

Postdoctoral Research Assistant in Computational Mathematics

Heriot-Watt University
Maxwell Institute for Mathematical Sciences
Salary: £29,099-£35,788 per annum
3 years from 1st August 2011
Vacancy Reference: 54/11/J

The topic of this postdoctoral project is the design, analysis and implementation of domain decomposition parallel solvers for partial differential equations.

Candidates should hold a PhD in an appropriate area of computational mathematics, (e.g. domain decomposition, numerical linear algebra or more general numerical methods for PDEs) and have the potential to contribute to all aspects of the project. The person appointed will be part of the Numerical Algorithms and Intelligent Software project (www.nais.org.uk), working with a broad range of mathematicians, computer scientists and HPC specialists.

Download an application pack from our website www.hw.ac.uk/jobs or contact the Human Resources Office, Heriot-Watt University Edinburgh EH14 4AS tel 0131 451 3022 (24 hours) email hr@hw.ac.uk quoting Ref 54/11/J Closing date: 4 July

Information for Candidates

Postdoctoral Research Assistant in Computational Mathematics

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The post is available at a mutually agreed date on or after 1st August 2011 and the employment period is for 36 months from 1st August 2011. This post and the NAIS project are funded by the UK EPSRC and the Scottish Funding Council.

The NAIS project (www.nais.org.uk) is a large, 5-year collaboration between the mathematics departments at Heriot-Watt University (where this job is), the University of Edinburgh and the University of Strathclyde, as well as with the School of Informatics and the Edinburgh Parallel Computer Centre, both at the University of Edinburgh. We have 4 lecturers and a significant number of postdoctoral researchers and PhD students employed full time on the project. A research network extends to other leading research centres across the UK and beyond.

The topic of this postdoctoral project is the design, analysis and implementation of domain decomposition parallel solvers for PDEs, working mainly with Sebastien Loisel and colleagues Lubomir Banas, Dugald Duncan and Gabriel Lord at Heriot-Watt University, as well as wider interactions with the rest of NAIS.

The domain decomposition method is an important algorithm for solving boundary value problems in parallel. Designing algorithms that have good parallel scaling properties is especially challenging. Optimized domain decomposition methods are further tuned to enhance the convergence properties. We are interested in finding new optimized domain decomposition algorithms and preconditioners. We also want to analyze and implement such methods. In addition to the design, analysis and implementation of new methods, we are interested in applications in meteorology or other fields. A typical shallow water model must solve an elliptic problem at each time step. We are interested in implementing scalable optimized methods for such applications and for nonlinear problems.

Candidates should hold a PhD in an appropriate area of computational mathematics, (e.g. domain decomposition, numerical linear algebra or more general numerical methods for PDEs) and have the potential to contribute to all aspects of the project. The person appointed will be part of the NAIS project (www.nais.org.uk), working with a broad range of mathematicians, computer scientists and HPC specialists.

Application Procedure Notes:

- Download an application pack from our website www.hw.ac.uk/jobs or contact the Human Resources Office, Heriot-Watt University Edinburgh EH14 4AS tel 0131 451 3022 (24 hours) email hr@hw.ac.uk quoting Ref 54/11/J Closing date: 4 July
- Please include your curriculum vitae, a research record, and a brief statement to indicate how your experience and interests will help you contribute to this project You must also give the names and contact details (including email addresses) of THREE or FOUR referees who can comment on your research.
- For full consideration, all materials must be received by the **closing date 4th July 2011**. We cannot guarantee to consider late applications.
- The University reserves the right to vary the candidate information or make no appointment at all. Neither in part, nor in whole does this information form part of any contract between the Universities and any individual.
- Please address any **informal enquiries** to Professor Dugald Duncan d.b.duncan@hw.ac.uk (Heriot Watt University) or Dr Sebastien Loisel (S.Loisel@hw.ac.uk).

Research Environment

The rest of this document provides information about the research environment.

1. Heriot-Watt University

Heriot-Watt University is the eighth oldest higher education institution in the UK. The name commemorates George Heriot, the 16th century financier to King James, and James Watt, the great 18th century inventor and engineer associated with steam power. The University originated as the School of Arts of Edinburgh in 1821. In 1966, Heriot-Watt became a University by Royal Charter.

The University is research-led and specialises in science and engineering, business and management, languages and design. Its research covers the full spectrum from fundamental and theoretical studies, through research of immediate relevance to industry and commerce, to practice-based studies. High quality research can be found in each of our seven main Schools, which are configured to provide the maximum of opportunities for multi- and inter-disciplinary programmes. Heriot-Watt is a vibrant, forward looking University offering a high quality learning experience and a welcoming and friendly environment. With an international reputation for innovative education, enterprise and leading edge research, it is one of the leading UK universities for business and industry. Often referred to as Scotland's international university, Heriot-Watt has four student campuses: three in Scotland - Edinburgh, the Scottish Borders and Orkney - and a campus in Dubai. The advertised job is located on the Edinburgh campus.

