Institution: Swansea University

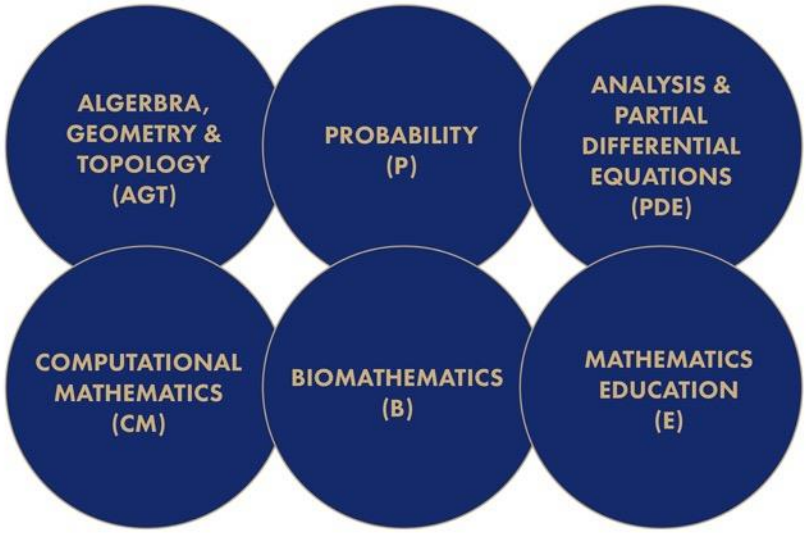
Unit of Assessment: 10 (Mathematical Sciences)

1. Unit context and structure, research, and impact strategy

1.1 Context and structure

This UoA comprises the Department of Mathematics at Swansea University, one of the founding departments of the University, which celebrated its centenary in 2020. Since September 2018, the Department is based in the **new purpose-built Computational Foundry**, the home of Mathematics and Computer Science.

The Department contains 26 permanent academic members of staff organised in six overlapping research groups:



Several members of staff belong to more than one research group, reflecting multi-faceted interests. Each group runs a regular seminar series and has organised at least one subject-specific international workshop within the current REF period. Non-Category A staff contribute to our overall research environment and are included in our research groups and hence also in this narrative, with their names in italics. Unless otherwise stated, data in this narrative relate to both Category A staff (100% submitted) and non-Category A staff.

1.2 From REF2014 to REF2021

For almost three decades from the mid-1980s, the Department focussed on pure mathematics research. Since 2013 a strategic investment has been made into diversifying mathematical research with emphasis put on the development of applied streams, interdisciplinary research, and collaboration with industry, while sustaining and enhancing existing pure mathematics strengths. This is in line with the Welsh Government Research Strategy for Wales.

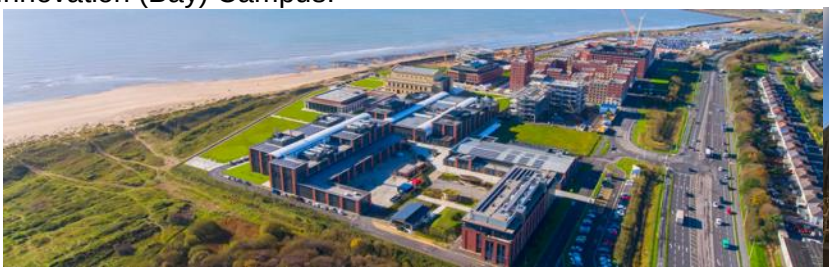
Taking advantage of new appointments, including several research fellows, since REF2014, as well as widening research interests of existing members of staff, new research groups have been created in **Bio-** and **Computational Mathematics**. The former is a part of the **Centre of Biomathematics**, launched in 2016 and co-led by the Departments of Mathematics and Biosciences. **Computational Mathematics** connects to the Liverpool-

Oxford-Swansea **Centre for Topological Data Analysis**, funded by a **£2.5M EPSRC** grant, and the **Swansea Academy for Advanced Computing**, funded by a **£3.5M Welsh European Office** grant. The members of the Department leading the Welsh Government-funded **Further Mathematics Support Programme Wales (FSMPW**) contribute to the **Mathematics Education** group, formed in 2014 and reflecting the UoA's growing interest in and influence over school mathematics education. The 2019 appointment of an Associate Professor in **Actuarial Science** is a seed for a research group in applied statistics and actuarial science.

The research development of the UoA has closely mirrored the strategy outlined in the UoA's REF2014 submission leading to:

(a) significant achievements and developments across all research groups,
(b) well-resourced environment for interdisciplinary activity,
(c) the facilitation of impact.

A central highlight is the **Computational Foundry (CoFo),** a new £32.5M purpose-built home for the Departments of Mathematics and Computer Science on the Science and Innovation (Bay) Campus.



The CoFo is a centre of excellence that enhances, supports and sustains research in mathematics of the highest calibre. Its mission for engagement with industrial partners and location next to the College of Engineering research base are together fostering interdisciplinary collaboration and encouraging industry-facing activities.

The creation of

(a) the **Centre for Biomathematics**,
(b) the **College of Science Doctoral Training Centre,**
(c) the **EPSRC-funded Centre for Doctoral Training in Enhancing Human Interactions and Collaborations with Data and Intelligence Driven Systems (EHI)**

evidence the enhancement of interdisciplinary research directions foreseen in the REF2014 submission.

We are also benefitting from high-level involvement in three multi-institution multi-disciplinary training networks:

(a) the **Swansea-led UKRI Centre for Doctoral Training in Artificial Intelligence**, **Machine Learning and Advanced Computing**,
(b) the **STFC Centre for Doctoral Training in Data Intensive Science**,
(c) the nine-institution **European network for Particle Physics, Lattice Field Theory and Extreme Computing (EuroPLEx)**.

Interdisciplinary activity and the realisation of impact have been significantly advanced by the UoA's staffing strategy. New appointments have focused on research areas with strong potential for connecting to other disciplines:

(a) Picco, Powathil – mathematical oncology;
(b) Dłotko – topological data analysis;
(c) Villamizar – applied algebraic geometry, computer-aided geometric design;
(d) *Wright* – actuarial science.

Furthermore, the appointments of:

(a) Lucini, a Lattice Field Theory specialist and Director of the **Swansea Academy of Advanced Computing**, as Head of Department,
(b) Fathizadeh (**Sêr Cymru COFUND Fellow**),
(c) Ren (**UKRI Future Leaders Fellow**),

have led to the formation of our new **Computational Mathematics** research group and already contributed directly to an increase in cross-community interaction, such as involvement with the successful bid for Swansea to be one of the founding sites of the five-**year £30m Health Data Research UK** project [Powathil]. The formation of the **Mathematics Education Group** in 2014 has reinforced the Department's interest in widening access and the transition from school to university. An Associate Professor [*Lyakhova*] leads the **Further Mathematics Support Programme Wales**.

Cross-disciplinary colloquia, e.g., the **Biomaths Colloquium Series** (since 2014), knowledge exchange meetings, e.g. a 2017 **Maths-Engineering Workshop** and a **Mathematical Sciences Unplugged** seminar series [Mercuri] aimed at stimulating synergies of researchers across the University who use mathematics in their work, are examples of the increasing opportunities for interaction within Swansea. These have been accompanied by an expansion of interdisciplinary projects involving members of the UoA, both new appointees and existing members of staff, and other disciplines at Swansea. Examples include:

(a) prototype models of graphene-based electronic nano-devices [Moroz/Engineering],
(b) machine learning and phase transitions [Lucini/Engineering],
(c) cancer modelling [Powathil/Biomedical Engineering],
(d) stochastic models of environmental change [Yuan/Biosciences],
(e) simulations and data analysis for financial modelling [Wu/Computer Science],
(f) modelling of Covid-19 [Lucini/Biosciences/Medicine].

