MATHEMATICAL INSTITUTE

Job description and selection criteria

Job title	Postdoctoral Research Associate in the Mathematics of Solid and Liquid Crystals
Division	Mathematical, Physical and Life Sciences
Department	Mathematics
Location	Centre for Nonlinear PDE, Gibson Building
Grade and salary	Grade 7: starting salary £29,249 - £35,938 p.a.
Hours	Full time
Contract type	2 years fixed term
Reporting to	Professor J M Ball
Vacancy reference	105521
Additional information	This post is funded by European Advanced Investigator. The successful candidate must take up the post no later than 1 October 2013.

Introduction

The University

The University of Oxford is a complex and stimulating organisation, which enjoys an international reputation as a world-class centre of excellence in research and teaching. It employs over 10,000 staff and has a student population of over 21,000.

Most staff are directly appointed and managed by one of the University's 130 departments or other units within a highly devolved operational structure - this includes 5,900 'academic-related' staff (postgraduate research, computing, senior library, and administrative staff) and 2,820 'support' staff (including clerical, library, technical, and manual staff). There are also over 1,600 academic staff (professors, readers, lecturers), whose appointments are in the main overseen by a combination of broader divisional and local faculty board/departmental structures. Academics are generally all also employed by one of the 38 constituent colleges of the University as well as by the central University itself.

Our annual income in 2010/11 was £919.6m. Oxford is one of Europe's most innovative and entrepreneurial universities: income from external research contracts exceeds £376m p.a., and more than 60 spin-off companies have been created.

For more information please visit http://www.ox.ac.uk

MPLS Division

The Mathematical, Physical and Life Sciences (MPLS) Division is one of the four academic divisions of the University of Oxford. We have over 6,000 students and research staff, and generate over half of our funding from external research grants.

The MPLS Division's 10 departments and 3 interdisciplinary units span the full spectrum of the mathematical, computational, physical, engineering and life sciences, and undertake both fundamental research and cutting-edge applied work. Our research addresses major societal and technological challenges and is increasingly interdisciplinary in nature. We collaborate closely with colleagues in Oxford across the medical sciences, social sciences and humanities.

Today's scientific research not only crosses traditional subject boundaries, but also transcends national boundaries: MPLS scientists collaborate with researchers from around the world, and play leading roles in many international projects.

For more information please visit: http://www.mpls.ox.ac.uk/home

The Mathematical Institute

The Mathematical Institute, as Oxford's Department of Mathematics is known, is one of the leading mathematics departments in the world, with a significant research profile in central areas of contemporary mathematical research. It is the main focus of mathematics research in Oxford for both pure and applied. The inclusive nature and overall size of the department are key factors in the provision of an outstanding research environment for its members. The large number of faculty, post docs and students in the department, all supported by excellent facilities, allows us to maintain a critical mass in research groups encompassing a wide spectrum of mathematics, while the integrated nature of the department fosters collaboration between fields.

The research activities of the institute are organised within a framework of interlinked and overlapping research groups. The fact that these research groups have indistinct boundaries and nontrivial intersections reflects a widespread recognition within the department of the unity of mathematics and the importance of cross-fertilisation between fields.

The spread of research interests is also reflected to a large extent by the current holders of our statutory chairs; these are listed at http://www.maths.ox.ac.uk/about/statutory-professors

The Institute acts as the focus of activity in pure and applied mathematics. Its facilities, such as the Whitehead Library (for research in Mathematics) and the computer network, are available for all members of the faculty. Most lectures and research seminars in Mathematics take place in the Institute, though some first-year and second-year lectures are held nearby in the lecture theatre of the University Museum. The Mathematical Institute will move into newly built accommodation on the University's recently acquired Radcliffe Observatory Quarter in September 2013.

Many members of the Institute have received prestigious prizes and other special recognition for their work; some recent examples can be found at http://www.maths.ox.ac.uk/news/awards-prizes.