2. The Department of Mathematics at Heriot-Watt University

The [Department of Mathematics](http://www.ma.hw.ac.uk/math) www.ma.hw.ac.uk/math currently consists of 27 permanent academic staff, and is part of the School of Mathematical and Computer Sciences which has three component departments: Mathematics; Actuarial Mathematics and Statistics (AMS); and Computer Science (CS). There are 20 mathematical sciences academics in the AMS Department. The Mathematics department is located on the Riccarton Campus in Edinburgh in the Colin Maclaurin Building shared with Actuarial Mathematics & Statistics. This adjoins the building which houses Computer Science. There are currently 45 mathematical sciences PhD students.

Honorary Professors include: Sir John Ball, FRS; Jack Cowan; and John Toland, FRS.

In applied mathematics there are particular strengths in computational mathematics, applied analysis and PDEs, differential equations, mathematical physics and mathematical biology and ecology. We have good contacts with other parts of the University, particularly in Petroleum Engineering. We are committed to excellence in research, and to enhancing our research activities through the [Maxwell Institute for Mathematical Sciences](#) research partnership with the University of Edinburgh, one of the largest mathematical sciences research groupings in the UK. There is a strong overlap of research interests in stochastic differential equations between the Mathematics and AMS departments, and the possibility to develop connections with Computer Science through the new NAIS centre this job is associated with.

The Computing facilities in the department are excellent and are based on a Unix network. We have a parallel computing cluster for research use, and the NAIS project has access to the facilities at the Edinburgh Parallel Computing Centre mentioned earlier.

Teaching

This is not a teaching position, although we would be happy to discuss giving the person appointed the opportunity to develop their career skills and gain experience by doing a limited amount of teaching.

3. The Maxwell Institute for Mathematical Sciences

3.1 Background

The Maxwell Institute www.maxwell.ac.uk brings together within a single body the research activities of:

- the Department of Mathematics at Heriot-Watt University, Edinburgh;
- the Department of Actuarial Mathematics & Statistics at Heriot-Watt University;
- and the School of Mathematics at the University of Edinburgh.

It aims to be an internationally pre-eminent centre for research and for postgraduate training in the mathematical sciences, and to offer an environment that is able to attract and foster the very best mathematical talent from around the world. Maxwell includes researchers working across the whole spectrum of the mathematical sciences and provides a new and exciting environment for fostering collaborative and interdisciplinary research.

Maxwell is part of the Edinburgh Research Partnership(ERP) in Engineering and Mathematics, recently established by Edinburgh and Heriot-Watt Universities, which consists of five joint research institutes in a range of subject areas and a joint graduate school. The ERP is partly funded by the Scottish Funding Council (SFC).

Since its official launch in October 2005, the Maxwell Institute has made new permanent appointments of which two chairs and two lectureships were funded by the initial SFC investment. It has been successful in securing major grants – and unusually successful in winning two high-profile Science and Innovation awards.

- (2007-2009) £370K Bridging the Gaps award: this is aimed at facilitating interdisciplinary research between mathematics and the engineering disciplines covered by the ERP.
- (2007-2013) The Centre for Analysis and Nonlinear PDE, a joint venture of the Maxwell Institute, was funded by an EPSRC grant worth £3.5M, awarded in 2007. CANPDE has hired a number of young researchers and offers a variety of courses, seminars and meetings on both pure and applied themes related to nonlinear partial differential equations. For more information, see <http://www.maxwell.ac.uk/PDEs>
- (2009-2014) The job currently being advertised is funded by another £4.7M Science & Innovation Award to establish the Centre for Numerical Algorithms and Intelligent Software (joint with the University of Strathclyde). See <http://www.nais.org.uk>

Maxwell also played a leading part in establishing the Scottish Mathematical Sciences Training Centre. This is a consortium involving the seven Scottish Universities with post-graduate mathematics programmes which provides a raft of first-level graduate courses for PhD students across Scotland. This is a part of our commitment to an expansion of graduate student numbers and provision.

3.2 Maxwell Institute Research

As noted above, the Maxwell Institute covers research in the whole range of the mathematical sciences, and we entered 106 research-active staff in the recent UK Research Assessment Exercise. We were highly rated in Pure and Applied Mathematics. This is reflected by a buoyant seminar programme, encompassing all areas of mathematics, and by the regular organisation of conferences and workshops. Close links with the Edinburgh-based [International Centre for Mathematical Sciences](http://www.imsc.ed.ac.uk) further strengthen the research environment and The Maxwell Institute Graduate School offers exciting opportunities for postgraduate training in a broad range of areas of mathematics. It currently has approximately 80 research students studying for the degree of PhD or MPhil.

