating research environment for its staff.

The School has a team of 13 Professional Services staff, led by the School Manager. This team provides excellent support for research and enterprise, finance, teaching, student support and outreach, releasing academic staff from non-core activities and allowing them to concentrate on their primary duties, including research.

The School has a Director of Research (DoR) and a Research Manager, both of whom promote research in the School by facilitating grant applications, coordinating responses to calls from grant-awarding bodies, and providing a stimulating environment and framework in which researchers can thrive. The DoR is assisted by a deputy who covers a well-defined portion of the brief (currently research grant facilitation). The DoR chairs the School's Research Committee, which advises on research strategy, policy, and presentation. The recommendations of the Research Committee feed into the decisions of the School Management Team (SMT), of which the DoR is a member. The DoR also represents the School within the faculty as a member of the faculty's Research Advisory Group.

Research in the School of Mathematical Sciences covers a wide range of topics in the mathematical sciences, from pure to applied. Growth on the scale that we experienced over the course of the REF period places additional demands on management, and has the potential to alienate members of staff. To mitigate this risk, the School has been structured into six Research Groups (with a seventh, *Statistics & Data Science*, added in September 2020):

- Algebra & Number Theory,
- Combinatorics,
- Complex Systems & Networks,
- Dynamical Systems & Statistical Physics,
- Geometry & Analysis,
- Probability & Applications.

Each research group is managed by a Head of Group who line manages group members, represents its interests at the School's Research Committee, and provides strategic direction and co-ordination.

Prior to the formation of these groups (in 2014–15), the School was divided along traditional lines into Pure Mathematics, Applied Mathematics, and Statistics. The new structure was instrumental in breaking down research silos – in most groups, activity ranges across the spectrum from pure to applied. For example, in the *Geometry & Analysis* group, some researchers pursue foundational work in differential geometry while others work on numerical simulations in relativity, or apply topology to data science. The *Probability and Applications* group encompasses pure probability theory, financial mathematics, and the mathematics behind the control of malaria, while the *Combinatorics* group tackles pure combinatorics alongside game theory in economics and combinatorial optimisation. The research groups constitute much more than a convenient classification system: groups meet together at regular seminar series and collaborate on, for example, doctoral training centre applications.

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The research group structure is expected to change in the long term to accommodate the shifting patterns of research interests within the School. For example, we have long been committed to increasing the School's strength in Statistics, one of the aspirations contained in the School's *Research Strategy* for this REF period. As a result of targeted appointments made over the period, a standalone Statistics group is now viable. In September 2020, the statisticians separated from *Probability & Applications* to form the new *Statistics & Data Science* group, expanding by two further appointments in the process.

1.3 Our Strategy

Our overall strategic aim during the REF period has been **to pursue the highest quality research while cultivating a supportive research environment**. We have sought to increase our capacity for more applied or applicable work, while further increasing the quality of foundational research. To this end we have used new appointments to both refresh existing research areas and move into new ones, and, as a consequence, have increased and diversified our funding portfolio (→ *Section 3*). Another aim has been to support the School's decisive entry into the field of data science, backed by our partnership with the ATI. A significant by-product of this focus has been the strengthening of research-informed teaching in the School, most obviously in the form of a new MSc in Data Analytics.

The new appointments during the REF period are summarised below, illustrating the School's direction of travel, its progress in meeting the above aims, and the vitality of its research activity.

Objective 1: Strengthening Statistics

Historically, research in statistics has focused on the design of experiments. While this was a good complement to combinatorics, a long-term strength of the School, the need to broaden the scope of our statistical research was apparent. We have strengthened this area by recently appointing **Griffin, Liverani, Shestopaloff** and **Yoo**, who take the School into diverse new areas, including statistical inference for infectious diseases, Bayesian modelling with applications, and Markov chain Monte Carlo methods for statistical inference. Liverani initiated a collaboration with colleagues in the School of Medicine and Dentistry, securing funding from the European Regional Development Fund (ERDF) and the Barts Charity for a project on AI-based disease monitoring and tracking. Griffin and co-authors evaluated the relative cost-effectiveness of various interventions to control malaria in sub-Saharan Africa. The findings informed the policy of the *Global Fund*, as detailed in one of our impact cases.

Objective 2: Initiating research themes in Optimisation and Machine Learning.

The research areas of optimisation and machine learning are synergistic, and strengthen the existing *Combinatorics* and nascent *Statistics* groups. **Ward** brings expertise in discrete optimisation and operations research from the perspective of the theory of algorithms. **Fischer** has a similar perspective, but has interests at the lively intersection of game theory, economics and theoretical computer science. **Benning**'s central interest is in inverse problems, and his work touches on optimisation, functional analysis, machine learning, image processing, compressed sensing and data analysis. The promise of all three of these early career researchers has been recognised by the award of substantial grants (two EPSRC New Investigator awards and a Leverhulme Early Career Fellowship). These themes are further strengthened by a new appointment starting in September 2020.

Objective 3: Expanding the reach of research in pure mathematics.

Three strong appointments in Number Theory, **Lester, Saha and Sasaki**, open up a major new research direction for the School. These early career researchers have placed Queen Mary solidly on the number theory map, and, through a number of substantial papers in top-ranked journals, have

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made notable progress on the theory of automorphic forms, the Langlands correspondence and the Artin conjecture. External recognition of the promise of these researchers includes the award of a £580k EPSRC grant on Automorphic Forms starting in June 2020. Although based in the *Algebra & Number Theory* group, Lester has strong ties to *Geometry & Analysis*. In other developments, **Nguyen** joins a small but powerful group in Differential Geometry, **Rincon** adds to the School's existing expertise in exploring the interplay between Combinatorics and Algebraic Geometry, and **Ruzhansky** and **Shao** boost the School's expertise in partial differential equations. In 2018, Buzano and Nguyen were awarded EPSRC funding of £613,000 to study 'Advances in Mean Curvature Flow: Theory and Applications'.

Objective 4: Supporting research in Relativity

We have an exceptionally strong *Relativity* group, bolstered by new appointments **Figueras**, **Godazgar** and **Markakis**. The group has a particular interest in gravitational physics and expertise in numerical analysis applied to relativistic systems. The group has made significant contributions to the cutting-edge and active area of gravitational waves. Markakis is a member of the Laser Interferometer Gravitational-Wave Observatory (LIGO) consortium, which coordinates experimental work on the detection of gravity waves. Figueras contributes to the development of *GRChombo*, a computer code to solve the equations of general relativity in extreme situations, such as the collision of black holes, a source of gravity waves. Aside from its value to astrophysicists, *GRChombo* has been used by Intel as a testbed for developing optimisation and profiling tools for its vectorising compilers. This group has been very successful in attracting funding – including two new Royal Society University Research Fellowships, one renewal and two enhancements – and its managed growth is contributing strongly to the ongoing sustainability of the School.

Objective 5: Targeting more applicable and impactful research

With the arrival of **Farber** and **Skraba** (together with a recent appointment not in place at the census date) the School has moved into applied and computational topology, a topic that is emerging as one of the important mathematical foundations for applied data science. **Moriarty** has interests in applied probability, game theory and control theory, which he applies to real-world energy systems. **Glau** and **Rodosthenous** bring expertise in stochastic processes and mathematical economics to address problems in financial mathematics – a new direction for the School – while **Huang** and **Maltsev** initiate research in mathematical biology. These research directions have been strongly supported by the Alan Turing Institute, through which Farber, Huang, Moriarty and Skraba have received significant funding from various sources. Maltsev's research excellence has been recognised by the award of a Royal Society Research Fellowship.

