PhD Project Descriptions for Fusion CDT Website

Project Title
High-Field Superconductors under Strain that Enable Spherical Tokamaks for Fusion Power Generation (Experimental PhD).
Supervisor/s
Prof. D. P Hampshire (Durham)
External supervisors/s and affiliation (if applicable)
Application to CCFE for support has been made.
University
Durham University
Is this project suitable for a part-time student*? Please provide detail below if this is not possible or if this is possible but with some restriction. * There are a range of possible part time participation levels, e.g. 50%, 4 days a week etc. and we encourage supervisors to be mindful of this when answering this question.
Yes, the project is suitable for full-time or part-time (e.g. 50%, 4 days a week etc.). The University and Research groups are committed to advancing equality. We aim to ensure that our culture is inclusive, and that our systems support flexible and family-friendly working, As recognized by our Juno Champion and Athena SWAN Silver awards, we recognise and value the benefits of diversity throughout our staff and students.
Is this project suitable for flexible working*? Please provide detail below if this is not possible or if this is possible but with some restriction. *Flexible working could include non 9-5 working hours on a continuous or frequent basis. For example a computational project may lend itself well to mornings and evenings, this could be particularly important to students with caring responsibilities.
This is an experimental project and PhD students often need access to fellow students and staff. Although, we are always happy to adapt to flexible working as needs change, we recommend that students who need flexible working, have a look at one of our computational projects being offered.
Project Description: Please note the following: • The description should include a clear link to fusion. We recommend including a short introductory paragraph providing a high level overview of the project and context. • Please think about the language you are using and make it inclusive – for example, avoid words that might be perceived to have gender connotations (e.g. strong, bold, robust). • Please mention the training that will be provided as part of this project beyond the initial taught element and skills that might be acquired through the course of the PhD, i.e. communication, scientific writing, analytical skills etc.

- Please try to avoid use of abbreviations – if they are used, please ensure they are defined.
- Please don't include any entry requirements, such as degree classification, that are not consistent with your department's PhD entry requirements. You may wish to link to the entry requirements web page provided by your department, where available.

Please try to not exceed one page

Background to the PhD Research Project::

The ITER (International Thermonuclear Experimental Reactor) Tokomak that is being built in Cadarache in France is one of the most exciting scientific projects at the beginning of the 21st century (http://www.iter.org/). It will produce 500 MW which is about ten times the power needed to run the machine. Superconductivity is the enabling technology for this project since without it, the magnets that hold the plasma would either melt or consume more energy than the tokamak produces. Approximately one third of the cost of ITER comes from the superconducting magnets which use low temperature superconductors. Recent work has demonstrated that the next generation of fusion tokamaks may be most effective at higher fields than ITER - more than ~ 16 Tesla – which opens the question of whether we can develop high-temperature superconductors, that have higher current densities and upper critical fields, to enable commercial fusion energy http://www.superpower-inc.com/content/2g-hts-wire. The current density in these high temperature superconductors is still typically less than 1 % of the theoretical limit in high magnetic fields and there is no agreement about why it is so pitifully low. In Durham, we have developed purpose-built facilities to make transport critical current density $J_C(B,T,\varepsilon)$ measurements as a function of magnetic field (B), temperature (T) and strain (ε) on 2G tapes. This PhD is directed at measuring the best available conductors, using our state-of-the-art horizontal Helmholtz-like 15 Tesla magnet system in Durham, as well as using the magnets at the International high-field facilities in Grenoble. The timescale for first-plasma at ITER (2025) offers a wonderful opportunity for early career Physicists to help pioneer our understanding of high field superconducting materials for fusion applications.

