Institution: University of Portsmouth

Unit of Assessment: 10 Mathematical Sciences

a. Overview

The Department of Mathematics has experienced considerable growth in research activity, due to strategic appointments over recent years. This submission includes 11 FTE Category A staff under the unified REF2014 unit UoA10 Mathematics, covering Pure and Applied Mathematics and Operational Research, including development and application of these areas. Research in mathematics is focussed on two main areas:

Applied Mathematics (in the Nonlinear and Complex Systems Group): 7 staff included in this submission: Banaji, Burbanks, Burridge, Hennig, Osbaldestin, Pickett, and Waters.

Operational Research (primarily in the Logistics and Operational Research Group): 4 staff included in this submission: Chlebikova, Jones, Li, and Song.

b. Research strategy

Prior to the RAE2008, most Applied Mathematics research at Portsmouth was focussed on Cosmology and Gravitation. At the RAE, an Applied Mathematics submission was formed by the Institute of Cosmology and Gravitation (ICG) together with 2 members of Mathematics staff (Burbanks and Osbaldestin), while staff from the OR grouping contributed to a Business and Management submission with members of the Portsmouth Business School.
Since 2008, there has been a strategic realignment of Mathematics and Physics research within the Faculty. Building upon its established world-class reputation for research at the interface between theory and observations, and upon the University's engagement with the South-East Physics Network (SEPnet), the ICG expanded its international research profile in field-survey cosmology and the underpinning astrophysics. Research excellence in Mathematics was refocused on Dynamical Systems and Operational Research: strategic investment, in tandem with considerable success in undergraduate and taught postgraduate recruitment (together with strategic replacement of retiring staff) enabled new appointments that expand and strengthen Applied Mathematics and Mathematical aspects of Operational Research activities in the department. The success of this strategic re-focus is evident in a new submission of the ICG to REF UoA9 and a separate submission of Applied and OR research by the Department of Mathematics to REF UoA10.

The Department of Mathematics strategy in the period 2008-2013 has been to grow and develop the two main groups, Operational Research and Applied Mathematics, as vibrant research communities, delivering high quality outputs and engaging with public- and private-sector users.
Strategic plans for 2008-2013 were created with the following broad aims:

- To recruit staff to strengthen our existing areas of expertise, combined with appointments that provide opportunities for activity in emerging areas of strategic interest: 6 new appointments have been made in Applied Mathematics and 5 in Operational Research.
- To develop a supportive research environment in which early career staff are mentored by more experienced researchers, together with institutional support for improving grant applications and training in postgraduate supervision (section c. People).
- To increase numbers of Postdocs and PhD students across both research groups. Additional internal funds have been provided, with the majority earmarked to fund a rolling programme of bursaries and the remainder contributing to academic staff costs to support additional supervision and research activity.
- To support staff to establish and maintain internal and external collaborations, including those of an interdisciplinary nature. “Pump-priming” funds were provided for engagement with users and participation in the formation of research grant consortia.

Operational Research (in the Logistics and Operational Research Group):
The work of the Logistics and Operational Research Group (LORG) is focussed on mathematical aspects of Operational Research (OR) with strengths including the theory underlying multi-objective

optimisation, polynomial optimisation, and combinatorial optimisation. Fundamental research in these areas also leads to the development of more realistic and flexible methodologies and algorithms that can be applied to solve problems in situations arising in the healthcare, logistics, and renewable energy sectors, and the group has also engaged in impact-generating activities in these areas.
Our strategy post-2008 was to grow and develop the existing LORG, spanning the spectrum of fundamental Mathematical developments in OR, (including the development of novel multiple-criteria methodologies, the theory of cutting and packing, multi-objective optimisation, and specific logistics-based models). We have made new staff appointments (including strategic replacements of retiring staff) to achieve a balance between our existing strengths and new opportunities in theoretical areas of importance, via strategic selection of candidates. Five new lecturers were appointed during 2008-2013, including Song (2011) with experience in cutting-and-packing algorithms, and Li (2013) in polynomial optimisation, complementing existing local strengths including Jones (theory and application of multi-objective optimisation) and Chlebikova (combinatorial optimisation). We have enhanced our ability to meet growing demand from external user organisations in the public and private sectors (chiefly in healthcare, renewable energy, commercial, and industrial areas) for research underpinning new multi-objective optimisation techniques and their applications.