Objective 6: Appointments to maintain existing strengths

Other appointments during the REF period strengthen and refresh the existing research interests of the School. **Muirhead**, **Shamis** and **Sodin** add considerable power to the *Probability and Applications* group in the area of stochastic processes and statistical physics, while **Clark** ensures the sustainability of dynamical systems research within the *Dynamical Systems and Statistical Physics* group (a theme that will be further strengthened by an additional appointment in September 2020). Sodin's research programme has received exceptional support in the form of a Royal Society Wolfson Research Merit Award, Philip Leverhulme Prize and ERC Starting Grant.

The net effect of appointments made during the REF period has been a substantial increase in research capability. The number of independent research staff (academics on teaching and research contracts, and postdoctoral research fellows) has increased from 46 to 58.2 FTE, and postgraduate research assistants from 8 to 16.5 FTE.

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1.4 Approach to identifying, enabling and supporting impact

The School's current Impact Champion, appointed in August 2016 to lead the development of our impact strategy, has instituted a rigorous pathway to impact.

The first stage in this pathway is the discovery of *potential impact*. To this end, the School takes a pro-active approach to alerting staff to the need to exploit suitable research projects for impact generation. For arriving staff, this happens during induction. Thereafter, staff members are reminded on a regular basis of resources such as support from the Impact Champion or Research Manager and the School's Intranet, which contains a detailed explanatory 'Impact' section with examples of top-ranking REF2014 case studies. By these means, staff become aware of the impact potential of their activities, and individual discussions are held with academics to uncover new potential impact cases. This approach has proved successful. For example, through this pathway, it was discovered that a member of the *Geometry and Analysis* group specialising in relativity theory (**Valiente-Kroon**) had worked on applying transformation optics to cloaking. It transpired that this work had applications to antennas for aircraft or satellites, leading to one of our current impact cases: '*Transformation optics – from cloaking to revolutionary satellite antennae*'.

Once potential impact has been uncovered, its owner is encouraged to further *develop impact*, and offered material support where necessary. The nature of this support varies, and to date has taken the form of postgraduate research studentships or research assistants to collaborate on the underpinning research, or a reduction in workload in other areas. Staff are also encouraged to access Queen Mary's Impact Acceleration Accounts (UKRI or institutionally funded), through which four projects have successfully secured additional funding. Once an impact case has reached a sufficiently mature stage, it is considered for inclusion in the School's REF annual review, at which point it is evaluated internally and/or externally. The impact case pipeline is recorded and monitored by the Research Manager and Impact Champion.

The School has also benefited from the UKRI-funded COVID-19 Rapid Response Impact Acceleration Account. A grant of £10k from this account supported a study – led by **Lacasa** from Queen Mary and including the Universities of Bristol and Exeter – to investigate mechanisms for balancing load on scarce medical resources. By optimising the transfer of critical ICU patients between hospitals and optimising the allocation of new patients, the greatest number of patients can be given access to life-saving treatment. The algorithm proposed by the researchers has been validated using realistic data from the UK and Spain, and we expect this work to produce impact in future.

Looking beyond the current REF, we consider impact potential when making new appointments. Indeed, six of the appointments made in the REF period had capacity for impact generation as a major criterion. Beyond the REF, a priority for the School is to strengthen ties to non-academic organisations, and a first step towards achieving this is the recent inauguration of the position of 'Industry Lead'.

1.5 Structures to facilitate interdisciplinary research

In 2018, in a major five-year £5M investment, the University joined the Alan Turing Institute (ATI) as a partner university and established the *Institute of Applied Data Science* (IADS). The School plays a significant role in IADS; **Farber**, who is based in the School, initiated the establishment of IADS and acts as its current director, as well as representing the University as Turing University Lead at 50% FTE. The IADS coordinates world-class research activity in data science and artificial intelligence across Queen Mary and industrial partners. It brings together researchers from all faculties to tackle a broad range of social, political and health issues. Research themes currently being explored include: ethics in medicine, bioethics and human rights, development economics, analysis of genetic and genomic data, statistical models for cancer risk, machine learning, artificial intelligence for data analytics, and national cyber security. **Farber's** dual role as IADS Director and

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Turing University Lead ensure optimum collaboration between the University and the ATI. For specific examples of research collaborations beyond Queen Mary enabled by IADS, see Section 4.

1.6 Maintaining an open research environment

Queen Mary operates an open access repository, 'Queen Mary Research Online' or *QMRO*, where academics can easily record publication details and deposit 'post-prints' of accepted articles through a database called *Elements*. To maximise compliance with REF and UKRI open access policies, the School's Research Manager sends monthly reminders to research-active staff to deposit accepted papers in the repository in a timely manner (and academics can delegate this task to the Research Manager in the three-month window following a paper's acceptance). The School maintains a feed from QMRO to academics' individual webpages, providing a list of all publications, links to published articles, and deposited post-prints. The Research Manager meets all new academics, fellows and research assistants soon after their start at Queen Mary to explain the support available to them, and to highlight the requirement to comply with the open access policy. The Research Manager also meets with UKRI grant holders to explain the routes to open access available to them, and how to access funds for publishing via the 'Gold open access' route. The School achieves a better than 98% compliance with the REF open access policy.

This open access approach extends to data and simulations. Generally, reproducibility in mathematics relies on nothing more than pencil and paper. An exception in the School is the work on relativity, part of which relates to numerical simulations. To aid reproducibility, the code used in numerical relativity simulations is open-source and uploaded to GitHub/GitLab. Members of the *Geometry and Analysis* group contribute to the [Einstein Toolkit](#) and to [GRChombo](#), both open access. A [data vault](#) is being built for sharing simulation data; when complete, the group's simulation data will be available through this repository. As parameter files and essential checkpoint files used in simulation studies are stored on GitHub, it is always possible to retrieve the version of the code used in a specific paper and regenerate the data if needed. Essential checkpoint files are stored separately in external hard drives. Other types of data which do not take much space, such as waveforms and apparent horizons, are also stored in hard drives, and made available upon request.

1.7 Research integrity

Queen Mary has adopted the commitments of the UUK *Concordat to Support Research Integrity*. Though the scope for unethical conduct is less in mathematics than in many other disciplines, the School is nevertheless committed to the principles enunciated in the *Concordat*. The *Queen Mary Doctoral College* offers training to PGR students as part of their development programme (→ Section 2). Events include training sessions in *Honesty, Rigour, Care: Researching with Integrity* and *Authorship in Research*. Finally, the University became a signatory to the San Francisco Declaration on Research Assessment (DORA) in 2020, and the School has embedded its principles in its appointment and promotion processes. Journal impact factors are not used in any assessment or selection procedures, citation counts are interpreted within context, and expert opinion is sought where appropriate.

2. People

2.1 Recruitment Strategy

We are reaching the end of an intensive period of appointing new academic staff. In line with Queen Mary's university-wide aim to "attract the best researchers from all over the world" [REF5a, Section 2] we have focused on identifying talent at an early career stage and making appointments at a junior

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level – except when there is a specific need, for example to provide leadership, that cannot be readily met by existing staff. This approach leaves scope for internal promotion to reward exceptional performance. Thus, of 27 permanent Teaching & Research appointments during the REF period (and continuing at the census date), just four (3.2 FTEs) were at professorial level. The scale of the appointments demonstrates the School's commitment to fostering new talent and developing the next generation of research leaders.