The **Centre for Biomathematics** is providing a cross-community focus for experts with interests on the interface between mathematics and biology or medicine. College/University funding has supported five co-supervised interdisciplinary PhD studentships on biomathematics topics, and interdisciplinary biomathematics projects are attracting external funding, e.g.:

(a) Yuan is co-Investigator on a NERC grant on the topic of models of environmental change that has brought a PDRA to the Centre,
(b) a Welsh Government/European co-funded research fellow, Bao (2017-19), worked on stochastic differential equations with applications to population modelling and the dynamics of epidemics.

Centre-run events, such as the **Workshops on Mathematical Medicine and Mathematical Pharmacology** and on **Mathematical Ecology** (2017) have attracted a wide range of participants from the UK and abroad, from disciplines ranging from mathematics, statistics and engineering to ecology, experimental biology and medicine. The Centre is also collaborating with Cardiff and South Wales in running **the LMS Joint Research Group in Biomathematics** [co-organised by Powathil] and contributing to the modelling of the Covid-19 pandemic in Wales [Lucini].

The vitality of our environment has generated many influential achievements, demonstrating a continuation of excellent research in pure mathematics alongside a growing portfolio of interdisciplinary topics. Highlights include:

(a) The novel machinery of framed motives which has led to the realisation of the celebrated Voevodsky programme is exerting significant influence on motivic homotopy theory and have been the subject of several conferences/seminar series [Garkusha];

(b) A rigorous framework for the theoretical study of a class of nonlocal physical models with attractive inter-particle interactions in a series of papers on Choquard equations that has made a major impact on the nonlinear PDE community, with hundreds of related publications already in print [Moroz];
(c) Extension of Grothendieck's scheme-theoretic foundation of algebraic geometry from rings to semi-rings leading to a new description of tropical varieties that has been the focus of international workshops and lecture courses around the world [Giansiracusa];
(d) Publication of the 800-page monograph:
Beggs, E.J.; Majid, S., *Quantum Riemannian Geometry*, Grundlehren der Mathematischen Wissenschaften 355, Springer, 2020;
(e) A multi-scale mathematical and computational modelling framework for the study of cancer progression and treatment effects that led to experimental confirmation of the model predictions and is being pursued by several external groups [Powathil];
(f) A unified framework for analysis of a large class of individual-based models beyond the mean-field expansion [Finkelshtein];
(g) A large deviation principle and renormalised entropy solutions for first-order scalar conservation laws with stochastic forcing [Wu].

We are fully embracing the open access research environment, in line with and extending beyond the REF open access policy. All staff upload accepted manuscripts to the institutional repository CRONFA. Most preprints are deposited on arXiv.org immediately after submission for publication to maximise dissemination and ensure equality of access to all readers. Research codes are made available to the community as

(a) open source, e.g., **HiRep**, **BSMBench**, **GUDHI** library, **Ball Mapper**, including user support via instructional videos,
(b) dissemination to individual networks, e.g., researchers working on cancer, 3d cell printing and tuberculosis at **St Andrews**, **Waterloo**, and the **Institute for Cancer Research** are using code of Powathil.

Data is being shared

(a) via open databases, e.g., contributions to the **OxCovid19** Database;
(b) on request to individual researchers, e.g., data of Lucini is being used by a group in **Graz**.

Contributions are being made to the community challenge of finding mechanisms for sharing very large datasets [Lucini].

The **Departmental Ethics Committee**, under the umbrella of the **College of Science Ethics Committee** and the Swansea University **research integrity policy framework** (see §2.3 REF5a**)**, oversees ethics assessments for research projects and grant applications as required.

1.3 <u>Supporting impact.</u>

In parallel with fostering interdisciplinary work, the UoA champions the identification and pursuit of pathways to potential impact of research to all staff. Collaboration with industry, healthcare, or policy makers, is actively advocated, and research-led outreach and teaching activities are promoted. Our participation in an **ICMS Workshop** on `**Mathematical Sciences and the Industrial Challenge Strategy Fund**' and in `**Big Mathematics Initiative**' events has enhanced appreciation of knowledge exchange and how to overcome its challenges. The importance of early engagement with potential end-users, effective two-way communication between those at different points in the chain between pure mathematics and industry, direct collaboration with external partners, and facilitation of sustained interaction between parties, are all appreciated and embedded in our approach.

Ongoing initiatives in support of impact include:

- industry-interaction events organised by the EPSRC-funded **Digital Economy Centre CHERISH-DE** (with, e.g., **IBM**, **Amazon Web Services**), which help establish initial contacts;
- secondments, e.g.,
  (a) via £2K grants offered by CHERISH-DE that have funded short secondments to the **Institute for Cancer Research** and **AstraZeneca UK** [Powathil],
  (b) via secondment of staff to external projects, e.g. Further Mathematics Support Programme Wales (**FMSPW)** [*Lyakhova*];
- sandpits to stimulate cross-disciplinary interaction and kick-start collaborative projects, e.g. events organised by **EHI** that focus on data-driven themes in Health and Well-Being, Smart Manufacturing, and Digital Economy Services;
- industry involvement in PhD projects, e.g.:
  (a) **AtoS** is supporting a PhD project on quantum computing;
  (b) **AstraZeneca** is involved in a collaborative PhD project on drugs for cancer treatment.

The need to resource impact development, in terms of time, money, and support from professional services, is fully recognised:

(a) the College of Science (CoS) awarded £14K to the UoA to support impact development;
(b) the Department of Mathematics workload model allocates a variable workload (up to 0.1 FTE) in recognition of the work involved in developing impact case studies;
(c) academic staff engage regularly with the CoS Impact and Engagement Officer.

Examples of our engagement in research and outreach activities with the potential to lead to direct and indirect impacts, some of which are submitted for this REF for evaluation, include:

- *Industrial and interdisciplinary collaborations*, e.g.:
  (a) Engagement with **GCHQ** via the **Heilbronn Institute** has led to impact on national security that is presented in a classified **case study**.
  (b) **BSMBench**, a flexible and scalable high performance computing benchmarking tool, is being adopted by **NVIDIA Networking**, **Intel**, **ATOS**, **IBM, Dell** to obtain robust indicators of performance of their computing technologies. Impact generated includes the mitigation of potential future losses related to performance regressions caused by fixes of processor design bugs [Lucini].
  (c) Development of an efficient and accurate solver, based on a formulation of Maxwell's equations utilising topological information about the circuit model, in collaboration with the industrial partner **EMWorks** that has purchased the licence and integrated it with their software to deliver an improved commercial product [Dłotko].
  (d) Development of a mathematical toolbox for applications in image and data processing, for which a patent has been awarded [Crooks].
  (e) Ongoing work on the Geometry Understanding in Higher Dimensions (**GUDHI**) library, which is used in industry (**Fujitsu**) [Dłotko].
  (f) Cancer modelling and its applications to drug development and clinical therapy optimisation [Picco, Powathil]; an agreement is in place with **AstraZeneca** to develop modelling approaches to inform drug development pathway.

- *Outreach, education and policy*:
  Staff with a range of research expertise collectively participate in the **Further Mathematics Support Programme Wales (FMSPW**) initiative. This programme led by Swansea is receiving £500K p.a. from the Welsh Government. We are actively involved in a variety of research-led outreach activities:

(a) Royal Institution Mathematics Masterclasses;
(b) encouraging students, especially girls and pupils from disadvantaged backgrounds, in taking advanced mathematics.