A summary of our main research areas is listed below.



COMPUTATIONAL MATHEMATICS

Research in computational mathematics covers a broad range of different areas and has strong interdisciplinary links. The focus of our work is on integrated modelling, formulation, analysis and numerical algorithms for differential equations, including ODEs, PDEs, integro-differential equations and stochastic DEs. Of particular interest is the development of methods and the numerical analysis of multiscale and homogenization problems; stiff and stochastic equations; stellar dynamics and the N-body problem; computational dynamics, especially

molecular dynamics; computational mathematical astronomy; nonlinear waves; fluid dynamics, with applications to the atmosphere and the oceans.

Applications arise from diverse areas of science and engineering, including biomedical science, finance, fluid dynamics, material science, molecular dynamics, modelling of neurons, oil reservoir simulation, phase transitions and wave propagation.

There are close connections between Computational Mathematics and other activities within the Maxwell Institute, such as **Applied Mathematics**, **Mathematical Biology**, **Mathematical Physics**, **Pure and Applied Analysis**, and **Probability and Stochastics**. Collaborations are in place with other major research groups in computational mathematics based throughout the UK and the world.



OPTIMIZATION

The [The Edinburgh Research Group in Optimization \(ERGO\)](#) is a loose association of researchers in the University's School of Mathematics, Business Studies, Chemical Engineering and Agriculture/IERM departments, together with the Edinburgh Parallel Computing Centre (EPCC) and the Optimization group in the Department of Mathematics and Computer Science at the University of Dundee. ERGO also has links with Quadstone and Edinburgh Petroleum Services (EPS). The main [research activities](#) of the [ERGO Group](#) are, in no particular order, large-scale optimization, global optimization, parallel computing and sparse matrix techniques applicable in optimization with a focus on the solution of real-world applications. Our regular research activities include [ERGO seminars](#). Our [recent publications and preprints](#) contain most of our research output. We run the [MSc in Operational Research](#) with a focus on computational techniques of optimization.



ACTUARIAL AND FINANCIAL MATHEMATICS

Research in actuarial mathematics includes stochastic process modelling of diseases and disability, risk theory, insurance solvency, pricing and hedging of guarantees, and mortality analysis including the modelling of future longevity.



ALGEBRA AND NUMBER THEORY

The main areas of research of the Algebra and Number Theory group are: representation theory, algebraic combinatorics, noncommutative algebra, quantum algebras, Lie algebras and automorphic forms, commutative algebra, algebraic geometry, algebraic number theory, algorithmic aspects of algebraic curves, combinatorial aspects of network design, geometric group theory, homological algebra, combinatorial and geometric semigroup theory, automata and languages.

The group has close links with the Geometry and Mathematical Physics research groups within the Maxwell Institute. There have also been recent interactions with the Analysis and Statistics groups.



ANALYSIS

The Analysis group works on a wide range of topics. Our particular strengths lie in harmonic analysis, spectral theory, linear and nonlinear elliptic, hyperbolic and parabolic PDEs, dynamical systems, stochastic analysis including stochastic nonlinear PDEs, foundations of numerical analysis and applications of the above to problems of physics, continuum mechanics, etc... The group has active links with most of the other groups in the Maxwell Institute including Applied Mathematics, Geometry and Topology, Computational Analysis and Probability. We run a very active joint research seminar and a working group seminar.



APPLIED MATHEMATICS

Research activities in Applied Mathematics cover a wide range of topics, many related to differential equations -- ordinary, partial and stochastic -- and dynamical systems. They include nonlinear waves, such as solitons, with applications to optoelectronics and continuum mechanics, electromagnetic and elastic wave propagation in complex and composite media, stellar dynamics and Hamiltonian mechanics, and fluid, solid and statistical mechanics. There are applications to oil-reservoir modelling, geophysical and astrophysical systems, turbulence, combustion, phase transitions and free-boundary problems, and to more general industrial and social modelling. The mathematical methods employed range from asymptotic techniques, in particular exponential asymptotics and homogenisation, to dynamical-system techniques,

analysis and numerical methods.

There are close links between Applied Mathematics and other activities within the Maxwell Institute, such as **Computational Mathematics**, **Mathematical Biology**, **Mathematical Physics**, **Pure and Applied Analysis**, and **Probability and Stochastics**. Regular seminars are organised for postgraduate students and staff.