As noted in Section 1, the School's Research Strategy envisioned a controlled expansion of academic and research staff over the REF period. Indeed, we have seen a 50% increase in the number of academic staff. The primary criteria for appointments have been research excellence and the potential to contribute to both the financial health of the School and its collegial atmosphere. While retaining strength in pure mathematics, the School has increased its presence in more applied areas. Fixed-term contracts are used only where necessary and, in the case of Teaching & Research staff, their application is restricted to replacing staff who have taken up fellowships. A small number of part-time contracts enable the retention of staff with valuable expertise who are unable, or prefer not, to work full-time.

Looking ahead, the School aims to consolidate the gains made over the past seven years and ensure sustainability by nurturing diverse funding streams and making judicious appointments to maintain research strengths.

As a clear demonstration of our commitment to gender equality, every job advertisement since 2013 has referenced the School's progress with respect to the Athena SWAN Charter, detailing our Bronze award and linking to our publicly accessible website, where potential applicants can find information on our support structure, family friendly policies, Athena SWAN, and the London Mathematical Society's *Good Practice Scheme*. More recently, the School adopted a more direct approach whereby existing staff in the relevant research area are asked to consider and highlight any female applicants they know who may be suited to the role. The School is also proactively inviting more female seminar speakers, thus diversifying our colleagues' networks with the ultimate aim of creating a more inclusive department.

The REF period has seen a modest improvement in gender balance. The proportion of female independent research staff has increased from 9% to 12%, and that of postdoctoral research assistants from 13% to 18%. We are focused on continuing this upward trend.

2.2 Staff development strategy: probation, appraisals, workload and leadership

Following appointment, staff pass through a probationary period (one year for research staff – PostDoctoral Research Associates (PDRAs) and Fellows (PDRFs) – and three years for lecturers and senior lecturers who are new entrants into higher education). During the probationary period, academic staff are assigned an experienced member of academic staff as a mentor. Probationary objectives are set and reviewed regularly; these objectives include the production of high-quality research publications, the submission of competitive grant applications, and may include industry collaborations to achieve impact beyond academia.

After completing probation, staff undergo annual appraisals, for which the appraiser is usually the head of the relevant research group. These meetings are the primary forum at which promotion prospects can be discussed, or adjustments in workload proposed in order to prioritise certain objectives. Annual appraisals assist academic staff in both professional and personal development, identifying the necessary support and training required for advancement. Early career staff must undertake skills training with PGCAP (PostGraduate Certificate in Academic Practice), and other staff are encouraged to use Queen Mary's ADEPT path to a Higher Education Academy Fellowship.

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In 2019, the School changed its approach to academic staff appraisals by having either the Head or Deputy Head of School attend as Academic Development Mentor to achieve uniformity across all appraisals, provide guidance and support for further career development. The aim of this is to ensure that appraisals are genuinely meaningful conversations that provide staff with relevant and consistent guidance, support, and clarity of expectations for promotion, from those most directly involved in the process. This system helps the School more readily identify staff who have met expectations for promotion, and to encourage staff to apply when appropriate. Staff feedback on this has largely been positive.

A workload allocation model is maintained on an annual basis by the Head of School, which acknowledges and allows credit for responsibilities such as PhD supervision, and allocates time on funded grants and for impact generation. The typical teaching load of two modules per year allows staff to devote considerable time (40%) to research. Additionally, the School is keen to promote *diversity in its leadership*. We operate an open process for filling leadership positions, encouraging expressions of interest from any member of staff.

Overall, we have an excellent record of spotting and nurturing research talent. During the REF period there were 23 promotions in total: 10 from Lecturer to Senior Lecturer, 3 from Lecturer directly to Reader, 7 from Senior Lecturer to Reader, and 3 from Reader to Professor.

2.3 Academic Staff

All new and early career academic staff are supported by an assigned mentor and a comprehensive training programme run by Queen Mary's *Academic Development* department, with training addressing areas such as research strategy, PhD student supervision, and research grant applications and management. Early career staff are given a lighter teaching load and reduced administrative duties (typically a half teaching load in the first year and a reduced overall load in the second), and receive additional financial support for travel and equipment. Permanent new academic staff also receive a £4,000 start-up fund over their three-year probation period to encourage networking and development, and all early career staff are given priority in the allocation of postgraduate research studentships. Over the REF period, a majority (12 out of 23) of those appointed at Lecturer or Senior Lecturer level were already allocated at least one discretionary (either EPSRC DTP or Institutional) PhD studentship by the end of the period.

New staff are set probation objectives in teaching, research and related activities, and supported in their development via regular meetings. These arrangements have proved to be effective, with all staff who reached the end of their probationary term during the REF period satisfactorily achieving their objectives. Staff appointed at Lecturer level are expected to transition to Senior Lecturer within six years of appointment, and this is usually achieved.

2.3.1 Policy for granting sabbatical leave

Recognising the importance of dedicated research time, the School supports academic staff who wish to apply for sabbatical leave, within the constraints of the School's operations. Queen Mary has a robust policy on granting sabbatical leave, and staff requesting leave are required to make a strong case for the benefit the leave will bring in terms of research or impact generation. During the REF period, leave was granted on 16 occasions, for a total of 139 months (12 months of which were unpaid).

2.3.2 Procedures to facilitate exchanges between academia and other sectors

Queen Mary's *Business Development Team* pairs academics with commercial partners, to promote contact and collaboration with industry and other sectors. In 2019, the School created the role of Industry Lead to further this objective (currently filled by **Glau**, who brings practical experience in

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collaborating with other sectors). This initiative is effectively suspended owing to the COVID-19 pandemic, but will restart as soon as the opportunity arises.

2.4 Postdoctoral Researchers

The School has a thriving community of postdoctoral researchers, with a total of 50 engaged for some portion of the REF period.

Queen Mary is committed to supporting the career development of postdoctoral researchers, as set out in the seven principles of the *UK Concordat*. Staff development is coordinated through Queen Mary's *Researcher Development Team*. The development programme includes workshops, courses, and events on topics such as applying for fellowship and research funding, educational and learning development, career planning and management, and leadership. In addition, one-to-one developmental coaching and mentoring options are available. One practical way in which postdoctoral researchers are brought into the School's decision-making process is via an allocated representative position on the School's Research Committee. More generally, postdoctoral researchers are always included in events organised in the School, whether developmental (for example, open access advice, funding opportunities, and grant writing workshops) or social (such as the annual dinner).

Additionally, Queen Mary's *Careers and Enterprise Team* offers dedicated career advice and support for researchers, and organises events to foster networking opportunities between employers and research alumni. They also run a programme that offers short-term internship opportunities in the private sector for postgraduate research students and postdocs.

2.5 Postgraduate Research Students

One of the key aims mentioned in our REF2014 submission was "to continue expanding our cohorts of postdoctoral and PhD researchers". We now enroll around 20 students on our PhD programme each year. Postgraduate research students are fully embedded in the research culture of the School.