Through FMSPW the Department has become actively involved in influencing and developing the new school mathematics curriculum for the education reform in Wales and the creation of **National Network for Excellence in Mathematics**. Research publications are emerging from this strand [*Lyakhova*, *Neate*].

- *Covid-19 pandemic:*
  The embedding of impact in the UoA's culture has enabled several rapid responses to the challenges of Covid-19 during the census period that are ongoing:

  (a) Lucini has become a member of the **Welsh Government Technical Advisory Cell Modelling Group** and, in an interdisciplinary collaboration with the Medical School [Gravenor], has played a leading role in the development and deployment of a **Covid-19 model** that has been used by the Welsh Government to inform policy decisions and public service operating procedure, and is presented in a **case study**.
  (b) Dłotko, *Harvey* and a PDRA contributed to the **OxCovid19 Database**.
  (c) *Wright* coordinated organisation of actuarial analysis of COVID-19 workstreams for the **Institute and Faculty of Actuaries COVID-19 Action Taskforce (ICAT)**.
  (d) *Lyakhova* was commissioned to prepare a report on **`Remote Teaching and Covid-19 Approaches to School Education'** by the Children, Young People and Education Committee (CYPEC) of the Welsh Parliament.
  (e) we delivered a **`Swansea Mathematics Online Transition Course**' for prospective maths students based on our research in April-July 2020.
  (f) **FMSPW** launched 11 student programmes, including a series of **`Bridging Mathematics for University**' video sessions delivered in April-July 2020 to which the UoA contributed; these initiatives helped to tackle inequality and promote diversity, with a 58% female audience and some attracting 24% BAME and 30% receiving free school meals.

1.4. Strategic plans.

Over the next five years, we will nurture an active research community in a vibrant environment that enables high-quality individual and collaborative research in **pure and applied mathematics**, and contributes to the vitality of the discipline at large. Expansion of our growing research portfolio, in particular into data science, applied statistics and actuarial science, is anticipated.

Pathways to developing the UoA will include:

- *Capitalising on the Computational Foundry (CoFo)*:

The recent investment in the infrastructure and co-location with Computer Science brings major opportunities. New research directions are being nurtured through:
(a) co-supervison of PhD projects [e.g., Beggs/Pauly (Computer Science)]
(b) joint events, e.g. weekly talks *Why My Research Matters*.

Research on data science resonates strongly with the CoFo vision and is expected to expand significantly, fostered by the **Liverpool-Oxford-Swansea Centre for Topological Data Analysis** and the **Health Data Research UK** project. Having a state-of-the-art building in the stunningly located **Science and Innovation Campus** also presents an ideal environment for hosting significant research meetings that plans are underway to exploit.

- *Building on actuarial science*:

Establishing research in applied statistics and actuarial science is a key strategic goal. Following the recruitment of an Associate Professor in Actuarial Science [*Wright*], the associated student cohort should generate an income stream sufficient to support new research-focused academic posts. A priority for such appointments will be areas of applied statistics allied with existing research groups, e.g.,

(a) **Biomathematics (B)**: expertise in statistical modelling would synergise with research in the Department of Biosciences,
(b) **Computational Mathematics (CM)**: statistical expertise would benefit analysis and interpretation of Monte Carlo generated data and development of novel and efficient machine learning methods.

- *Expanding cohort of researchers*:

We will sustain the enrichment of our research environment by

(a) supporting candidates to apply for personal fellowships,
(b) making opportunistic appointments when appropriate.

A priority will be recruitment to areas bridging expertise of current staff, e.g., computational PDEs would link the **PDE** & **CM** groups.

- *Maximising impact:*

Enhanced involvement with Data and Computer Sciences and expansion of the **Centre for Biomathematics**, will lead our drive to realise impact. Interdisciplinary and industrially linked PhD projects will sustain impact-related research and the development of statistics will present additional routes to engagement with end-users. Growth of research in **Mathematics Education** will maintain and expand wide-ranging impact through public engagement and influence on school-level mathematics curriculum and educational policy.

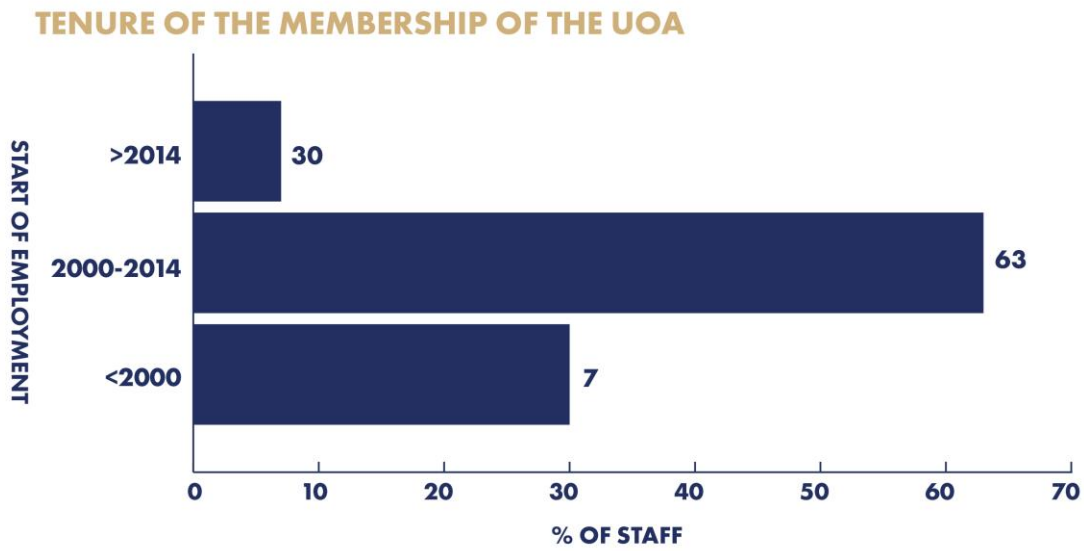
- *Capitalising on strategic links*:

Engagement with Swansea University's Strategic Partnerships, e.g., **Texas A&M University (TAMU)** and **Université Grenoble-Alpes**, has already led to new collaborative research projects [Giansiracusa/Pulita, Crooks/Russ, Powathil/Stephanou (**Grenoble**), Moroz/Berkolaiko (**TAMU**)] and two Swansea-Grenoble PhD studentships. We will continue to take advantage of such partnerships to establish further collaborations, capitalise on funding pathways for PhD students, and explore additional possibilities for engagement, e.g., joint master's degree programmes.

2. People

2.1. Staffing strategy

The prevailing unit staffing strategy is to attract and retain the best academic staff world-wide, irrespective of their gender, social, racial, national or cultural background and with careful consideration for historically embedded inequalities, as “mathematics knows no races or geographical boundaries.” (David Hilbert)



- *Vitality and sustainability*.

With 7% of members appointed before 2000, 63% between 2000-2013 and 30% (including four research fellows) since 2014, the Department has a stable core of membership that will sustain and grow its research activity over the years to come. In this census period, we have focused on recruiting academics at the beginning of their career who are potential future stars and world leaders. This resulted in the following appointments:

(a) three lecturers [Dłotko, Picco, Villamizar],
(b) a senior lecturer [Powathil],
(c) four research fellows [Bao (2017-19), Fathizadeh, *Harvey*, Ren],
(d) an associate professor entering academia from industry [*Wright*].