Applied Mathematics (in the Nonlinear and Complex Systems Group):
The main academic aims of the group are in Nonlinear Dynamics and its applications, including the development of algebraic techniques for determining integrability (n-body type problems and others), algebraic techniques for the analysis of chemical and biochemical reaction networks (finding specific criteria concerning the structure of a network, and qualitative information about its parameters, that restrict the qualitative behaviour). We seek novel methods for construction and analysis of trajectories (Orbital Mechanics of solar sails), criteria for (and construction and analysis of) dynamical systems that exhibit directed transport and collective phenomena (with applications to energy transfer in biomolecules and others), and the use of statistical mechanics to analyse geological hazards (e.g., improved models for landslide distributions, matching real-world data).
Our strategy was to grow the applied mathematics complement to develop research capability and increase engagement with users in particular areas of importance. Over the period 2008-date, 6 new appointments have been made, including: Waters 2010 (orbital mechanics), Banaji 2010 (chemical reaction dynamics), Hennig 2012 (transport, collective phenomena, biomolecules) and Simon 2009 (integrability, not included here). The recent strategy has been to broaden slightly the remit of the group, via the additional appointments of Pickett 2010 (numerical analysis, specifically adaptive mesh modelling) and Burridge 2012 (statistical mechanics), to develop cross-disciplinary applications. The group has expanded from 2 staff included in RAE2008 to 7 included in REF2014.

Strategy for 2014-2020:

- We aim to appoint at least 4 new lecturers in 2014-2017 with at least 2 in OR, together with further strategic replacements of retiring staff across the department.
- We will continue to favour appointments that reinforce our core strengths in Nonlinear Dynamics and Operational Research, balancing the need for interaction with user groups.
- Recently-awarded and pending external grants will strengthen our existing initiatives to support further Postdocs and PhDs in both groups. In line with the Faculty's strategic plans, we aim to fund 2 new bursaries per year (one per group) over the next 5 years.
- We plan to expand our successful taught postgraduate provision to meet increasing international demand in OR subjects, which will enable further staff recruitment. In tandem with external grant income to cover staff time, this will enable additional research activity.
- A strategic investment has been made (in 2013) to set-up a cross-faculty Operational Research Centre to develop further links with other disciplinary groups within the University of Portsmouth (and beyond). Initial funding has been secured to help set-up this virtual centre, which will provide administrative support for bringing together OR researchers spanning the spectrum from fundamental mathematics through to business applications, helping to provide a coherent focus for collaboration and impact-generating activities.
- We aim to capitalise on the expertise of our newly-appointed staff in Applied Mathematics by supporting them in the development of cross-faculty and external contacts contributing to impact-generation. Recent appointments have been targeted at developing future collaborations with practitioners in Earth and Environmental Sciences (Burridge), Biological

Chemistry (Banaji, Hennig), and Aerospace Engineering (Waters).
- We aim to increase the volume and diversity of external research income by increasing support for staff to make high-quality (internally peer-reviewed) funding applications (see c. People), together with broadening the variety of potential funding streams that we target.