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
<i>PhD students enrolled</i>	13	9	13	15	23	18	19

We have instituted a *PGR Open Evening* in November and a *PhD Opportunities Day* in January, to introduce potential applicants to Queen Mary and the School, with the aim of increasing the number of applications and maximising conversion rates (from initial approach to application to enrollment). The January event targets current and potential applicants to the School, and gives a unique insight into our research culture. It includes talks from the research groups in the school, information on the application process and funding, discussions with current students, and lunch with current students and staff.

2.5.1 Sources of funding

We have actively worked towards widening the range of funding sources for studentships in the School in past years. Rising EPSRC grant income has correspondingly increased our allocation of EPSRC-funded studentships; we manage more research grants that include studentships (from the *European Research Council*, *Leverhulme Trust* and *Royal Society*); the Faculty's *Research Support Fund* (→ Section 3) has been used to enhance substantial grant applications by adding a postgraduate research studentship; and the School itself is investing more in postgraduate research funding to increase our cohort of students. We are also advertising more of our research externally and globally and have attracted students funded by government schemes: CONACyT (Mexico), KAU

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(Saudi Arabia), LPDP (Indonesia), CSC (China), HEC (Pakistan), the Algerian Ministry of Higher Education, and the Malaysian Government and International Islamic University Malaysia. In order for our strategy of increasing postgraduate student numbers to be sustainable, we must continue to diversify sources of support, and this will be a major objective in coming years.

2.5.2 Training and development

As part of their training, first-year postgraduate research students attend and are examined on courses provided by the *London Taught Course Centre* (LTCC) for a total of 30 academic credits. Although the LTCC has a broad syllabus, it cannot address the needs of all students; therefore, with the appropriate approvals, it may be possible to substitute some LTCC courses with MSc modules offered by the School.

At an institutional level, training is provided by Queen Mary's Researcher Development team. The *Research Development Programme* at Queen Mary offers workshops throughout the year and includes training sessions designed for PhD students (such as *Getting started with your PhD*, *Working with your supervisor*, *Presenting your research to an audience*, and *Making a poster presentation*). The team also runs a *Skills Point Database* that monitors students' development activities (210 hours of which must be completed by every student over the course of their studies). This quantity of training is advised by the UKRI, and is roughly equal to two weeks of training and development per full-time year of study. These activities include attending and contributing to seminars, discussions or study groups.

Various training and development activities are run at the School level:

- The School's postgraduate *Training and Mentorship Seminar* covers two main activities: development of teaching practices within mathematics, and the creation of a professional portfolio as a mathematician. The first activity focuses on teaching assistant training and best practices in the classroom specific to the effective and clear communication of mathematics and mathematical concepts. The second addresses various issues surrounding life as a mathematics student, including formation of a comprehensive academic portfolio, giving talks, writing papers, looking for a postdoctoral position, and life beyond the viva.
- The *Queen Mary Internal Postgraduate Seminar*, QulPS, is a series of weekly School-funded talks run by students for students. QulPS provides a valuable forum for our research students to discuss their work, and creates an opportunity for them to gain experience in presenting mathematics to a non-specialist audience.
- Annually, the School organises a *Postgraduate Research Day*. This event takes place in late April or early May with the aim of showcasing the exciting research being undertaken in the School, and developing students' confidence. Third-year research students give 15-minute talks on their research, and second-year research students enter a poster competition. Among other prizes, the Ann Cook prize of £200 is awarded to the student who submits the best poster, and the student judged to have given the best presentation is awarded a prize of £250. The Eileen Colyer Prize of £1,000 is offered each autumn to a research student in the School to study at another institution for an extended period with an expert in their research area. The Ian MacDonald Award of £1,000 is awarded to the applicant judged to be the strongest potential PhD candidate by the Allocation Committee. The award is given after the candidate has fully enrolled on their PhD, and acts as a modest encouragement to the best students. All students applying for a studentship are automatically considered for the award. In addition to the Eileen Colyer Prize, there are also travel funds administered at the Research Group and Doctoral College levels.

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We have instituted a *PhD Forum*, which runs in addition to the existing biannual *Postgraduate Research Committee*. The Forum gives PhD students a platform to raise issues or concerns directly with members of senior management. These meetings take place twice a year, once in the autumn and once in the spring (and fortnightly during the COVID-19 crisis). All research students are encouraged to attend these informal meetings. Elected PhD student representatives act as advocates for the cohort, and are members of the appropriate committees.

2.5.3 PhD completion rates

A robust system has been in place for some years which monitors postgraduate student progress and reacts to potential warning signs. A primary supervisor is confirmed at the time of offer, and a secondary supervisor agreed when studies begin. A panel of two assessors meet with the student at least once a year to monitor progress and review plans for the coming year, with the secondary supervisor often being one of the assessors. At each progression point, students are required to submit a progress report on the research project, and an 'Activity Record' detailing development activities undertaken to date. The primary supervisor also submits a report detailing the student's progress. The assessment panel then meets with the student to review progress and decide whether or not the student should continue on the PhD programme. Following the progression assessment meeting, the panel either recommends that the student progresses to the following year or is 'referred'. In the latter case, performance indicators will be identified by the panel and the student will be reassessed within two months. At the referral assessment, the panel will recommend whether the student can progress, or whether their registration should be terminated or transferred to an MPhil programme. The whole process is closely administered by the Postgraduate Research Programmes Officer.

All supervisors, including secondary supervisors, must undertake the supervisor training offered at Faculty level, and attend refresher training every four years (recently increased in frequency to every two years). Academic Regulations are discussed and supervisors are advised of their responsibilities to their students. This is also a good forum to share best practice amongst colleagues.

The following table summarises the submission rates for those cohorts expected to complete within the current REF period. (The figures for 2014–15 and 2015–16 each exclude one part-time student due to complete in 2022.)

Cohort	Number of PhD students	Submission rate in 4 years
2009–10	7	100%
2010–11	9	78%
2011–12	9	89%
2012–13	19	100%
2013–14	13	100%
2014–15	9	100%
2015–16	13	92%

At least six postgraduate research students who graduated in the REF period hold lecturer or assistant professor positions worldwide.

Unit-level environment template (REF5b)

2.6 Equality, diversity and inclusion

Queen Mary's *Strategy 2030* states that "by the end of the term of this strategy, we will be the most inclusive research-intensive university in the world". The School is actively advancing its position with respect to the Athena SWAN Charter; we hold a departmental-level Bronze Award (obtained in April 2013 and renewed in 2016) and aspire to a Silver Award. The School's efforts in this direction have been monitored and promoted by its Athena SWAN Committee. In 2019, we extended the scope of our work on Equality and Diversity, and have expanded the Athena SWAN Committee into a wider-ranging EDI (Equality, Diversity and Inclusion) Committee.

We are a registered Supporter of the London Mathematical Society's (LMS) [Good Practice Scheme](#), and Queen Mary is a member of the Stonewall Diversity Champions programme, which assists employers in improving the workplace environment for lesbian, gay and bisexual staff. School members are also invited to contribute to the Faculty's WISE (Women in Science and Engineering) initiative – a networking group to enhance the role of female participation across all aspects of STEM.

The School's seminar series were moved into core hours (10:00 to 16:00) to create a more inclusive research environment for all, a transition that was completed at the start of the 2019–20 academic year. Staff with caring responsibilities – including postgraduate research students – can access specific funds to cover the costs of making special arrangements during attendance at conferences and other events. The scheme has been running since 2014, and has assisted 14 trips to conferences since then.