All appointees coming from academia have arrived in Swansea from world-leading mathematics departments including

(a) CalTech [Fathizadeh],
(b) Oxford [Picco],
(c) Max Planck Institute MIS, Leipzig [Ren].

Two of the fellowships [Bao (2017-19), Fathizadeh] have been co-funded with the Welsh Government (Sêr Cymru or Welsh Star Fellows), one of which will convert to a permanent position after the initial three years [Fathizadeh].

- *Coherence and versatility.*

Our strategy is to employ researchers whose interests fit into more than one research group or who show potential for multidisciplinarity. All Category A members of staff who have been recruited in the census period satisfy this criterion:

(a) Powathil (**B** & **CM**),
(b) Dłotko (**AGT & CM**),
(c) Picco (**B** & **CM**),

(d) Villamizar (**AGT** & **CM**),
(e) Fathizadeh (**AGT** & **CM** & **PDE**),
(f) Ren (**AGT** & **CM**).

Established members of staff are encouraged to broaden their research portfolios (e.g. through the **Mathematical Sciences Unplugged** series of seminars initiated by Mercuri, at which colleagues from other disciplines present mathematical problems in need of solution, or the multidisciplinary **Biomathematics** colloquia). This improves coherence of the research activities of this moderate size UoA, while keeping them broad at the same time.

- *Impact.*

Staffing strategy is also used to support the realisation of impact. The enhanced innovation and engagement strand of the University academic career pathway scheme (see §3.1 REF5a) is designed to recognise and reward those who demonstrate impact through knowledge transfer. The UoA now includes two members of staff employed on this strand:

(a) *Lyakhova*, made permanent and promoted to Associate Professor in the census period;
(b) *Wright*, appointed as Associate Professor in 2019.

Making new appointments in research areas with strong interdisciplinary research interests further supports our impact agenda.

2.2 <u>Staff development</u>

- *Early Career Researchers (ECR)*.

Newly appointed staff are given extensive support, mentoring and training to help develop fully their potential as researchers and university teachers, aligned with the **Vitae Concordat and Researcher Development Framework** (see §3.1.1 REF5a). This includes:

(a) mentoring of probationary staff by experienced colleagues;
(b) courses on PhD student supervision or personal tutor training and activities organised by the **Swansea Academy for Learning and Teaching at Swansea University**;
(c) training and support to achieve fellowship of the HEA;
(d) reduction of teaching loads;
(e) additional research funds, e.g. for attending conferences, establishing collaborations, and for research visits;
(f) support for preparation of funding applications.

Sêr Cymru research fellows have generous research funds and no teaching and administrative duties.

Dedicated early-career support schemes have benefitted the research of several ECRs in the UoA, e.g.,

(a) the **College of Science International Visitor Scheme** for ECR enabled Villamizar to host Mantzaflaris (**INRIA**) for an extended visit.
(b) *Harvey*, currently a Daphne Jackson Fellow, won a **Swansea University Florence Mockeridge Fellowship** that provided training and support to help maximise his research potential;
(c) Dłotko participated in the **UK Digital Economy Crucible** leadership programme**;**
(d) Giansiracusa participated in the **Welsh Crucible** scheme for future research leaders in Wales.

- *Staff training and support*.

All members of academic staff are enrolled in the **Swansea University Professional Development Review** (**PDR**), based on key performance indicators for both research and teaching. Academic staff discuss their performance, set targets, and indicate their requirements to achieve these targets twice annually with their reviewer (typically HoD).

Training needs are identified through this process. A range of courses is available through the **Swansea University Professional Services Directorates**. These include those organised by the **Research, Engagement and Innovation Services**, whose primary role is to:

(a) help academic staff build a sustainable financial base for their research,
(b) find collaborators and industrial partners,
(c) help identify ways of disseminating research results,
(d) provide up-to-date information about funding opportunities.

The **College of Science Research Hub** supports academics to develop funding applications.

- *Promotion*.

The PDR system has streamlined the promotion process leading to, since August 2013,

(a) five members of staff being promoted to Chairs,
(b) four to Associate Professorships,
(c) six to Senior Lectureships.

- *Sabbatical Policy*.

The Department has its own strategy to award each member of staff every five years a lecture-free semester. Every member of the UoA was able to take advantage of this during the census period. Highlights of value added by such sabbaticals include:

(a) a publication in a highly prestigious journal (JAMS) resulting from extended research visits to **Duisberg-Essen** and **Mittag-Leffler** [Garkusha];
(b) a collaboration in a new research direction leading to the recruitment of a jointly supervised PhD student (Swansea-Grenoble) and a UKRI Future Leaders Fellow as well as a co-organised international conference [Giansiracusa];
(c) diversification of research interests from the analysis of PDE to more applied topics including problems from computational chemistry during a sabbatical in **Eindhoven** [Mercuri].

2.3 Research students

The Department has a very vibrant PhD community. Based on past and continuing success, the UoA attracts a significant number of self-funded overseas students. Strategic pathways have been initiated for attracting students, providing them with top-class education and mentoring:

(a) the Department is actively involved in the Swansea University partnership with **Université Grenoble-Alpes**, which includes a joint PhD programme that has already brought two jointly-funded co-supervised studentships to the UoA;
(b) highly competitive **Swansea University Research Excellence Scholarships** (**SURES**), which are accompanied by generous research and training funds and have attracted a current Mathematics SURES recipient who came top of the University rank-ordered list;
(c) the **EPSRC Doctoral Training Partnership.**

Our core strength in pure mathematics is accompanied by a regular intake of around four-five PhD students per year spread over the **AGT**, **P** & **PDE** groups. Recent expansion into more applied areas has attracted additional students aligned to the **B** & **CM** groups, including students linked to the **Liverpool-Oxford-Swansea Centre for Topological Data Analysis** (**TDA**) and the **Centre for Biomathematics**. We plan to grow capacity in these areas in the next five years, as the profile of these vibrant newly established groups increases. All PhD students are fully integrated in the research groups to benefit from, and contribute to, a collaborative and supportive network comprising established academic staff, ECRs, and fellow PhD students.

We are also benefitting from involvement in three UKRI-funded centres for doctoral training, all with an interdisciplinary flavour, as well as a Horizon 2020 funded Marie Skłodowska-Curie Innovative Training Network (ITN).

- Giansiracusa is a co-Investigator in the **EPSRC CDT in Enhancing Human Interactions and Collaborations with Data and Intelligence Driven Systems**. Funded by EPSRC in 2019 the Centre will be training 55 PhD students, exposing them to challenging domains and applications of AI (e.g. in Manufacturing, Medicine, Economics, Law). Industrial partners of the Centre include **Ford** and **Facebook**.

- Lucini is a co-Investigator and the Technical Director of the **UKRI CDT in Artificial Intelligence, Machine Learning and Advanced Computing**. The Centre is a Swansea-led collaboration including **Aberystwyth**, **Bristol**, **Bangor** and **Cardiff** Universities and has as partners a wide range of companies, from large multinational enterprises (e.g. **Atos, Microsoft**) to SMEs (e.g. the Swansea-based Data Analytics company **We Predict**), spanning industrial sectors from Finance to IT and Health.

- The **STFC CDT in Data Intensive Science**, led by Cardiff and involving Swansea and Bristol, provides training in Data Intensive Methods (including Bayesian statistics and Machine Learning) with application to Astronomy and Particle Physics. Currently training 20 students, the Centre is based on a close partnership with industries, which provide a placement for six months. Industrial partners include **Aviva**, **CRAY**, **E-On** and **Oracle**. Lucini is on the Board of Directors of this CDT.