c. People, including:
i. Staffing strategy and staff development

Our ambition is that staff are fully-engaged in vibrant research groups, supported by research staff and PhD students. We have planned and implemented an expansion in the numbers of researchers in both groups since RAE2008, making a number of permanent appointments (6 in Applied, and 5 in OR). We aim to appoint outstanding candidates who are research-active in one of the two main areas (Applied/OR) and display a track record of strong publications, grant acquisition and/or impact-generating activities, and to support staff once they arrive. New staff are given reduced teaching and administration loads during their first year of arrival, to enable them to devote time to making research progress, maintaining existing remote collaborations and developing new ones, and to initiate grant applications. New staff are paired with more experienced academic staff under a mentoring scheme and are represented at departmental and faculty research management committees by a Departmental Research Coordinator and faculty Associate Dean for Research.
Support for Funding Applications: Our strategy supports staff to apply for external funding, facilitated by the Institution's Research and Innovation Services (RIS). An institutional Peer-Review College reviews draft grant applications, providing constructive feedback. “Grant Hothouse” workshops provide training and the opportunity to run mock proposal reviews with a panel of referees. Particular attention is given to staff preparing applications for the EPSRC First Grant and similar schemes. Calls for funding applications are collected centrally and at Faculty and departmental level and are disseminated to all relevant staff.
Support for Consortium Initiation: Crucially, the department recognises the importance of exploratory meetings which might lead to collaborations and the formation of national and international funding consortia: departmental “pump-priming” funds are provided up-front for staff to attend these meetings (the outcome of which is necessarily uncertain). This has lead to successful involvement in consortia (recently, a successful €10M consortium bid for the project LEANWIND.)
Sabbaticals, Research Staff, and Students: All staff are encouraged and supported to apply for competitive internal Faculty funding for the appointment of Postdocs, for half-year Academic Staff Research Sabbaticals, and for bursaries for PhD students. In the period 2011-date, two staff in the department of Mathematics (one in each of the main research groups) gained half-year research sabbaticals. Achievement on sabbaticals is monitored at Faculty-level and constructive feedback is provided to staff. Two Faculty-funded Postdocs were also gained under the scheme (one in each of the main groups) and one Faculty-funded PhD bursary was secured. In addition, our strategy commits to investing additional internal funding in PhD Students and Postdocs, establishing a rolling programme of PhD bursaries, with at least two new studentships per year.
Personal Development and Career Progression: All staff and postdocs have an annual Professional Development Review with their line-manager to review progress, set goals and assess development needs (with reference to strategic plans) ensuring that all staff participate in relevant development events. Research is an integral part of the department's workload model. *Staff Development funds* (guaranteed £1K per staff member per annum) are provided for research visits, meetings, conference attendance, and for short-stay collaborative visitor support, and staff are encouraged to seek matching external funds. We recognise research leadership by rewarding staff who consistently exceed University and sector benchmarks via regrading to Principal Lecturer and promotion to Reader and Professor. The university has been quick to recognise the contributions of research staff through recent promotions (Jones to Professor in 2013, Burbanks to Principal Lecturer in 2012, and Banaji, Pickett, Burridge, Hennig, and Song, to Senior Lecturer, in 2011-2013).
Enhanced immersion of all staff within an extended research culture. A number of conferences and small workshops have been held in the department, including the 8th International Multi-Objective Programming and Goal Programming conference (2008), “Dynamics Day Pompey” (2010) and "Modern approaches to dynamical integrability" (2011), and an additional research seminar series in nonlinear dynamics has recently been launched. Members of the Nonlinear and Complex Systems Group, together with members of the Institute of Cosmology and Gravitation (ICG) are

encouraged to attend relevant seminar series and organise joint seminars, and Faculty and University Research Days provide networking opportunities across disciplines. We aim to develop additional research seminar programmes with increased participation of external speakers, in particular regular visits by eminent academics.

Visiting Scholars. The department offers additional support for visiting academics. The Logistics and Operational Research group hosted three year-long visiting lecturers, the most recent from China. Academic visitors are provided with office space and computing facilities and are fully integrated in departmental research activities.

Equality and diversity: We are committed to actively promoting the role of groups traditionally under-represented in science and related disciplines. This unit has a diverse staff profile with an ethnic background from 6 different countries, with approximately 30% of the FTEs submitted being women. The University joined the Athena SWAN charter in 2011 and will apply for Athena SWAN Bronze award in April 2014. The University has undertaken external audits by bodies including Stonewall Workplace Index and Working Families and has an institutional LGBT Staff Forum. The Head of Department (Osbaldestin), as chair of the Heads of Departments of Mathematical Sciences (HoDoMS), was heavily involved in the development of the *"Advancing Women in Mathematics: Good Practice in UK University Departments"* report commissioned by the London Mathematical Society and launched at the House of Commons in 2013.

Institutional Provision. The University of Portsmouth has an excellent environment for its research staff. Induction conferences are run biannually to introduce new staff to the University and highlight the opportunities available to them. The University values its research staff representation at University and Faculty committee level, providing a mechanism of raising awareness of research staff issues to senior colleagues in order to action change. The University's Research Staff Forum acts as to provide feedback on issues raised at University and Faculty level, as well as being a source of advice, guidance and information to researchers. A mathematics Postdoc (P Verrier) served on the forum as Faculty representative. The forum, which meets quarterly and is open to all research staff to attend, also provides a means of reporting back to the UK Research Staff Association to represent Portsmouth's researchers at a national level. The forum hosts visiting speakers on a range of topics of relevance to researcher staff, such as leadership in research and career opportunities for researchers, as well as having a social aspect. These activities create a strong sense of community amongst the researchers and support networking. Research staff are supported to devote time towards their continuing professional development. A tailored research staff training and development program, that is aligned to the Vitae Researcher Development Framework, is available to support this aim and includes course provision from a range of expert sources including those in-house, Vitae-supplied, and externally resourced. With the University's commitment to both the Concordat to Support the Career Development of Researchers and the EU HR Excellence in Research initiative, Portsmouth's researchers enjoy considerable support, emphasising the value that the University places on its research staff.