All staff sitting on interview panels for staff vacancies are required to undertake Queen Mary's *Unconscious Bias Training* as well as the University's *Recruitment and Interview Selection* courses, and must remain up-to-date by attending regular refresher courses. All staff interview panels are mixed-gender and, where possible, include individuals of different ethnicities. Interview panels for postgraduate research student admissions must have two staff members, both of whom have taken the *Recruitment and Interview Selection* course. The selection panel for PhD admissions is mixed gender.

EDI issues are also addressed through a number of more informal initiatives that nudge cultural norms. Seminar organisers are periodically reminded about the need to increase the number of female speakers, and are required to report progress annually. This is achieving progress, with the percentage of female seminar speakers in 2018–2019 exceeding 20% for the first time. In early 2019 the School established regular women's lunch meetings attended by PhD students, postdocs, academics and staff from the professional services team. These lunches are used to provide an informal and supportive environment for networking, as there are several research groups in the School with only one or two female members.

3. Income, infrastructure and facilities

3.1 Research income and strategies for generating research income

The School's five-year research strategy in 2014 sought to "increase and diversify research income streams by seeking, supporting and developing new opportunities across a range of funders" to achieve "an increase of 20% on the value of research grant awards in 2013/14, including a 5% contribution from non-EP SRC funders, by 2019/20". This is in line with one of Queen Mary's overarching aims to "Significantly increase external research funding from multiple national and international sources" [REF5a, Section 2]. The School excelled in this objective, even allowing for the increased number of Teaching & Research staff. **In the REF period, our research income**

averaged £1,630k per year (up from £755k in REF2014). In contrast to income, research grant awards give a better impression of current and future sustainability, and the amounts are even higher, reflecting the general upward trend (see the bar chart on page 14). The following table illustrates the diverse range of topics pursued at the School, supported by a range of funding sources. (All reported amounts represent the “Cost to funder”.)

Academic	Funder	Subject	Amount (PtF)
Bandtlow	EPSRC Research Grant	<i>Transfer operator methods for modelling high-frequency wave fields – advancements through modern functional and numerical analysis</i>	£437k
Beck	EPSRC Research Grant	<i>Nash equilibria for load balancing</i>	£622k
Buzano	EPSRC Research Grant	<i>Advances in mean curvature flow: Theory and applications</i>	£767k
Farber	Leverhulme Trust Research Grant	<i>Probabilistic and deterministic topology</i>	£253k
Farber	NSF/EPSRC Research Grant	<i>Topology of Automated Motion Planning</i>	£453k
Figueras	Royal Society University Research Fellowship	<i>New frontiers in numerical general relativity</i>	£549k
Godazgar	Royal Society University Research Fellowship	<i>Symmetries and energy in gravity</i>	£555k
Li (left before census date)	ERC Consolidator Grant	<i>Interactions between groups, orbits and Cartans</i>	£1040k
Maltsev	Royal Society University Research Fellowship	<i>Spectral Universality for Random Matrices</i>	£460k
Moriarty	ATI Fellowship	<i>Data-Centric Engineering</i>	£276k
Moriarty	EPSRC Research Grant	<i>Markov Chain Optimisation for Energy Systems</i>	£577k
Saha	EPSRC Research Grant	<i>Automorphic forms on higher rank groups: Fourier coefficients, L-functions, and mass distribution</i>	£581k
Saha	Leverhulme Trust Research Grant	<i>New investigations in automorphic forms</i>	£294k
Sodin	Royal Society Wolfson Merit Award		£100k
Sodin	Philip Leverhulme Prize		£100k

3.1.1 Support for grant applications

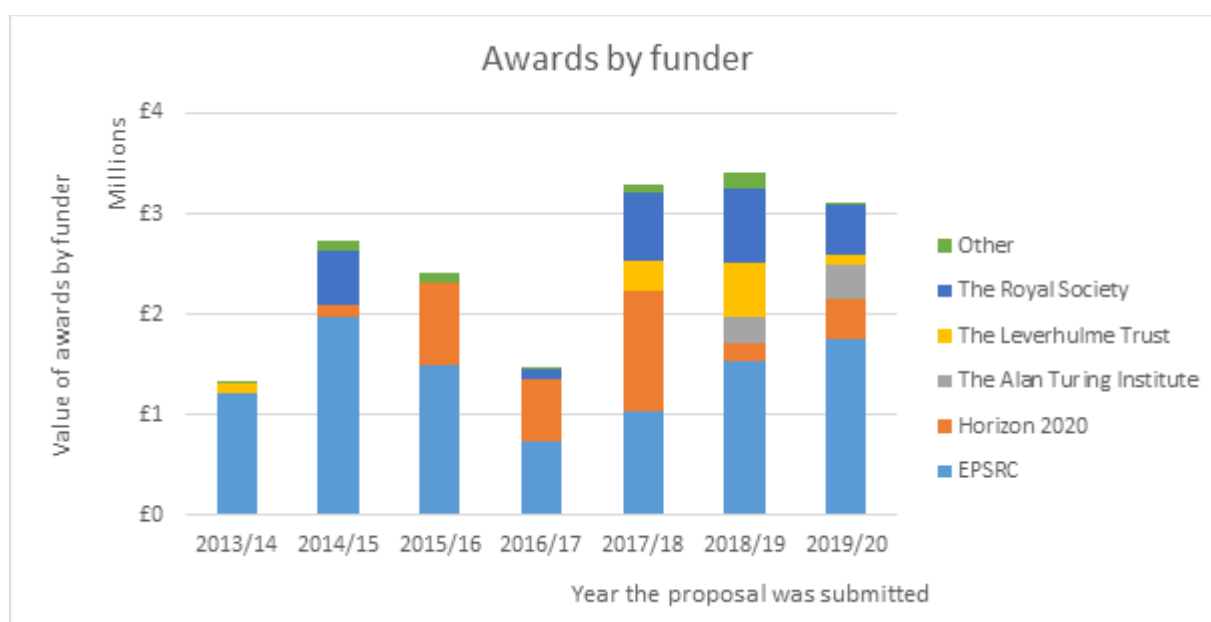
The School has a robust framework for managing grant applications, from introducing academics to funding opportunities to supporting staff throughout the application process. All academic staff and postdoctoral researchers receive a fortnightly bulletin of funding opportunities by email; all new members of research staff meet with the Research Manager (with academics also meeting the Director of Research); and all are made aware of current opportunities for funding, the need to submit professional, competitive project proposals, and the support offered by the School. Since 2019, the Research Manager and Deputy Director of Research have run funding workshops for all research-active staff. These workshops include personal reflections of academics on their experience of the grant application process, followed by an open discussion.

Grants may be enhanced by matched funding from the Faculty's 'Research Support Fund', a scheme that applies to New Investigator Awards and grant applications over a certain threshold. Commitments are often in the form of new or extended contracts for Postdoctoral Research Assistants or Postgraduate Research Studentships (to be allocated by the applicant). The faculty recognises that large grants are not the norm in Mathematics, and the School has been allowed some flexibility in the usual £750k threshold for this scheme. Successful applicants can also access a 'Research Enabling Fund' amounting to 10% of the grant's overheads, which can be used to promote research in a flexible way.

3.1.2 The grant application pipeline

Grant applications are overseen by the Research Manager. Every proposal is internally peer reviewed by two members of academic staff, who comment on various aspects of the proposal and suggest improvements. For fellowships and other funding channels that involve an interview, we arrange, with the EU Unit of the Joint Research Management Office (JRMO) if appropriate, mock interviews for the applicant. This initiative was introduced in 2017. In the same year, the School sought and obtained permission to submit grant applications to STFC with a fixed quota of one application per year, something the School has taken advantage of since it became available.