- The H2020 funded **Marie Skłodowska ITN for Particle Physics, Lattice Field Theory and Extreme Computing** (**EuroPLEX**) comprises of nine European Institutions: **Parma** (coordinator), **Humboldt University Berlin**, **Bielefeld**, **Trinity College Dublin**, **Edinburgh**, **Universidad Autonoma de Madrid**, **University of Southern Denmark**, **Regensburg** and **Swansea**. The objective of the network is to train 15 Early Stage Researchers that are enrolled as a part of the training in PhD programmes in the partner universities. Partners of the network include **Google** and **Nvidia**. Lucini leads the EuroPLEx work package on Advanced Statistics and Data Analysis, is the first supervisor of a Swansea-based ECR ITN Fellow, and is second supervisor of a Fellow hosted in Madrid.

PhD studentships on **interdisciplinary** topics, funded through the UKRI-funded CDTs together with five CoS-University co-funded projects in the Centre for Biomathematics and two University-funded projects in the Centre for Topological Data Analysis, are helping to sustain and develop the interactions between UoA members and other disciplines and end-users that are recognised to be valuable for the generation of impact.

All PhD students have intensive research training as well as training on transferable skills and research project management provided by the **College of Science Doctoral Training Centre**. They are expected to attend and speak at research seminars, there is a student-organised seminar series, and they participate in subject-specific informal seminars (e.g. Tropical Geometry [Giansiracusa]). Every PhD student is expected to give at least one talk in the annual **Welsh Mathematical Colloquium at Gregynog**. Five PhD lecture courses were delivered by visiting professors within the **Erasmus+** programme.

The UoA has awarded 32 PhDs in the census period, the majority of whom progressed to academic positions in the UK, Germany, Spain, China, Saudi Arabia, Pakistan and Iraq. Other destinations include high-level financial institutions, e.g., **Close Brothers Modern Merchant Bankers**, **OSTC Stockbrokers**, the **Intellectual Property Office,** and the **NHS**.

2.4 Equality and diversity

The UoA has academic staff with very diverse cultural, national, and ethnic backgrounds. Members of staff originate from Europe (including all UK nations), Asia, both Americas, and Australia, and 66% have a first language other than English. It is our strategy to **maintain this diversity by attracting the best talent regardless of origin**.

While there is a visible gender imbalance at present (19% of permanent academic staff in the Department are female), addressing this imbalance is a priority. Progress since REF2014 is encouraging and is providing a promising pipeline:

(a) Out of the five permanent members of staff appointed, two are female (both Category A staff).
(b) The gender balance of postgraduate research students has improved markedly, with the proportion of female PhD students increasing from 33% (2012/13) to 50% (2018/19).
(c) Of promotions of academic staff in the Department, 25% have been of female staff, exceeding the female proportion of academic staff as a whole.

We strive to be an inclusive and diverse place to work/study and are continually seeking to embed the principles of equality, diversity, and inclusion. We took an active part in a successful CoS Athena SWAN bid for a Bronze Award and have recently also been awarded an **Athena SWAN Bronze Award** as a part of the Computational Foundry. Policies arising from this engagement in the Athena SWAN process include:

- Advertisements for academic and postdoctoral appointments and PhD studentships:
  (a) include statements about commitment to equality and diversity,
  (b) are checked for gender bias in language using a gender decoder tool,
  (c) are disseminated as widely as possible through staff contacts and subject networks, including European Women in Mathematics.
- Departmental staff meetings include equality and diversity as a standing item and are held in core hours, usually during lunchtime.
- Networking events and focus groups provide opportunities for staff and students to discuss equality and diversity issues.
- Organisers of research workshops and seminars seek gender-balance in speakers, e.g., two recent workshops had equal numbers of male and female speakers.
- Publicity materials are monitored for gender and ethnicity.
- Female staff are supported to participate in leadership programmes, e.g., Aurora [Picco].
- All members of the UoA have taken an `Equality and Diversity at the Workplace' course and unconscious bias training is under development for both staff and PhD students.

In addition, and in line with the University Code of practice, all members of the UoA team with responsibility for decisions on the selection of outputs and impact case studies for this submission undertook mandatory equality training, including specialised courses on equality and diversity and unconscious bias. The submission comprises one best-quality output from each Category A staff member with the balance made up of the best-quality outputs from the available pool of eligible outputs that includes outputs of former eligible colleagues.

A family friendly policy is in place in the UoA, allowing for flexibility of working arrangements whenever possible, e.g.,

(a) the **Algebra and Topology Seminar** series holds lectures during lunchtime and tends not to arrange talks during school half-term holidays, to allow participants with young families to better manage their professional and parental duties;
(b) academic staff who return from maternity or adoption leave have six months free from lecturing duties;

(c) co-funding and hosting a **Daphne Jackson Fellow** [*Harvey*] underlines our commitment to supporting those returning to active research after a career break.

We contribute to addressing the root causes of gender and societal imbalance by:

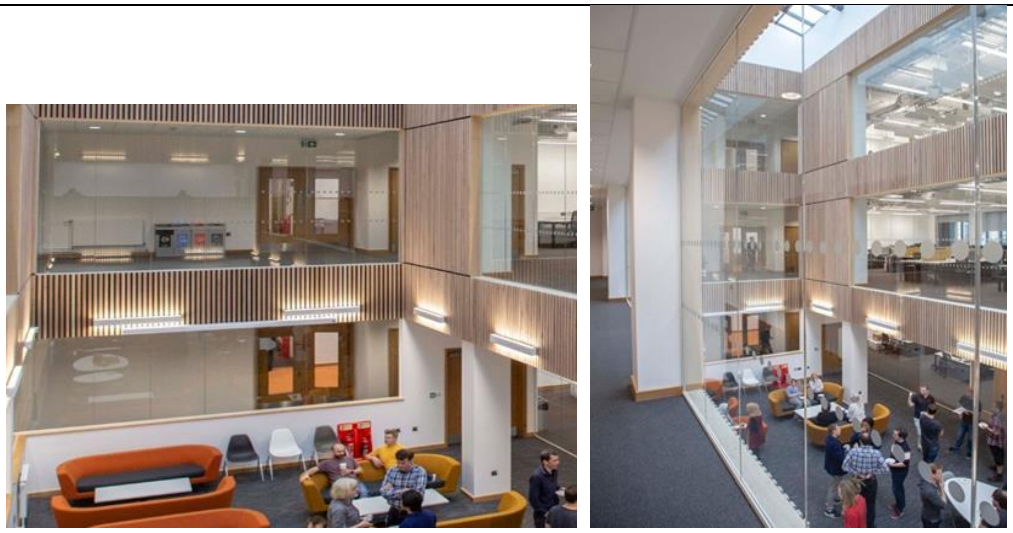
- **actively promoting** STEM subjects among girls through research-led masterclasses for Year 10 girls and other FMSPW-led activities tackling gender, racial and economic inequalities;
- **creating and promoting role-models** through:
  (a) the **Soapbox Science** events,
  (b) **Science Festivals**,
  (c) school conferences on `**Celebrating Women in Mathematics**',
  (d) departmental `**Meet Your Lecturer**' sessions;
- **engagement** with events to encourage female researchers, e.g.,
  (a) speaking in `**Women in PDEs**', Oxford, 2018 [Crooks];
  (b) organisation of the `**Women in Shape Analysis (WiSh)**' conference [Villamizar];
- the **research agenda** of the Mathematics Education group includes the uptake of mathematics in schools and transition from school to university.