ii. Research students

Vision. Our aim is the fostering of fully-fledged independent researchers, rather than just the completion and defence of a PhD thesis. (Recent successes include PhD graduates who have become Postdocs and academics, including C Mulhern, who is now a Postdoc at the prestigious Max Planck Institute for the Physics of Complex Systems, Dresden.)

Strategy to increase numbers of PhD students. The department recognises that research students form an important part of a vibrant research environment and that this is an area in which growth is needed. Presently the department has 9 PhD students and recently accepted applications from 5 further students. Strategic staff appointments in 2014-2017 together with grant income will enable us to consolidate teaching loads, increasing resilience of staffing (following a substantial increase in undergraduate numbers in the period 2008-date) which will enable an increase in the number of PhD students supervised. In addition to receiving training in PhD supervision, early career researchers will be paired (as 2nd or 3rd supervisors) with more experienced staff on supervision teams, in order to gain experience, which will increase the pool of PhD supervisors.

Recruitment. The department seeks to attract high-quality applicants and receives international applications, particularly in the area of Operational Research and Logistics. The institution's International Office assists in the applications process and the Registry ensures rigorous quality

assurance, with particular reference to ensuring commensurability of qualifications and the candidate's ability to converse productively in English. A rigorous interview process is followed for shortlisted candidates, whether International or home/EU, with an emphasis on quality.

Induction and Training. Students from both research groups, at various stages of their studies, work in a large shared office. New students attend induction and training sessions run by the University of Portsmouth Graduate School, which provides dedicated space for running PGR workshops, PhD vivas, and meetings, augmenting local provision. New PGRs receive departmental training on the mathematical techniques and software used in their research area. All PhD students in the Nonlinear and Complex Systems Group must attend a series of weekly taught lectures covering graduate level Dynamical Systems theory and other relevant topics. Postdocs and staff, including those of other departments, are encouraged to participate.

Supervision. All PhD students meet with at least one member of their supervision team at least once per week and are required to submit for approval an email summary of each meeting, containing notes, progress, and agreed goals. The full supervision team (usually comprising three staff) meets the student at least once per term. The Graduate School has invested in the SkillsForge software, used to track meetings, progress, and identify development needs.

Annual Appraisal and Major Review. All PhD students at the University of Portsmouth must pass a major review at the end of their first year, which requires them to submit a written report, followed by a mini-viva with two assessors, including a Faculty assessor chosen from a cognate discipline. All students have annual appraisals with their full supervision team.

Immersion in Research Culture. The department of Mathematics has a programme of meetings and seminars, including weekly formal seminars in the two main research groups. Research students and postdocs are expected to present their work in progress, as well as finished projects, in these seminars series and externally. The Faculty of Technology runs an annual Research Day at which all PhD students and Postdocs must present a poster and/or a seminar. Time is provided for the students, postdocs, and staff to meet and discuss their research with other practitioners and users, in preparation for presenting their work at external conferences.

d. Income, infrastructure and facilities

The OR group has been the most successful in attracting external income, with extensive involvement in consortia with UK and international bodies in business and the public sector. Crucially, the department recognises the importance of meetings that might lead to collaborations and the formation of national and international funding consortia: departmental funds are provided for staff to attend these meetings before funding is secured. This strategy resulted in:

- A successful EU Interreg bid: “2OM: Offshore Operations and Maintenance Mutualisation.” yielding £932K in total (£152K for Portsmouth over 2012-2015) aimed at sharing best practice and experience, which helped to foster further collaboration. The group translated this success into accessing mainstream EU funding, with the following notable success:
- A successful EU FP7 consortium bid (with University College, Cork) was made in 2013 for “LEANWIND - Logistics of offshore wind farms” that will yield up to €10M in total. *The bid was rated the highest among all EU applications for this programme, scoring 12.5/15.*

Other successful consortia post-2008 include the following projects:

- SEABILLA – €10M consortium (€240K for University of Portsmouth).
- LOGMAN – €1.82M consortium (€157K for University of Portsmouth).
- CADRE – €320K consortium (€80K for University of Portsmouth).