Above all, there has been a significant cultural change in recent years. More academic staff, particularly at the junior level, see it as the norm to apply for research funding, and the number of successful grant applications has risen over the REF period. (Refer to the histogram below. Note that the figure for 2019–20 is provisional and likely to increase, as grant applications to the value of about £1.11M are pending at the time of compiling this Environment Statement.)



Unit-level environment template (REF5b)

Grant applications that fail by a small margin are covered by a 'Near Miss' internal School scheme that provides modest funding for the disappointed applicant. This funding allows a component of the project to go ahead, and prepares the recipient for a fresh application in the future. Starting in 2018, we debrief unsuccessful grant applicants a couple of weeks after the unwelcome news has arrived, with the ultimate aim of improving the competitiveness of future applications for the whole School and encouraging the individual to learn from the setback and make renewed attempts. In this way, among others, grant applications are given the maximum probability of success, and applicants the maximum encouragement and support to submit.

3.2 Organisational infrastructure supporting research and impact

Not only has the volume of research increased over the REF period, but so too has the complexity of the research environment in which we operate. The Research Manager, a role created during the REF period, is critical in facilitating all research-related activities in the School, from tracking and disseminating funding opportunities to ensuring open access compliance, providing guidance on impact and managing the impact pipeline, and supporting all aspects of research funding (such as giving advice on funder guidelines and requirements, preparing budgets, assisting with all administrative aspects of proposal preparation, and monitoring successful grants).

Our diverse [seminar series](#) and study groups are a strong feature of our research environment, and we are committed to supporting them in future. In addition to the weekly specialist seminars run by the research groups, there is a [School Colloquium](#) whose purpose is "to provide accessible and engaging introductions to a broad range of topics of current research interest in any branch of mathematics or its applications". The School Colloquium generally meets three times per semester and attracts a steady stream of eminent external speakers, including Fields Medallists, and is followed by a reception that brings together the whole School. Another event that promotes interactions between research groups is the Internal Colloquium, where two members of the School give short (25-minute) presentations on their work or recent developments in their area. Links with other London colleges are strengthened through joint seminar series: the [London Algebra Colloquium](#), the [London Topology and Geometry Seminar](#), the *London Analysis and Probability Seminar* and the [London Mathematical Finance Group](#). Seminar series are subject to an annual Equality, Diversity and Inclusion audit, with data going back to 2015-16. **The percentage of female speakers over all seminar series has grown from 16.3% in 2015-16 to 22.1% in 2018-19.**

Maintaining and improving access to research resources continues to be a priority for the School. Thanks to careful management of resources, 17 important mathematics and statistics journal subscriptions were added to the library's portfolio in 2019, and others became available through a subscription to Project Euclid.

3.3 Operational and scholarly infrastructure supporting research and impact

Queen Mary has invested approximately £18M in a transformative project to create an inspiring building that accommodates our community of students and staff and promotes collaboration both within and between research groups. The School has occupied the transformed building since September 2019, and staff were consulted on and involved in the building design throughout the renovation process. The new infrastructure has created new opportunities for collaboration and discussion.

The basic structure of the old mathematics building was retained, but all services were replaced and additional space created by extending the building. The interior and exterior appearances of the building were transformed and enhanced, and the refurbishment incorporated effective heat insulation and other solutions for high energy efficiency and sustainability, achieving BREEAM 'excellent' certification. (BREEAM is the world's leading method for assessing the sustainability of buildings.) The new building includes high-quality teaching spaces, a range of private and group

Unit-level environment template (REF5b)

study areas over all the floors, and a new social space to act as an informal hub for School-related events and activities. Each floor has two research breakout areas, which, as the illustration below indicates, provide an excellent environment for research collaboration. Postgraduate research students also are benefiting from these dedicated breakout spaces and a fully equipped modern office environment. We have ensured that all essential research-focused rooms – student and research staff offices, breakout areas, seminar room and the common room – are fully accessible. Collegiality and social interaction are promoted through regular coffee mornings, and all staff and PhD students frequent our well-equipped common room.



School of Mathematical Sciences Building (left), staff common room (top right) & research break out room (bottom right)

3.4 Addressing equality and diversity issues in research

Our EDI Committee monitors data on grant applications regularly. While our data shows that male academics tend to apply for larger grants than their female counterparts, there is no obvious discrepancy in success rates by gender. This data is made available to all staff to raise awareness and encourage further and larger grant applications. Female staff and prospective fellows are encouraged and fully supported to seek grants promoting gender diversity, such as the Royal Society Dorothy Hodgkin Fellowship, the Daphne Jackson Fellowship, and the London Mathematical Society's Grace Chisholm Young Fellowship.

3.5 Utilisation of infrastructure, facilities and expertise in relation to impact

Standard mathematical and statistical software, including *Matlab*, *R*, *Stata* and *Mathematica*, is maintained and supported at an institutional level by Queen Mary's IT Services department. More specialist software is developed and supported in-house. An example is *GAP*, an open-source computational system for group theory and discrete mathematics. **Soicher** is Chair of the [GAP](#)

Unit-level environment template (REF5b)

[Council](#), and has developed widely used GAP packages for studying graphs with group actions and for combinatorial designs. **Figueras** has contributed to software, *GRChombo*, used to perform simulations in numerical relativity, for example, the collapse of pairs of black holes or neutron stars. Both GAP and GRChombo are examples of tools developed jointly with other higher education institutions. Although IT support is centrally managed, a staff presence is maintained in the building, improving communication with users and accelerating response times.

A number of people in the School use Queen Mary's High Performance Computing resource, *Apocrita*, in their research. **Huang** uses Apocrita to run stochastic simulations to characterise tumour growth and assess how mutations accumulate in normal tissue cells. The use of HPC is critical, as biological systems are complex, stochastic, and evolving, and it is often difficult or even impossible to obtain analytical solutions. Huang also uses Apocrita to run Bayesian inference to estimate key parameters of the models from experimental data. The School's use of the HPC resource amounts to about £100K per annum in income in kind in recent years (source: REF4c).

4. Collaboration and contribution to the research base, economy and society

4.1 Support for research collaborations, networks and partnerships

The main formal structure for research collaboration beyond Queen Mary is the Institute of Applied Data Science (IADS; see Section 3). For example, the following research collaborations were enabled by IADS, and illustrate its effectiveness.

Funded by the ATI's *AI for Molecular Biology* programme, **Huang** has a pilot project '*Identifying driver ecDNA through quantitative analysis of cancer genomic data and generative models*', in collaboration with the Barts Cancer Institute (Barts) and University College London (UCL). Evidence increasingly suggests that extra-chromosomal DNA (ecDNA) can drive many cancers, and this project aims to construct a model for quantitative analysis of driver ecDNA. The School provides expertise in stochastic modelling for this project, complementing partnering expertise in genomic analysis (Barts) and machine learning methods (UCL). A long-term follow-up grant is planned.