3. Income, infrastructure and facilities

3.1 Infrastructure and facilities

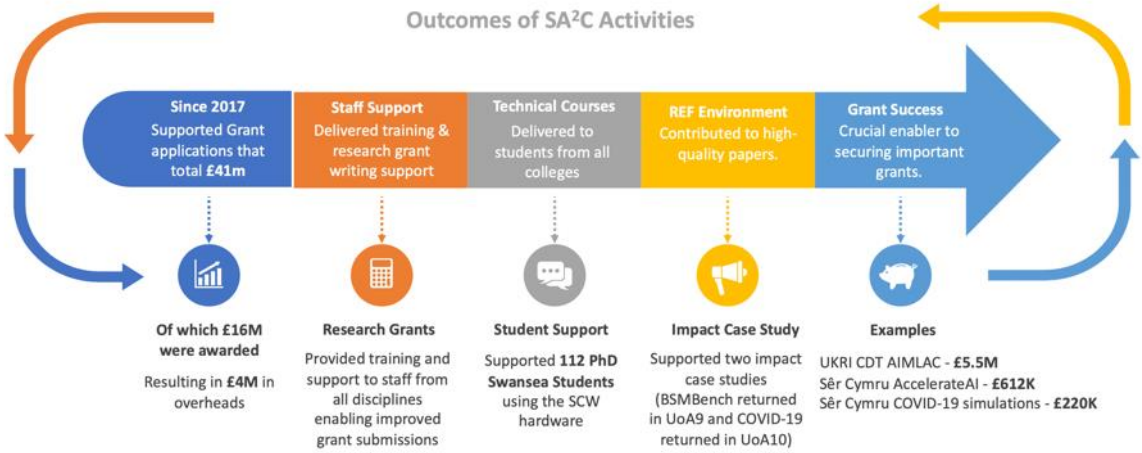
The £32.5M **Computational Foundry (CoFo),** backed by a major university infrastructure investment and **£17M** from the European Regional Development Fund (ERDF), houses state-of-the-art facilities including:

- individual offices for all academic members of staff including post-doctoral fellows,
- dedicated office space for all post-graduate students,
- teaching space for undergraduate and postgraduate courses in Mathematics and Computer Science,
- bespoke laboratories set up to support research and innovation,
- shared spaces for collaboration between industry, research and students,
- meeting rooms,
- social areas and networking spaces,
- a common room, the **Research Crucible**, surrounded by glass in order to enhance engagement of staff with activities.



The 1300 sq. ft **Reading Room** with an extensive collection of books and periodicals is the focal point of the department and a valuable facility for research and departmental events.

Through the **Swansea Academy of Advanced Computing (SA^{2}C)**, Swansea is a major partner of the **£15M Supercomputing Wales** (**SCW**) project, part-funded by the ERDF, whose aim is to provide the high-performance computing (HPC) infrastructure for researchers in Wales.



Lucini, whose HPC expertise is recognised through leading roles in national HPC bodies such as the five-person **DiRAC Technical Directorate**, is the Swansea principal investigator for SCW. This project has a value in excess of **£5M** for the institution and has attracted external supporting research funding of **£3.5M**. Directed by Lucini and hosted at

the Computational Foundry in the Department of Mathematics, SA^{2}C acts as a focal point for the Swansea University HPC, Big Data and Machine Learning user community. It manages one of the two SCW systems and is home to six Research Software Engineers and two System Administrators. Researchers in the UoA, and in particular the **Computational Mathematics** group, are strongly embedded in the activities of SA^{2}C, and benefit from access to the expertise of the Research Software Engineers for code development and optimisation and from time (free at the point of use) on the SA^{2}C -managed supercomputing system. For instance, in the census period, Lucini's research has been supported by nearly nine million core hours on the SCW system and our COVID-19 impact case study has taken advantage of the skills of the SCW Research Software Engineers.

The **College of Science (CoS) Research Hub** is an important resource that underpins our securement of research funding. Comprehensive support to all staff applying for research grants includes:

(a) help with identifying opportunities,
(b) assistance in bid writing,
(c) financial costing.

The CoS Hub offers a bespoke **Fast Track Bid Mentoring Scheme**, consisting of a structured package of focused support, to academics who are targeting large grant capture. The Hub also organises rigorous mock panels, such as one held prior to the award of a **UKRI Future Leaders Fellowship** [Ren] to the UoA, to prepare applicants thoroughly for grant-related interviews.

The **Florence Mockeridge Fellowship Group** is a competitive University-wide initiative designed to offer intensive training and mentoring for promising prospective fellowship applicants such as *Harvey*, currently a Daphne Jackson Fellow in the UoA.

3.2 Income

Our research income has increased **15-fold**, with the average annual research income moving **from under £100K** in the REF2014 submission **to over £1.5M p.a.** in REF2021.

The **Liverpool-Oxford-Swansea Centre for Topological Data Analysis** is supported by the EPSRC grant New Approaches to Data Science: Application Driven Topological Data Analysis. A multidisciplinary team of mathematicians, statisticians, and computer scientists from Oxford, Swansea and Liverpool provide experience and expertise to drive the development and application of TDA to real-world problems. At Swansea, the Centre is represented by Dłotko and Giansiracusa. Highlights of interdisciplinary projects include:

(a) working with **Glaxo-Smith-Kline** on drug development and analysis;
(b) collaboration with **Swansea School of Management** on economic and financial data;
(c) collaboration with **GCHQ** on anomaly detection in data sets;
(d) analysis of nanoporous materials with **EPFL**;
(e) work with physicists on detecting phase transitions in complex systems such as QCD.

Two Sêr Cymru COFUND research fellowships, co-funded by the University and the European Commission under Horizon 2020's Marie Skłodowska-Curie Actions COFUND Scheme, have been awarded to talented researchers [Bao (2017-19), Fathizadeh] whose research agendas align with and extend the expertise of the UoA. These fellowships are part of the **Strengthening International Research Capacity in Wales** Fellowship Programme, administered by the Welsh Government, which aims to increase research capacity in STEMM-related subjects in Wales relevant to the '**Science for Wales' Grand Challenge** priority areas.

- Bao's fellowship, linking the **P** and **B** groups, was titled `Functional Stochastic Differential Equations and Applications to Natural Systems'.
- Fathizadeh was awarded a fellowship on `Noncommutative Geometric Invariants and their Applications', linking the **AGT**, **PDE** and **CM** groups, and has recently diversified to investigate neurophysiological activities in noisy time series.

A **UKRI Future Leaders Fellow**, Ren, working on `Computational tropical geometry and its applications', joined us in 2020 and provides a further connection between the **AGT** and **CM** groups.

The **NERC funded research project** `Interactions between sources of environment change: How do resource equality and coloured environments drive multi-trophic eco-evolutionary dynamics', of total value ca **£800k** and with Leeds and Swansea as partners and Yuan as this UoA's co-I, has developed a deterministic framework to describe experimental populations in environments incorporating environmental stochasticity.

A **Leverhulme Visiting Professor**, Friedemann Brock, has been hosted in the Department (2018-19). Brock, a world-leading expert in the symmetry of solutions of nonlinear PDEs, shared his expertise with the UoA and the wider UK community via close interaction with the PDE Group and a series of **Leverhulme Lectures** on `Symmetry, Rearrangements and Isoperimetry'.

Furthermore, the Department hosted the **Commonwealth Scholarship Commission Rutherford Fellow**, Faizullah Faiz, and six year-long visitors, Guang-ying Lv, Zhao-yong Sun, Li Tan, Xiaozhi Zhang, Shaoqin Zhang, and Guang-an Zhou, supported by the Chinese Ministry of Education.