Funding secured from streams supporting applications to industry also includes:

- Technology Strategy Board grant in Emerging Technologies - “Embedded Energy Management System”; in collaboration with the University of Portsmouth Institute for Industrial Research (IIR). Consortium grant. Expected value to group £33K.

Strategic investment enabled the instigation of the ORIBUS Project – “a research network to develop and apply the science and technology of operational research to build advanced and innovative business processes”, now further strengthened by funding to help establish our cross-faculty Operational Research Centre.

Support for new staff (section c.) resulted in successful First grants in the Applied group:

- EPSRC First grant. “Control Based Bifurcation Analysis for Experiments”, £85K.
- EPSRC First grant. “Stability and order preservation in chemical reaction networks”, £100K.

Researchers in Nonlinear and Complex Systems are also co-investigators on grants including:

- Leverhulme Trust, “Structural conditions for oscillation in chemical reaction networks”, £99K.
- Wellcome Trust, “Integrating monitoring and modelling for real-time tracking of cerebral circulation and metabolism”, £229K over two years.

We will continue to focus on funding streams to support OR research in collaboration with both academic and non-academic partners and aim to diversify funding for Applied Mathematics research through interdisciplinary access to channels from a range of different sources.

In addition to providing departmental computing facilities and licenses for specialist Mathematical software (including Mathematica, Maple, Matlab, and others) our researchers use dedicated desktop client software to access SCIAMA, a 1000+ cores distributed-memory High-Performance Computing cluster, managed by the Institute for Cosmology and Gravitation. (SCIAMA provides over 2TB of memory, 85TB of fast parallel storage, and 10TB of NFS storage, supported by 3 interconnection networks: 100bT, Gigabit, and Infiniband.) Maths staff use the cluster for tasks including numerical integration of huge ensembles, and parallel exploration of high-dimensional parameter spaces. These activities are supported by a dedicated supercomputing technician.

e. Collaboration and contribution to the discipline or research base

Collaboration with research users in industry has directly informed our research strategy.
We aim to develop a culture of engagement with other organisations that leads to mutually beneficial relationships. We work to promote expertise with a view to developing relationships on a national and international level, leading to research collaborations, participation in international consortia, and engagement with users. The Department ensures full involvement in these projects by funding visits to international project preparation events before funding is secured. When we engage with end-users, the University’s Research and Innovation Services (RIS) often acts as a conduit, as does our Institute of Industrial Research (IIR), which has an enviable record of industrial and commercial experience. One particular focus is in the direction of renewable energy research (exemplified by the current LEANWIND project). In order to foster collaborations, the department encourages long-stay research visits from staff at existing and prospective partners and has hosted year-long visiting lectureships for staff from Chinese Universities, together with Summer Internships, including annual interns from City University Hong Kong.

Group involvement in Major EU funded consortia and with industrial partners includes:

- LOGMAN (Logistics and Manufacturing Trends and Sustainable Transport) project, with AustriaTech, SYKE Finnish Environment Institute, and several others.
- SEABILLA (Sea Border surveillance) project, with Alenia Aeronautica, BAE Systems, Selex, Thales, Telespazio, EADS Defence and Security, and several others.
- 2OM (offshore wind energy) a consortium of Universities led by Le Havre, with partner CRiTT (transport and logistics) supported by many companies, including AREVA, Port of Ramsgate, Marine South East, aiming to liaise with UK and French off-shore wind industries.
- LEANWIND (Offshore wind energy) in collaboration with 31 entities, including ACCIONA Infrastructures and Energy, Maersk Training, A2SEA A/S, and EDP Innovations.
- Plans for an EU cost action with partners in Coimbra (Portugal) and Rotterdam (Holland.)

Collaborations with local industry include:

- CADRE (Congestion Avoidance Dynamic Routing Engine) funded by South East England Development Agency (SEEDA), with Comsine (lead partner), Hampshire County Council, Smartcom Software, Transport Research Laboratory (TRL), and ViaMichelin.
- IMAS (Cost-Effective Inventory Management in the Armed Services through Improved ABC Optimisation) funded by Centre for Defence Enterprise (MoD), with Polaris Consulting Ltd.
- EEMS (Embedded Energy Management System) funded through the Technology Strategy Board’s Emerging Technologies - Energy Efficient Computing competition - brokered by the University's RIS, and in collaboration with the University's IIR, with partner Xyratex.