The Mathematical Institute is on three sites. The Oxford Centre for Collaborative Mathematics (OCCAM) is based in the Gibson Building. Detailed information about the Mathematical Institute may be found at http://www.maths.ox.ac.uk/

Oxford Centre for Nonlinear PDE

The Centre for Nonlinear PDE (OxPDE), was launched in 2007 (funded by an EPSRC Science & Innovation award of £2.5 million). The Centre is directed by Prof Sir John Ball. Its aim is to promote the study of nonlinear PDE in order to provide a sharper focus for fundamental research in the field in the UK and raise the potential of its successful and durable impact within and outside mathematics. The Centre has focused on the fundamental analysis of nonlinear PDE, and numerical algorithms for their solution. Areas of interest include the calculus of variations, nonlinear hyperbolic systems, free boundary problems, inverse problems, homogenization, infinite-dimensional dynamical systems, geometric analysis for PDE arising in solid and fluid mechanics, materials science, liquid crystals, biology and relativity.

With 9 faculty members (2 more to be appointed in 2013), 5 postdoctoral researchers and 15 research students, the Centre runs a thriving visitor programme, an active events programme, a regular Monday seminar series and a Thursday lunchtime seminar series, a dedicated technical report series and a highly successful undergraduate summer research project scheme. Outreach activities include hosting national PDE events and visitors' calendars, supporting and contributing to PDE Centre for Analysis and Nonlinear PDE at events at other UK Universities, with a particularly strong cooperation with the Maxwell Institute in Edinburgh.

Further information on the group's activities and members is available at http://www.maths.ox.ac.uk/groups/oxpde/ .

Job description

Applications are invited for a two year postdoctoral research associate post to work on projects in the *Mathematics of Solid and Liquid Crystals* under the direction of Professor Sir John Ball FRS. The successful applicant will take up the post no later than 1 October 2013, and will be based in the Oxford Centre for Nonlinear PDE (OxPDE). The post is funded by a European Advanced Investigator grant awarded to Professor Ball. The successful candidate will form part of a team funded by the grant which currently consists of two postdoctoral research associates and six DPhil students.

The Post

The successful applicant will work on aspects of the following projects or related topics outlined below.

The prediction and analysis of microstructure arising from solid phase transformations

Most alloys undergo phase transformations at one or more critical temperatures, at which the underlying crystal lattice changes shape, e.g. from cubic to tetragonal. Such phase transformations generate complex patterns of microstructure whose morphology is important for determining the macroscopic properties of the material. Over the last 30 years a successful theory has been developed for understanding such microstructure based on nonlinear elastostatics and the calculus of variations. But we are far from being able to predict microstructure morphology in general, one of the main obstacles being that this is a dynamical phenomenon for which elastostatics can only provide limited information.

Project 1. Develop appropriate dynamical models for microstructure evolution, prove their well-posedness, and study the problem of approach to equilibrium as time tends to infinity. Understand what features of microstructure are predictable in the infinite time limit.

Project 2. Develop computationally tractable intermediate theories of microstructure evolution. Full dynamical models are too computationally intensive to be practical, and what is needed are models that capture essential features of the evolution but are less detailed and don't involve repeated costly computation of essentially the same morphology in different parts of the specimen.

Project 3. Investigate the role of interfacial energy in influencing solid phase transformations and the corresponding microstructure, and clarify on the basis of atomistic models how interfacial energy can best be incorporated into continuum models.

Project 4. Analyse and design experiments illuminating phase nucleation. The initial focus here will be on understanding interesting experiments of H. Seiner in which austenite is nucleated in martensite by localized heating but the nucleation occurs at corners of the specimen far from the point where the heating is applied. This leads to deep questions about quasiconvexity, the central convexity condition of the multi-dimensional calculus of variations.

The Landau – de Gennes theory of liquid crystals.

This theory of liquid crystals is based on a matrix order parameter, the Q-tensor, for describing the distribution of the orientation of the liquid crystal molecules. Although the theory of choice among physicists it has only relatively recently been studied much by mathematicians, and presents many interesting mathematical issues blending modelling, nonlinear analysis, dynamical systems and topology. Much more mathematical attention has been devoted to the Oseen-Frank theory, which is simpler and can be regarded as a limiting case of the Landau – de Gennes model.