Skraba is PI of the '*Topological Data Analysis for Maritime Data*' project, which is funded by the ATI's *Defence and Security* programme and counts Oxford University as a partnering institution. The project, which engages with the UK Defence Security and Technology Laboratory (Dstl), brings together algebraic topology and defence technologies to detect anomalous behaviour in areas of national interest, such as smuggling, illegal fishing and piracy. Broadly, by finding appropriate stratifications of the data, the project aims to detect anomalous behaviour both earlier and more comprehensively. The project has achieved early practical success, detecting behaviours such as AIS (Automatic Identification System) Spoofing. AIS Spoofing exploits a vulnerability in AIS allowing ships' identities to be mimicked and exploited in maritime communications. For example, a ship can be made to appear to be within hostile waters, prompting a territory to take retaliatory action as a result.

4.2 Developing relationships with key research users

Moriarty was invited by the British Army to present on the mathematics of risk to the 47 Regiment Royal Artillery, the regiment responsible for Tactical Uncrewed Aerial Systems (used for intelligence, surveillance, target acquisition and reconnaissance). Risk is a key aspect of the regiment's operations. Major Tom Luker later wrote to the School expressing his appreciation of the presentation: "[Moriarty] was able to communicate the important tenets of the subject most clearly [and] showed how an abstract subject has obvious pragmatic benefits."

Unit-level environment template (REF5b)

4.3 Wider contributions to the economy and society

Lacasa has helped develop a COVID-19 'Track and Trace' app for mobile phones. Developed primarily in conjunction with the Spanish government, the app has already been downloaded by 5 million people (as of 02/11/2020). There are ongoing discussions with the UK government about the development of a similar app, and Lacasa and others in the team have submitted a related paper to *The Lancet*.

Bianconi's work on multilayer networks has been picked up by the *World Bank*. Policy Research Working Paper 8438 – '*Multidimensional Connectivity: Benefits, Risks and Policy Implications for Europe and Central Asia*' – studies the multifaceted nature of international connections and their effects on individual countries. The paper compares traditional methods of analysis with those based on multilayer networks (a way of modelling complex systems that incorporates several coexisting and interacting network layers). In a letter to the School, one of the authors of the report, lead economist David Gould, describes the research work of Dr. Ginestra Bianconi and her collaborators as "useful and informative for the research conducted at the World Bank".

4.4 Engagement with diverse communities

As part of Queen Mary's annual takeover of the Tate Exchange space at the Tate Modern, **Glau** organised an interactive project which ran from 11-16th June 2019. She and a team of PhD students from the School worked with Tate visitors to 'Create the [Mathematical] Universe' with the help of a spinning top and pieces of felt, exploring ideas of infinity and the foundations of mathematics. Visitors were invited to create their own piece of the Universe for the exhibit, and images of visitor-made pieces formed part of an [online gallery](#). **Liverani** and **Beheshti** organised and hosted the [2019 LMS Women in Mathematics Day](#) at Queen Mary. Additionally, a number of School members regularly contribute engaging and informative presentations to the 'Pint of Science' global science festival, which typically reaches 24,000 attendees per year (across 600 events in over 45 cities).

4.5 Collaboration and contributions to the research base

The School has contributed strongly to the research base by hosting meetings and participating in globally collaborative research.

4.5.1 Organisation of meetings and conferences

Members of the School have organised important meetings during the REF period, including the 29th *International conference on Formal Power Series and Algebraic Combinatorics* ([FPSAC 17](#)), with local organising committee chairs **Fayers** and **Prellberg**, and the 66th *British Mathematical Colloquium* ([BMC 14](#)), organised by **Noohi** and **Tomašić**, with over 300 participants. **Moriarty** was principal organiser of the *Isaac Newton Institute* programme [The Mathematics of Energy Systems](#), which ran in the spring of 2019. **Beck** was conference chair of the EPS conference *Statistical Physics of Complex Systems* (Stockholm, 2019), and a member of the organising committee of the *Condensed Matter Spring Meeting* of the European and German Physical Societies (EPS/DPG; Berlin, 2018; 8000 participants). **Jerrum** was a core panel member for the 2014 *International Congress of Mathematicians: Section 14, Mathematical Aspects of Computer Science*. (The panel deliberated in the previous REF period, but its composition was only made public in 2014.)

Unit-level environment template (REF5b)

4.5.2 Long-term visits

Numerous members of the School made longer-term visits to programmes at international research institutes during the REF period:

- **Fink** attended 'Combinatorial Algebraic Geometry', Fields Institute (Canada), four months in 2016; 'Tropical Geometry, Amoebas, and Polytopes', Mittag-Leffler Institute (Sweden), one month in 2018.
- **Goldsheid** attended 'Periodic and Ergodic Spectral Problems', Isaac Newton Institute (UK), January to June 2015.
- **Harris** attended 'Advances in Nonequilibrium Statistical Mechanics: large deviations and long-range correlations, extreme value statistics, anomalous transport and long-range interactions', Galileo Galilei Institute for Theoretical Physics (Italy), May to July 2014; 'Large Deviation Theory in Statistical Physics', ICTS (India) August to October 2017.
- **Jerrum** attended 'Counting Complexity and Phase Transitions', Simons Institute for the Theory of Computing (USA), March to May 2016.
- **Khoruzhenko** attended 'Periodic and Ergodic Spectral Problems', Isaac Newton Institute (UK), January to June 2015.
- **Klages** is Convenor of the Advanced Study Group 'Statistical Physics and Anomalous Dynamics of Foraging', Max Planck Institute (Dresden, Germany), July to December 2015; Mercator Fellowship (DFG) supporting a visiting professorship at the TU Berlin (Germany), May to December 2019.
- **Maruri-Aguilar** attended 'Uncertainty quantification for complex systems: theory and methodologies', Isaac Newton Institute (UK), January to June 2018.
- **Moriarty** attended 'The Mathematics of Energy Systems', Isaac Newton Institute (UK), January to May 2019.
- **Rincon** attended 'Nonlinear Algebra', ICERM (USA), 1 month in autumn of 2018; 'Tropical Geometry, Amoebas and Polytopes' programme, Mittag-Leffler Institute (Sweden), 2 months in spring of 2018; 'Geometric and Topological Combinatorics', the Mathematical Sciences Research Institute (USA), 5 months in autumn of 2017.
- **Skraba** attended 'Applied and Computational Algebraic Topology', Hausdorff Institute (Germany), 2017.
- **Tomašić** had one-month visits to the Max Planck Institute for Mathematics (Bonn, Germany), Institut des Hautes Études Scientifiques (France), and Institut Henri Poincaré (France).
- **Valiente-Kroon** attended 'Geometry and Relativity', Erwin Schrödinger Institute (Austria), July to August 2017.

4.5.3 Non-academic organisations

Academic staff involved in projects with external organisations include **Bianconi** (*Bank of England*), **Figueras** (*Intel*), **Griffin** (*Global Fund*), **Lacasa** (*Tooso*, an artificial intelligence technology startup acquired by *Coveo* in 2019), **Moriarty** (*Electricity North West*), and **Valiente-Kroon** (*Isotropic Systems Ltd*, a small telecommunications equipment company based in London).

Unit-level environment template (REF5b)

4.6 Indicators of wider influence and recognition

Various indicators of esteem are listed below, grouped according to type.