GEOMETRY AND TOPOLOGY

The main areas of research of the geometry and topology group are algebraic geometry, algebraic topology, differential geometry, geometric group theory and surgery theory. More specific research areas include birational geometry (especially of 3-folds), Kaehler geometry, topics in gauge theory, geometry of moduli spaces and high-dimensional manifolds and knot-theory.

The group has links with the following research groups within the Maxwell Institute: Algebra, Analysis, and Mathematical Physics.



MATHEMATICAL BIOLOGY

Research in mathematical biology concerns the application of mathematics to cell biology, medicine, ecology and evolution. Some of our work is focussed on specific applications and is done in collaboration with experimental biologists or field ecologists. Other work is more theoretical in nature, developing fundamental modelling techniques with potential applications to a wide range of biological problems. Our models include ordinary and partial differential equations, and spatially discrete models such as cellular automata.



MATHEMATICAL PHYSICS

The [Edinburgh Mathematical Physics Group](#) consists of 15 permanent academic staff, 6 postdoctoral research fellows and 13 postgraduate students. Our main [areas of research](#) are string and M-theories, classical and quantum integrable systems, topological quantum field theories, low-dimensional quantum gravity, statistical mechanics of random surfaces; although our interests are varied and span a wide range of topics in modern mathematics and physics. We have close ties with the Algebra and Topology/Geometry groups. Our regular research activities include a weekly seminar series, as well as student seminars and journal clubs on a variety of topics, most recently [generalised geometry](#) and [D-branes](#). We have our own [preprint series](#) which contains most of our research output.



PROBABILITY AND STOCHASTICS

Research in Probability and Stochastics is focussed mainly on Stochastic Differential Equations and Stochastic Partial Differential Equations, including theoretical results, methods for numerical solution, and applications. There is also work on problems in analysis related to probability theory.

There are links with the following research areas within the Maxwell Institute: Analysis, Applied Mathematics, Computational Mathematics, Financial and Actuarial Mathematics, Mathematical Biology, Optimisation and Statistics.



STATISTICS

Bayesian inference, computer-intensive methods, automated pattern recognition, sampling and resampling and multivariate analysis, with applications in forensic science, the mathematical and statistical evaluation of evidence, the earth sciences, agriculture, biology, ecology and applications of stochastic analysis to economics and finance. There is a regular seminar. There has been a long and fruitful collaboration with [Biomathematics and Statistics Scotland](#)(BioSS). Colin Aitken is one of the key members of the [Joseph Bell Centre for Forensic Statistics and Legal Reasoning](#) which conducts research at the interface of statistics, law, forensic science and artificial intelligence and involves the Centre for Law and Society and the Artificial Intelligence Applications Institute of the University of

4. Related Organisations



4.1 Edinburgh Parallel Computing Centre/HPC-Europa

The Edinburgh Parallel Computing Centre (EPCC, <http://www.epcc.ed.ac.uk>) is a key part of the NAIS project. EPCC is one of Europe's largest centres for research on advanced and grid computing. Founded at The University of Edinburgh in 1990, EPCC is a leading European centre of expertise in advanced research, technology transfer and the provision of supercomputer services to academia and business. EPCC offers NAIS staff and students access to a wide range of HPC hardware and software resources, as well as training and code development support.

4.2 The International Centre for Mathematical Sciences



One of our most important connections is with the International Centre for Mathematical Sciences (ICMS) www.icms.org.uk. ICMS was created in 1990 as a collaborative initiative between the University of Edinburgh and Heriot-Watt University. It is at present housed at 15 South College Street, with excellent facilities for mathematical meetings and workshops.

ICMS supports research in mathematics in a number of ways. Its most visible activity is the organization of workshops in the mathematical sciences. A distinguishing feature of ICMS's workshop programme is its ability to respond rapidly to current developments in research, organizing workshops of international importance at relatively short notice. The current programme of workshops is supported by substantial grants from EPSRC and the Scottish Funding Council.

ICMS is playing an increasing part in the support of Maxwell activities (such as CANPDE and NAIS meetings), supporting the Scottish Mathematical Sciences Training Consortium and other pan-Scottish research activities.

4.3 Other Institutes and Societies

Several neighbouring research institutes offer collaborative research opportunities. The Institute for Astronomy, housed in the Royal Observatory building, is within a few minutes' walk. The Roslin Institute, the NERC Centre for Ecology and Hydrology (Edinburgh) and the e-Science Institute are just a few kilometres away.

Mathematicians at the Maxwell Institute also benefit from, and have a substantial role in running, the Edinburgh Mathematical Society. The Royal Society of Edinburgh is Scotland's National Academy of Science and Letters and provides further support for researchers based in Scotland.