Project 5. Define, give criteria for the existence of, and classify defects in the Landau - de Gennes theory. In the Oseen-Frank theory defects appear as singularities of the vector field, although some observed singularities have infinite energy. In the Landau – de Gennes theory the Q-tensor corresponding to energy minimizers is smooth, so that defects have to be understood differently.

Project 6. Investigate thermodynamically consistent dynamic Q-tensor models and the approach to equilibrium as time tends to infinity. Here there are a variety of models of different complexity. The dynamics is important, for example, in the switching of liquid crystal displays.

Project 7. Study the eigenvalue constraints on the Q-tensor. Physically, the definition of the Q-tensor requires that its eigenvalues are greater than -1/3. However in the usual Landau – de Gennes model this constraint is not respected. An analysis of Ball & Majumdar (anticipated in earlier work of Katriel et al) leads to a bulk energy function that blows up as the least eigenvalue tends to -1/3, thus leading to Q-tensors that are physically realistic. However a key problem is to prove, in static and dynamic models, that the eigenvalues are strictly bounded away from -1/3, and so far this has only been achieved in special cases.

Project 8. Study as rigorously as possible the passage from molecular models of liquid crystals to continuum ones. This is a difficult but important area since the correct form for continuum theories is unclear; for example, the Landau – de Gennes theory is based on the Q-tensor, which is a normalized second moment of the molecular distribution function, and it is not clear when such a description is valid.

For an introduction to both the mathematics of solid phase transformations and the Landau-De Gennes theory of liquid crystals see
http://people.maths.ox.ac.uk/ball/Teaching/parisox.pdf

Main skills and experience required (selection criteria)

Essential

- a PhD awarded, or submitted, in mathematics or a related discipline;
- a good publication record judged by the stage of his/her career,
- expertise in analysis and other subject areas relevant for the projects listed above (such as partial differential equations, the calculus of variations, continuum mechanics, scientific computation, dynamical systems)
- an interest in developing and applying fundamental mathematics for the understanding of science
- the ability to work together with others as part of a research team

Desirable

- a research record in some aspect of nonlinear analysis applied to problems in mechanics

Working at the University of Oxford

For further information about working at Oxford, please see:
http://www.ox.ac.uk/about_the_university/jobs/research/

How to apply

If you consider that you meet the selection criteria, click on the **Apply Now** button on the 'Job Details' page and follow the on-screen instructions to register as a user. You will then be required to complete a number of screens with your application details, relating to your skills and experience. When prompted, please provide contact details of two referees who are familiar with the research of the applicant. You will also be required to upload your application materials: a letter describing how you meet the selection criteria, a full curriculum vitae, a full list of publications and a statement of research interests and plan for research during the Fellowship.

Please save all uploaded documents to show your name and the document type.

Applicants should ask their referees to send their letters of reference directly to

The Administrative Assistant (Vacancies)
The Mathematical Institute
24-9 St Giles'
Oxford OX1 3LB
Fax: 01865 273583
Email: vacancies@maths.ox.ac.uk

by the closing date (a letter by email is sufficient) **quoting the vacancy reference 105521.** Referees should preferably not be from the same institution and one should be the applicant's current, or most recent, supervisor.

All applications must be received by **12:00 noon UK time on Monday 17 December 2012. Interviews are expected to take place during week commencing 14 January 2013.**

Information for Priority Candidates
A priority candidate is a University employee who is seeking redeployment owing to the fact that he or she has been advised that they are at risk of redundancy, or on grounds of ill-health/disability. Priority candidates are issued with a redeployment letter by their employing departments and this letter ***must*** *be attached to any application they submit.*

The priority application date for this post is *12 noon* **UK time on** Monday 3 December 2012

Full details of the priority application process are available at:
http://www.admin.ox.ac.uk/personnel/end/red/redproc/prioritycandidate

Should you experience any difficulties using the online application system, please email recruitment.support@admin.ox.ac.uk

To return to the online application at any stage, please click on the following link www.recruit.ox.ac.uk

Please note that you will be notified of the progress of your application by automatic e-mails from our e-recruitment system. **Please check your spam/junk mail** regularly to ensure that you receive all e-mails.