4.6.1 Journal editorship

More than a third of academic staff are on the editorial board of at least one journal. This list covers editorial terms that overlapped part, but not necessarily the whole, of the current REF period: **Baule** (*Helion*, *Nature's Scientific Data*), **Beck** (*Europhysics Letters*, *Physica A*, *Chaos*, *Solitons & Fractals*), **Bianconi** (chief editor of *J. Phys Complexity*; editor of *Scientific Reports*, *PLOS One*, *Entropy*, *Chaos*, and *Solitons & Fractals*; and 3 others), **Buzano** (*Geometric Flows*), **Coad** (*Statistical Methodology*, *Sequential Analysis*), **Farber** (*Journal of Applied & Computational Topology*, *Topological Methods in Nonlinear analysis*, *Knot Theory & its Ramifications*, the *European Mathematical Society's Monographs in Mathematics series*), **Fink** (*Theoretical Computer Science A*, the *London Mathematical Society Journals*), **Glau** (*Journal of Computational Finance*), **Gnedin** (*Advances in Applied Probability*, *Stochastics*, *Probability Surveys*, *ALEA*), **Harris** (*Europhysics Letters*), **Jerrum** (*SIAM J. on Computing*, *Combinatorics*, *Probability & Computing*, *Random Structures & Algorithms*), **Just** (*J. Phys. A*, *PLOS One*), **Klages** (*Physical Review Letters*), **Lacasa** (*Complexity*, *PLOS One*, *Complex Systems*), **Latora** (*Chaos*, *J. Complex Networks*), **Liverani** (*J. Royal Statistical Society Series C*), **Majid** (*Int. J. Geom. Meth. Mod. Phys.*), **Maruri-Aguilar** (*J. Algebraic Statistics*), **Nicosia** (*J. Complex Networks*, *PLOS One*, *Frontiers in Physics*, *Review*), **Ruzhansky** (two book series – *Progress in Mathematics*, Birkhäuser, and *Monographs & Research Notes in Mathematics*, Chapman & Hall – and 18 journals), **Sodin** (*Geometric & Functional Analysis*), and **Valiente-Kroon** (*Classical & Quantum Gravity*).

4.6.2 Participation in grants committees

Panels and Committees: Several academic staff are active on grant award panels. **Arrowsmith**, **Beck**, **Klages**, **Majid**, **Moriarty**, **Ruzhansky** and **Valiente-Kroon** have all been members of interviewing, selection, or prioritisation panels for the EPSRC (or UKRI); **Figueras** was a member of the Royal Society International Newton Fellowship Committee; and **Majid** and **Ruzhansky** have been panel members for funding bodies abroad.

Fellowships: Many members of the School have held fellowships during the REF period: **Bantilan** (ERC PDRF), **Benning** (Leverhulme Early Career Fellow), **Bianconi** (ATI Fellow), **Farber** (ATI Fellow), **Figueras** (Royal Society University Research Fellow), **Glau** (ATI Fellow), **Godazgar** (Royal Society University Research Fellow), **Harris and Klages** (Fellows of the London Mathematical Laboratory), **Lacasa** (EPSRC Early Career Fellow), **Latora** (ATI Fellow, Leverhulme Research Fellow), **Liverani** (ATI Fellow), **Maltsev** (Royal Society University Research Fellow), **Markarkis** (Marie Skłodowska-Curie Fellow), **Moriarty** (EPSRC Early Career Fellow, ATI fellow), **Skraba** (ATI Fellow), **Toghani** (Marie Skłodowska-Curie Fellow), and **Schaefer** (Marie Skłodowska-Curie Fellowship).

4.6.3 Fellows of learned societies

Arrowsmith and **Beck** are fellows of the Institute of Mathematics and its Applications.

4.6.4 ERC Grants

The following hold or have held ERC grants: **Figueras** (Starting Grant), **Li** (Consolidator Grant) and **Sodin** (Starting Grant).

Unit-level environment template (REF5b)

4.6.5 Awards and prizes

Among the prizes and awards won by members of the School are: **Fischer**: [‘Best full paper award’](#) at the 20th ACM Conf. on Economics and Computation (USA, 2019); **Huang**: ‘Best presentation award’ at the European Conf. on Mathematical and Theoretical Biology (Sweden, 2014); **Jerrum**: [‘Best paper award’](#) at the Intl. Colloq. on Automata, Languages and Programming (Track A) (Czech Republic, 2018); **Lacasa**: USERN Prize in Formal Sciences 2019; **Rincon**: [Colombian National Prize](#) in Exact, Physical, and Natural Sciences (awarded by the Alejandro Angel Foundation, 2015); **Ruzhansky**: [Ferran Sunyer I Balaguer Prizes](#) 2014 and 2018; **Skraba**: ‘Best paper award’ at the Pacific Visualization Symposium (Taiwan, 2016); and **Sodin**: Royal Society Wolfson Research Merit Award (2017).

4.6.6 Membership of Research Council or similar committees

Arrowsmith: Member of the EPSRC Mathematical Sciences Strategic Advisory Team; **Beck**: Chair of the EPS Statistical and Nonlinear Physics Division; **Bianconi**: Scientific Advisory Board of the Potsdam Institute for Climate Impact Research, Member of the Erdős and Renyi Prize Committee 2018, Committee Member for the Young Scientist Award for Socio- and Econophysics 2019; **Glau**: Committee of the Applied Probability Section of the Royal Statistical Society; **Griffin**: Scientific advisor to the Global Fund (an organisation that raises and distributes funds to fight HIV, malaria and TB); **Johnson**: Secretary of the British Combinatorial Committee; **Markakis**: Member of APELLA (Greek Universities Faculty Electorate Body); **Moriarty**: Industrial Advisory Committee Member, Supergen Energy Networks Hub; **Nicosia**: Member of the EPSRC Early Career Forum for Mathematics, Member of the Executive Committee of the Complex Systems Society; **Prellberg**: Scientific Advisory Committee, PIMS Collaborative Research Group in Applied Combinatorics; **Ruzhansky**: Board Member, International Society for Analysis, its Applications and Computation; **Valiente-Kroon**: Treasurer, Institute of Physics’ Gravitational Physics group.

4.6.7 Invited keynotes, lectures or conference chair roles

Academic staff were invited participants at the Banff International Research Station (Canada) 6 times, 9 times at the Schloss Dagstuhl – Leibniz-Zentrum für Informatik (Germany), 5 times at the International Centre for Mathematical Sciences (Scotland, UK), 5 times at the International Centre for Theoretical Physics (Italy), and 21 times at the Mathematisches Forschungsinstitut Oberwolfach (Germany). **Beck** gave an invited talk at the Conference on Complex Systems in Singapore in 2019 (~1000 participants) and a plenary talk at Sigma-Phi conference in Corfu, Greece, in July 2017 (~400 participants). **Bianconi** gave plenary talks at the 16th International Conference in Complex Systems and Networks in Berlin, Germany, in 2019, at StatPhys27 in Buenos Aires, Argentina, in 2019 (~700 participants), and at the Conference on Complex Systems in Thessaloniki, Greece, in September 2018 (~700 participants). **Prellberg** gave a plenary talk at the Sigma-Phi conference in Rhodes, Greece, in 2014.

4.6.8 Cooperation and collaborative arrangements for PGR training

The School is an extremely active contributor to the *London Taught Course Centre* (LTCC). **Majid** is a Joint Director for the LTCC with responsibility for pure mathematics. In the current (2019–20) academic year, six members of academic staff present courses at LTCC: **Bianconi**, **Coad**, **Gnedin**, **Skraba**, **Sodin** and **Valiente-Kroon**. Two of the School's emeritus professors are members of the LTCC's seven-strong Advisory Board