Lucini has been the recipient of a **Wolfson Research Merit Award,** a **Royal Society** scheme for outstanding scientists who would benefit from a five-year salary enhancement to help recruit them to or retain them in the UK. The value of this grant is **£75,000**.

In addition, the Department has benefitted from the aforementioned **Supercomputing Wales Award (£3.5M** for the period 2015-2020).

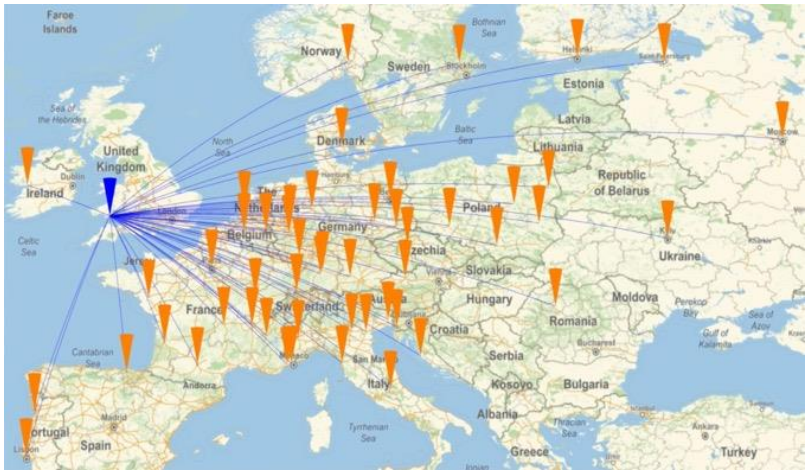
The **National Network of Excellence in Mathematics** (**NNEM**) is a pan-Wales project that has brought **£750k** of external funding to the UoA and is providing a structured approach for mathematics support for ages three to 18 through a Wales-wide virtual collaboration of identified lead Schools, Higher Education Institutions and Consortia. The research of the Mathematics Education Group is enriched by a collaboration of *Lyakhova* with *Joubert (2017-19)*, the NNEM Research Co-ordinator until 2019, that has formed the basis of the UoA's discussion with the Welsh Government about a new mathematics curriculum. This collaboration also takes advantage of engagement with Texas A&M University, facilitated by the **Swansea-Texas Strategic Partnership**.

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

The vitality of the UoA is evidenced *inter alia* by its involvement in, and leadership of, a wide range of national and international collaborations and initiatives, together with the international reputations of its staff. The depth and breadth of our activity, encompassing staff at all career stages, demonstrates the significant contribution that we are making to the vibrancy and sustainability of the discipline both in Swansea and globally.

- *Academic collaborations, networks, and supporting the global researcher pipeline*

We have a strong record of **disciplinary and interdisciplinary collaborative research**, underpinned by our regular seminar series, academic visitors to the Department, and visits of members of staff to other institutions. Since 2014, 80% of our research outputs involve a collaborator from outside Swansea, and 70% result from an international collaboration. We have active collaborations with members of over 50 academic institutions around the world. The range of this collaborative activity is illustrated by the following maps:



Several of these collaborations build on the **Swansea-Grenoble** and **Swansea-Texas Strategic Partnerships.**

Activities co-organised with other UK institutions, typically supported by jointly held research grants:

- **subject networks**:
  - LMS Scheme 3 Joint Research Groups:
    - Mathematical modelling of random multicomponent systems, Durham-Reading-Swansea-York;
    - Biomathematics, Cardiff-South Wales-Swansea;
    - Applied Algebra and Geometry, York-Edinburgh-Oxford-Swansea;
  - LMS-WIMCS-Bath Analysis Days;
  - South Wales Analysis and Probability Seminar;
- **Liverpool-Oxford-Swansea Centre for Topological Data Analysis**;
- **collaborative provision** of research-student training through our involvement in multi-institution doctoral training centres;
- **South Wales & South West LMS Regional Meeting and Workshop**, held in Swansea in 2013;
- **Wales Mathematical Physics** online seminar, revived in 2020;

- organisation of the annual **Wales Mathematics Colloquium** in Gregynog in 2015 and 2019.

Contributions to **interdisciplinary networks** are evidenced by

- Lucini being a member of the management board and technical committee of the pan-Wales project Supercomputing Wales,
- Powathil being an expert panel member on the project `Predictive Modeling for Healthcare Technologies Through Maths'.

Several staff have contributed short courses of advanced lectures to the **training of PhD students,** e.g.,

- Brzeziński: lectures at the Białowieża School on Geometry and Physics, Poland, 2016;
- *Evans*: Erasmus courses, Dresden, 2015, 2016;
- Finkelstein: Erasmus course Bielefeld 2018; IRTG group 2017;
- Lytvynov: Erasmus courses, Wroclaw, 2016, 2017, 2018;
- Moroz: lectures at University of Pisa, 2015 and A&M University, USA, 2017;
- Crooks: lectures at Capital Normal University, Beijing, 2014, and an LMS Research School, Edinburgh, 2019.

The LMS funded visit of Mercuri to collaborate with M.M. Fall at **AIMS-Senegal** contributed to knowledge transfer to developing countries.

During the census period we acted as **external examiners** for over 30 doctorates from universities in the UK, France, Germany, Italy, Portugal, Denmark, China and Australia. The 2021 **LMS Undergraduate Summer School** (moved from July 2020 due to the Covid-19 pandemic) will take place in Swansea.

- *Contributions to the economy and society*

Collaborations outside of academia have increased markedly since REF2014. Examples of **interactions with industry** include:

(a) studying the effects of DNA damage repair inhibitors [**AstraZeneca**; Powathil];
(b) applications of compensated convexity methods for image and data processing to digital watermarking [**Fortium Technologies Ltd**; Crooks];
(c) development of an efficient and accurate solver based on an alternate (T-Omega) formulation of Maxwell's equations [**EMWorks Ltd**; Dłotko];
(d) spline approximation for computer-aided geometric design (CAGD) [**Numerical Geometry Ltd**; Villamizar].

Industry-facing initiatives, such as

(a) funding for secondments and international mobility:
    - Powathil – **Astra Zeneca**, **Institute for Cancer Research**;
    - Dłotko – **Royal Osteoporosis Society**, **Child Mind Institute New York**;
    - Lucini – **IBM, New York**,

(b) bespoke events with individual companies (e.g., **IBM**, **Amazon Web Services**) in the Computational Foundry,

are organised by **Cherish-DE** and providing a facilitating framework for such engagement.

Impact on society through **public** and **school engagements** and **influence on policy** has expanded. Highlights include:

(a) Founded in Swansea in 2010, the **Further Mathematics Support Programme Wales** (**FSMPW**) is a pan-Wales organisation which aims at widening access to mathematics education in Wales and encouraging students in taking advanced

mathematics. This initiative has resulted in the UoA influencing curriculum and educational policy changes. Examples of FMSPW-organised events include:
  - annual series of **Royal Institution Masterclasses** [Year 9 (2010-2019); Year 10 Girls (2017-2019)],
  - the **British Science Festival Family Weekend** (2016),
  - the **Swansea Science Festival** (2017-18),
  - the **Urdd Eisteddfod**,
  - **conferences for schools** on `Mathematics is Your Future' and `Celebrating Women in Mathematics',
  - **continuing professional development** events for school teachers.

(b) Crooks, *Lyakhova* and Villamizar spoke in the Swansea series of **Soapbox Science**, where female scientists talk about research to passers-by.