PhD Research Project and Supervision :

In this PhD research programme, the student will measure both the fundamental and extrinsic properties of superconducting materials including the critical current density $J_C(B(\theta),T, \varepsilon,)$. Important research questions include: What is the mechanism that determines the critical current in high magnetic fields of high temperature superconductors? How can we optimise HTS materials to enable commercial fusion energy ? What is the role of anisotropy/reduced dimensionality in these materials? Why is the critical current density in state-of-the-art materials 2 or 3 orders of magnitude lower than the theoretical limit in high magnetic fields? Can we understand the nature of flux pinning and flux flow in high Jc materials under strain ? This is a fabulous PhD project that is ideal for a student with a first class degree in Physics and a broad interest in materials and applied Physics. They will be expected to network with scientists throughout the world working on fusion.

The PhD supervisory team will include Prof. Damian Hampshire who is an experienced member of the high-field applied superconductivity and fusion energy community. The 4 year PhD is funded through the Fusion CDT partnership which gives an excellent exposure to many of the best Universities in the UK, an excellent taught course in fusion energy and exposure to the fusion community across Europe. The PhD is formally based at Durham for access to high magnetic fields and cryogenic facilities, but the training in the fusion CDT means you spend about 6-8 months during the first year of your PhD at CDT partner Universities and will include regular visits to CCFE. It will also probably involve working in an International laboratory (usually the USA, Japan or EU) for at least one collaborative project in the 2nd or 3rd year. The Research Groups are committed to developing an environment that produces world-class science and is inclusive, flexible and family-friendly.

Skills the student will learn during the PhD:

i) Transferable Skills.

Communication: Presentations at conferences and developing collaboration.
Personnel: Networking skills. Working with expert senior staff, junior staff and staff providing services.
Writing: Reports, Conference and Journal publications.
Computerised Data Acquisition and Analysis.
Technical Design: CAD Design of hardware with new functionality and understanding materials
Knowledge: Understanding magnetically confined fusion and high field superconductors.
Time management.

ii) Specialist Skills and Know-how.

Knowledge: High field superconductors for fusion applications.
Use of: High magnetic fields; Cryogenic liquids; High performance computers; High current power supplies; Low voltages; materials at high and at cryogenic temperatures.
Design of new experiments.

Please add a sentence or two about any opportunities and/or requirements for collaboration, international travel and any atypical aspects. For example:

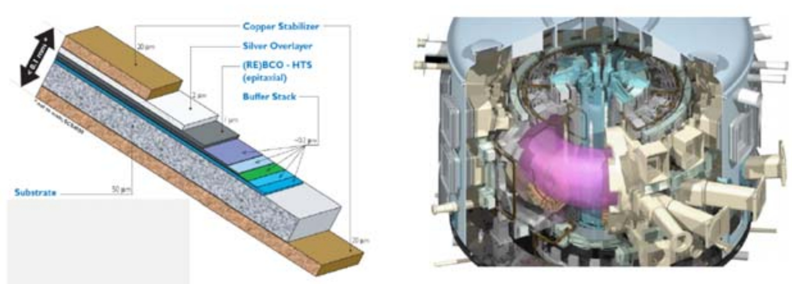
The project will be mainly based in York, but will require long stays particular to the US, for several weeks at a time.
or
The project will be mainly based in Oxford, but there is the opportunity for travel to conferences and collaborations with other groups.

The project will be mainly based in Durham University, but will include regular visits to CCFE. It will involve overseas travel to: Japan or the US for a collaboratory for 6 – 8 weeks; the USA and/or Japan and/or Europe for conferences and collaborations; Japan or France to use International High Field Facilities.

For further information prospective applicants should contact….. (please provide name and email address)

Please contact Prof. Damian Hampshire at: d.p.hampshire@durham.ac.uk – send your CV, a covering e-mail that includes a brief explanation of why you are interested in Superconductivity and Fusion Energy and your availability for interview. Web-pages: http://www.ccfe.ac.uk/JET.aspx and http://community.dur.ac.uk/superconductivity.durham/personnel.html. CCFE is the fusion research arm of UKAEA.

Please remember to email a picture to go alongside the project description on the website to ruth.lowman@york.ac.uk



Transport critical current density as a function of magnetic field, temperature and strain: (LHS) 2G High temperature superconducting tape; (RHS) The ITER tokamak showing a burning plasma.