Research with external collaborators illustrating inter-disciplinary work includes: Collaboration on solar sails (Waters) with the Department of Aerospace Engineering at the University of Strathclyde. Development of algebraic methods for the study of chemical reaction dynamics (Banaji) with the Department of Biomolecular Chemistry at U. Wisconsin and Electrical and Electronic

Engineering at Imperial College, London. Directed transport in Hamiltonian systems (Hennig) with Institute for Theoretical Physics, Humboldt, Berlin, Institute for Physics, Augsburg, and Max Planck Institute for the Physics of Complex Systems. Application of statistical mechanics to geological hazards (Burridge) with Earth and Environmental Sciences at Portsmouth. Burbanks has recently joined a collaboration with the Department of Chemistry and Biochemistry at the University of Utah, Logan, USA, to study superfluidity in doped Helium-4 clusters.

Members of both groups have been active in organising workshops and conferences. Hennig organised a mini-symposium "Stochastic Systems" at the international Dynamics Days (2010) and the international workshop 'Dynamics Day Pompey 2010' with plenary speaker Serge Aubry (Saclay). Waters and Simon (NCSG) co-organised the workshop "Modern approaches to dynamical integrability" (2011) for which LMS funding of £3700 was secured. Li was General Secretary for the 5th China-Australia Workshop on Optimization Theory and for the 1st International Symposium on Optimization and Complex Systems (China, 2011). The Logistics and Operational Research Group receives support from the OR Society and Southern OR Group for its workshops, including a one-day workshop on Logistics and Operational Research for the Offshore Wind Farm Sector (2013). Jones is a member of the International Organising Committee for the Multi-Objective Programming and Goal Programming (MOPGP) conference series (2000-present) and conference Chair for the 8th International MOPGP Conference (Portsmouth, 2008), having organised the first of these bi-annual conferences in 1994 and been a key part of its International Committee since.

Researchers in both groups are active as Editors and reviewers for many journals. Hennig reviews for journals including Europhysics Letters, Journal of Mathematical Physics, Journal of Physics A: Mathematical and General, Journal of Physics: Condensed Matter, New Journal of Physics, Nonlinearity, Physical Review Letters, Physical Review B, Physical Review E, and Physica D: Nonlinear Phenomena. Banaji reviews for the SIAM Journal of Applied Mathematics, for a number of funding bodies, and also for Zentralblatt and Mathematical Reviews. Jones is a member of the Editorial Board of the International Journal of Health Management and Information. Simon (NCSG) reviews for a number of journals including: Annales de l'Institut Fourier, Discrete and Continuous Dynamical Systems, and Nonlinearity. Chlebikova reviews for Algorithmica, Discrete Applied Mathematics, and Discrete Mathematics, and Waters reviews for Celestial Mechanics and Dynamical Astronomy. Li is guest editor for the Pacific Journal on Optimization and a reviewer for journals including the SIAM Journal on Optimization, and Mathematics of Computation.

Osbaldestin is a Fellow of the Institute of Mathematics and its Applications and Jones is Southern Region representative on the National Council of the British Operational Research Society.

Staff in both groups are invited to give keynote addresses and seminars at international conferences. Li was invited to speak at the 2nd Sino-German Workshop on Optimization, Modeling, Methods and Applications in Industry and Management and the International Conference on Spectral Theory of Tensors (both in China, 2012). Waters was invited to speak at the 8th AIMS Conference on Dynamical Systems, Differential Equations, and Applications (2010). Jones was plenary speaker at the International Conference of the Multiple Criteria Decision Making Society (Spain, 2013), and at the Applied and Computational Mathematics Conference (Brazil, 2013). Hennig was invited to speak at the International Conference “Nanotechnology” (Chemnitz, 2008), the Annual Conference of the German Physical Society (2009 and 2010), Dynamics Days (Bristol, 2010), the International Workshop “Nonlinear Lattice Dynamics” (Potsdam, 2011), and at the international conferences “Nonlinear Waves and Solitons in Lattices” (2012) and “Quodons in mica: Nonlinear localised travelling excitations in crystals” (Spain, 2013). Banaji has been invited to speak at many conferences, including at "Theorems on Biological Circuits IV" (Harvard, USA, 2011) and was the invited keynote speaker at the fNIRS 2012 conference on near-infrared spectroscopy (UCL, London) and at Algebraic and Numeric Biology (Austria, 2010), giving the opening keynote talk.