(c) *Lyakhova* was an invited speaker at a Mathematics Greek Legacy Outreach Conference at the Royal Institution (2014).

(d) Brzeziński gave a public lecture at ICMS, Edinburgh (2018).

Media coverage includes:

(a) Villamizar was interviewed on the **BBC Wales Science Café** (2017);

(b) *Lyakhova* featured in the Welsh Government press release on the **National Network for Excellence in Mathematics** and follow-up coverage by the **BBC** (2016).

- *Academic esteem, leadership, and service*

Our research is having considerable impact on the discipline at large. Performance data on outputs of Category A staff (captured on SciVal using 2014-2020 Scopus data) include:

- the field-weighted citation impact is 1.30 (with one being the average for the discipline),
- 14.3% of publications are among the top 10% of most cited publications worldwide,
- 18.4% of publications are in the top 10% of journals (by CiteScore).

The following examples provide additional evidence of the esteem and leadership of the UoA in the global academic community.

Invitations: Over 300 invited conference presentations, research seminars and research visits have been undertaken by members of the UoA. Highlights include:

- Beggs: plenary at *Semiquantisation and Poisson-Riemannian Geometry at Quantum Spacetime*, Zakopane, 2016;
- Brzeziński: plenary opening lecture at *International Workshop on Algebra and Its Applications,* Fez, 2014;
- Crooks: plenary at *Models in Population Dynamics, Ecology and Evolution*, Leicester, 2018;
- Dłotko: INI Satellite Workshop: *Future Directions in Network Mathematics*, London, 2016;
- Fathizadeh: *Workshop on Non-commutative Geometry, Index Theory and Mathematical Physics,* Oberwolfach, 2018
- Garkusha: *Framed Motives of Algebraic Varieties (after V Voevodsky)*, IHES, 2016;
- Giansiracusa: *Tropical Geometry in the Tropics*, IMPA Sao Paulo, 2015;
- Lucini: *37th International Conference on High Energy Physics (ICHEP14)*, Valencia, 2014;
- Mercuri: *XI Brazil-Italy Workshop in Nonlinear Differential Equations,* Varese 2019;

- Moroz: *Batsheva de Rothschild Seminar on Hardy-type Inequalities and Elliptic PDEs*, Israel, 2018;
- Powathil: *Biomarkers of Radiation in the Environment: Robust tools for risk assessment*, NATO Advanced Research Workshop, Armenia, 2017;
- Wang: *International Conference on Spatial Probability and Statistical Physics*, Chinese Academy of Science, 2017;
- Wu: LMS-EPSRC Durham Symposium on Stochastic Analysis, Durham, 2017;
- Yuan: *Workshop on Ecological and Biological Systems*, IMA Minnesota, 2018.

Organisation of international meetings: Members of the UoA from all career stages have been active in organising international research meetings in Swansea, elsewhere in the UK, and overseas.

Examples include:

Swansea	- Algebraic Spline Geometry, 2019 - Symmetries and Asymptotic Patterns in Nonlinear PDEs, 2019 - Probability and NonLocal PDEs: Interplay and Cross-Impact, 2018 - Dragon Applied Topology Conference, 2018 - UK-Japan Workshop on Analysis of Nonlinear PDEs, 2018 - Workshop on Stochastic Dynamical Systems, 2017 - Biomathematics 2017
UK	- The XXXIV International Symposium on Lattice Field Theory, Southampton, 2016
Overseas	- Motives in St. Petersburg, Euler International Mathematical Institute, St. Petersburg, **Russia** 2018 - 17^{th}/18^{th} Workshops on Noncommutative Probability - Lévy Processes and Operator Algebras with Applications, Będlewo, **Poland**, 2016, 2018 - ICM Satellite Conference: Stochastic Processes, Analysis, and Mathematical Physics, Osaka, **Japan** 2014 - Sixth Encuentro Colombiano de Combinatoria ECCO & CIMPA Research School: Combinatorics meets Algebra, Geometry and Optimisation, **Colombia** 2018 - Special Session in the 12th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Taipei, **Taiwan** 2018 - Conference on Stochastic Processes and their Applications, Moscow, **Russia**, 2017 - 35^{th}- 39^{th} Workshops on Geometric Methods in Physics, Białowieża, **Poland** 2016-2020 - The IHES 2020 Summer School on Motivic, Equivariant and Non-commutative Homotopy Theory, **France**

Editorial roles: We have contributed to the **editorship of over 25 journals and book series**, including:

(a) Jacob (retired 2020) is **Editor-in-Chief** of De Gruyter Studies in Mathematics, and co-edited *Festschrift Masatoshi Fukushima*, World Scientific, 2015, and *Special Issue for Herbert Heyer, Communications in Stochastic Analysis 2016*.

(b) Memberships of journal editorial boards include:
   - LMS research journals [Crooks (2008-18), Giansiracusa] and *Newsletter* [Brzeziński (2016-19)];
   - *Fractional Calculus and Applied Analysis* [Jacob (retired 2020)];
   - *Proceedings of the Royal Society of Edinburgh* [Moroz];

- *Electronic Journal of Probability* [Wang];
- *Nonlinear Analysis: Hybrid Systems* [Yuan].

(c) Lucini was editor of a special issue of the *International Journal of Modern Physics A* "Lattice Gauge Theories beyond QCD", 2016, and chaired the Editorial Board of the "Proceedings of the 34th Annual International Symposium on Lattice Field Theories", SISSA, 2016.

Leadership roles in funding organisations and learned societies:

- Brzeziński was **Chair** of the **Flemish Funding Agency** (**FWO**, Belgium) Mathematics Grants and Projects Panel (2019-2020), where he was an expert (2015-2020); he is a member of the **Science and Technology Working Group** advising on the future of **FWO** (2020).
- Moroz is a member of the **College of Reviewers of the European Science Foundation** and the **Discipline Committee** (Mathematics) of the **Czech Science Foundation**.
- Wang was a panel member of the **National Nature Science Foundation** of China (2017).
- Brzeziński, Crooks, and Giansiracusa are full members of the **EPSRC Peer Review College** and have participated in **EPSRC Prioritisation Panels**; Crooks has acted as **chair** for an EPSRC Prioritisation Panel and **deputy chair** of a **UKRI Future Leader Fellowship Sift Panel.**
- Giansiracusa is a member of the **EPSRC Advisory Group for the Additional Funding Programme for Mathematical Sciences** and was a member of the **LMS Research Policy Committee** (2014-2020).
- Crooks is a **Member-at Large** of **LMS Council** and a member of the **LMS Publications Committee.**
- Powathil is **Secretary** of the international **Society for Mathematical Biology** (2020-).

We have peer reviewed for over 15 funding bodies around the world and many academic journals.

Awards, fellowships and prizes:

- Dancer was awarded the 2017 **Schauder Medal** for Nonlinear Analysis by the **Schauder Centre for Nonlinear Studies**, Nicolaus Copernicus University, Toruń, **Poland**;
- Moroz held a Visiting Professor Fellowship, Technion, **Israel** (2015) and guest professorship at Osaka Prefecture University, **Japan** (2016);
- Brzeziński was awarded the state title of Professor by the **President of Poland** (2016);
- Lucini was elected a **Fellow of the Learned Society of Wales** (2018);
- Giansiracusa held an **EPSRC Career Acceleration Fellowship** 2011-2015;
- Powathil presented his research at the **Parliament `SET for Britain**' event (2015).

We trust that this combination of disciplinary leadership, interdisciplinarity, collaboration, esteem, and service show the UoA to be playing a significant role in the mathematics community.