PhD Project Descriptions for Fusion CDT Website

Project Title
Modular High-Field Superconducting Magnets with Remountable Joints for Fusion Energy Applications (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::

Modular magnets with demountable superconducting joints will be required for commercialisation of fusion energy. They will operate at cryogenic temperatures in high magnetic fields. In this project, the PhD student will design, develop and test new demountable superconducting joints made using both traditional low temperature and high temperature superconductors. These joints must meet the requirements: low-cost, low-loss, thermally, electrically and mechanically stable, and remote-handling ready. Staff with expertise and facilities in Durham (Superconductivity Group) and CCFE (STEP and RACE) will collaborate in the design and fabrication of these joints. Testing at high currents will be in high-field cryogenic facilities in Durham.

At the beginning of the 21st century, the ITER (International Thermonuclear Experimental Reactor) Tokamak that is being built in Cadarache in France is one of the most exciting scientific projects (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.

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). Unfortunately the ITER superconducting magnets will not be suitable for commercialisation of fusion energy because they are not modular or demountable. If one of the TF coils at ITER is damaged, it will take at least one year to replace it. Furthermore in commercial tokamaks, modular magnets and joints will need replacing using remote handling because the levels of activation will make direct human entry impossible. CCFE have world-class expertise at RACE, including more than 20 years handling remote operations for JET. This PhD will bring together the expertise to develop next generation demountable superconducting joints for fusion energy applications.

PhD Research Project and Supervision :

The PhD research project will be experimental. It will include a collaboration between Durham University and The Culham Centre for Fusion Energy (CCFE) designing, fabricating and measuring joints for new demountable magnets. The student will focus on developing novel joint designs, considering both traditional low- and high-temperature superconductors. The timescale for first-plasma at ITER (2025) offers a wonderful opportunity for early career Physicists to help pioneer new demountable magnet designs using low- and high-temperature superconductors. They will be expected to network with scientists throughout the world working on fusion. 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.

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.

References: (i) P.O. Branch, Y. Tsui, K. Osamura and D. P. Hampshire. Weakly-Emergent Strain-Dependent Properties of High Field Superconductors. Nature Scientific Reports 9:13998 (2019). (ii) United Kingdom Patent Application No. 1707392.5 Inventors: T Lee, E Surrey and D P Hampshire. Applicant: University of Durham. Title : Superconducting Magnet. Date Lodged with IPO: 11 May 2017 (iii) Yeekin Tsui, Elizabeth Surrey and Damian Hampshire. Soldered Joints - An essential component of demountable HTS fusion magnets - SUST 29 075005 (2016) - Highlights of 2016 : SuST Highlights of 2016

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:

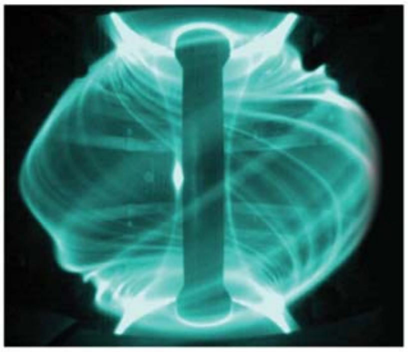
The project will be mainly based in York, but will require long stays particular to the US, for several weeks at a time.
or
The project will be mainly based in Oxford, but there is the opportunity for travel to conferences and collaborations with other groups.

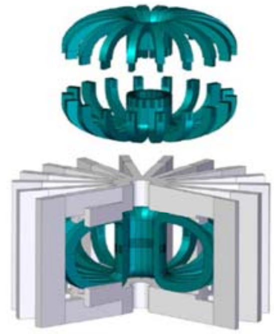
The project will be mainly based in Durham University, but will include regular visits to CCFE. It will involve overseas travel to: Japan or the US for a collaboratory for 6 – 8 weeks; the USA and/or Japan and/or Europe for conferences and collaborations; Japan or France to use International High Field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





(Left) A magnetically confined plasma burning at about 10 times the temperature of the sun. (Right) Demountable Toroidal-Field Coils allowing in-vessel maintenance and new topologies for magnet design – Bromberg et al. MIT.