PhD Project Descriptions for Fusion CDT Website

Project Title
Computational Time-Dependent Ginzburg-Landau (TDGL) Theory for High-Field Superconductors in Compact Fusion Energy Tokamaks (Computational PhD).
Supervisor/s
Prof. D. P Hampshire (Durham)
External supervisors/s and affiliation (if applicable)
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 a computational PhD so we are happy to consider flexible working.
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:

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.

After ITER, we expect new tokamaks to be built across the world that will help enable *commercial* fusion energy (eg DEMO - Demonstration Power Plant - and STEP – Spherical Tokamak for Electricity Production). It is a completely open question as to which high-field superconductors are the best choice to produce the high-fields needed in commercial fusion. The PhD will inform the fusion community's materials choice and future designs for commercial MCF tokamaks.

The timescale for first-plasma at ITER (2025) offers a wonderful opportunity for early career Physicists to help develop our understanding of high field superconducting materials for fusion applications.

Computational PhD Research Project and Supervision:

In this PhD research programme, the student will develop Time Dependent Ginzburg-Landau (TDGL) theory to model polycrystalline low temperature superconductors and high temperature superconductors with inclusions. Recent work has demonstrated that the next generation of fusion tokamaks may be most effective at ~ 16 Tesla – which opens the question of whether we can develop new composite superconducting materials that have higher performance and are cheaper at 16 Tesla than those currently available. In addition, the values of current density in high-field superconductors are pitifully small, typically less than 1 % of the theoretical limit in high fields, and there is no agreement about why it is so low. In this PhD, we will use computational techniques to model and identify the mechanism for flux pinning and the modes of flux flow in high field superconductors. The focus for the PhD will be to identify routes for increasing the high-field critical current values by a factor of 10 in superconductors used in fusion applications and hence achieve values closer to their theoretical limits.

The PhD supervisor is Prof. Damian Hampshire who is an experienced member of the high-field applied superconductivity and fusion energy community. The 4 year PhD will be funded through the CDT in fusion at Durham University. We expect the PhD student to be based in Durham and to make regular visits to CCFE. We also expect them to work in an International laboratory (usually the USA, Japan or EU) for at least one collaborative project in the 2nd or 3rd year.

This is a fabulous PhD project that is ideal for a student with a first class degree in Physics and a broad interest in fusion, materials and applied Physics. They will be expected to network with scientists throughout the world working on fusion. 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 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. The Research Group is 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.
Knowledge: Understanding magnetically confined fusion and high field superconductors.
Research and critical thought.
Time management.

ii) Specialist Skills.

High field superconductors modelled using TDGL for fusion applications.
Advanced computation using HPC and theoretical skills.

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

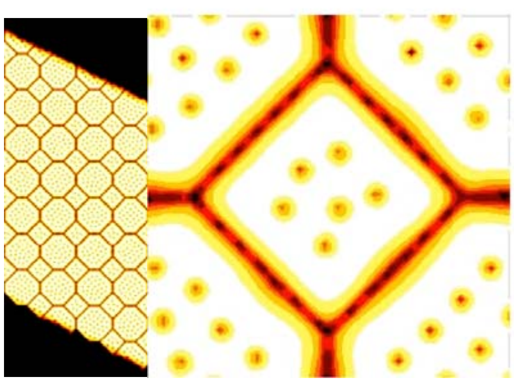
The project will be mainly based in York, but will require long stays particular to the US, for several weeks at a time.
or
The project will be mainly based in Oxford, but there is the opportunity for travel to conferences and collaborations with other groups.

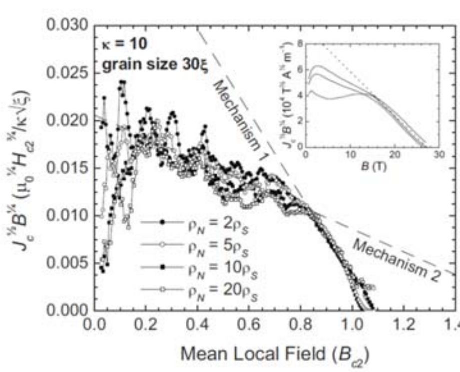
The project will be mainly based in Durham University, but will include regular visits to CCFE. It will involve overseas travel to: Japan or the US for a collaboratory for 6 – 8 weeks; the USA and/or Japan and/or Europe for conferences and collaborations; Japan or France to use International High Field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





LHS – The flux-line lattice in a high-field polycrystalline superconductor. RHS – The critical current density (Jc) versus the applied field (on a Kramer plot) for a superconductor with grain boundaries of different resistivities.