Ph.D. Research Projects available in the Superconductivity Group

Background (The text below is not typically British, but in the modern era……):

**Experimental:**
Members of the superconductivity group in Durham have published arguably the most important $J_c(B,T,\varepsilon)$ data on low temperature superconducting materials and developed a theoretical scaling law which successfully combines phenomenological and microscopic theory and is widely used in the fusion energy community. These data characterise the supercurrent density that a material can carry as a function of the magnetic-field, temperature and strain.

Facilities: For the best experiments, we combine world-class commercially available equipment with probes that have been designed and built in-house. Commercial cryogenic equipment in-house includes two high-field magnet systems, a fully equipped PPMS system, a new high-pressure system and a He-3 system. In addition to the 15-17 Tesla vertical magnets, we have a 15 Tesla Helmholtz-like 40 mm bore, split-pair horizontal superconducting magnet system which is unparalleled in the university sector world-wide. The world-class high field facilities and instruments are supported by a number of specialist probes designed and built in-house for making strain, magnetic, resistive and optical measurements on superconductors. For example, the $J_c(B,T,\varepsilon)$ data were obtained using an instrument built in Durham for use in our high field systems and in international high-field facilities in Grenoble, France.

Members of the superconductivity group in Durham pioneered the discovery of a new class of nanocrystalline superconductivity materials with exceptionally good tolerance to high magnetic field. These materials provide a new paradigm for high-field conductors. The upper critical field in Chevrel phase superconducting materials was increased from 60 T (Tesla) to more than 100 T and in elemental niobium from ~ 1 T to ~ 3 T. This work involves: fundamental and applied scientific investigations into nanocrystalline high-field materials where the important length scales for superconductivity are similar to the length scales for the microstructure; fabricating and understanding the physics of this new class of high magnetic field superconductors.

Facilities: DSC, DTA, XRD, glove box, a range of milling machines and furnaces as well a HIP operating at pressures of 2000 atmospheres and up to 2000 C.

**Theoretical:**
Using supercomputing facilities both in Durham and available as National computing facilities, group members have produced the first visualisation of flux flow in polycrystalline superconductors calculated from the Time-Dependent-Ginzburg-Landau (TDGL) equations. This has provided a solution to the so-called ‘grand-summation problem’ which identifies the complexity of the different forces that operate on fluxons in high fields in high Jc materials.

**Ph.D. Research Projects**

All PhD students are funded by the group to attend International conferences to present their publishable work in either poster or oral form see Personnel: http://community.dur.ac.uk/superconductivity.durham/personnel.html

PhD starting October 2015: Ductile High Field Superconductors for Fusion Energy Applications
Supervisor: Prof. D. P. Hampshire – available starting October 2015. We expect to fill the post early in 2015.

Superconductivity is an essential component of future commercial tokamaks. Recent work has demonstrated that the next generation of fusions tokamaks may be most effective at ~ 16 Tesla – which opens the question of whether we can develop new composite materials that extend the use of ductile superconductors from 10 Tesla up to 16 Tesla. The development of multifilamentary high field superconductors has been driven by the costs and technical needs of MRI body scanners and high energy particle physics accelerators such as the LHC in CERN. This PhD research will develop our understanding of the theoretical and practical limits of all ductile high field superconductors. We will use our state-of-the-art high magnetic field, cryogenic and fabrication facilities in Durham including our horizontal split-pair 15 Tesla magnet system to make and measure new ductile superconducting composite materials. Our ambition is to develop new ductile high-field superconductors that enable the next generation of very high-field fusion tokamaks.

The PhD in Durham is funded through the York fusion DTN partnership which gives an excellent exposure to many of the best Universities in the UK, an excellent taught course in fusion energy, exposure to the fusion community across Europe and an opportunity to go abroad or stay in the UK to do a short collaborative project in the 2nd or 3rd year.

Please send your CV directly to DPH at d.p.hampshire@durham.ac.uk with a few sentences saying why you are interested in the PhD research.

Also:

**Ph.D.- Research project: Superconductivity in high magnetic fields**
Superconductivity is the enabling technology for MRI body scanners, particle accelerators and fusion energy. We have world-class high magnetic field facilities. In this Ph.D. project we intend to measure and understand the supercurrent that can flow in superconducting materials in high magnetic fields. We expect that our measurements will provide an insight into why the critical issue of why supercurrent densities in high fields for both high temperature and low temperature superconductors remain more than three orders of magnitude below theoretical limits.
Contact: Prof. Damian Hampshire d.p.hampshire@durham.ac.uk and send your CV.

**Ph.D.- Research project: Superconductivity for high-field Fusion Energy applications – CDT in Fusion Energy**
Superconductivity is the enabling technology for the $20B ITER project that the Department of Energy in the USA concluded is the most important large scale project in the world during the next 20 years. About one third of the cost is the superconducting magnets that will hold the burning plasma scheduled to ignite in 2025. Durham is a partner in the EPSRC Centre for Doctoral Training in the Science and Technology of Fusion Energy lead by York. [http://www.york.ac.uk/fusion-cdt/](http://www.york.ac.uk/fusion-cdt/) Students spend a total of about 9 months at York University and other partner Universities in the CDT and the remaining ~ 3 years at Durham. The course gives excellent exposure to Universities throughout the UK, includes a well structured course in fusion energy, an opportunity to go to Japan or the USA to do come collaborative work in the 2nd or 3rd year. The PhD is awarded from Durham University. The PhD provides the opportunity to make measurements on superconductor in high fields in Durham that are relevant for fusion energy applications.
Contact: Prof. Damian Hampshire d.p.hampshire@durham.ac.uk and send your CV.

**Ph.D.- Research project: Nanocrystalline Superconductivity**
Members of the superconductivity group in Durham pioneered the discovery of a new class of nanocrystalline superconductivity materials with exceptionally good tolerance to high magnetic field. These materials provide
a new paradigm for high-field conductors which has been patented and then published in the premier Physics journals. Equipment in-house includes DSC, DTA, XRD, glove box, a range of milling machines and furnaces as well a HIP operating at pressures of 2000 atmospheres and up to 2000 C. The upper critical field in Chevrel phase superconducting materials was increased from 60 T (Tesla) to more than 100 T and in elemental niobium from ~ 1 T to ~ 3 T. In this work, we control the microstructure (grain boundaries and defects) on the length scale of the superconducting coherence length to increase the resistivity and hence the tolerance of the superconductors to high magnetic fields. This research Ph.D. project will involve fundamental and applied scientific investigations into nanocrystalline high-field materials where the important length scales for superconductivity are similar to the length scales for the microstructure and will be focussed on fabricating and understanding the physics of this new class of high magnetic field superconductors.

Contact: Prof. Damian Hampshire d.p.hampshire@durham.ac.uk and send your CV

**Ph.D.- Research project: Theoretical Computational Studies of High-fields Superconductors**

Members of the group produced the first visualisation of flux flow in polycrystalline superconductors calculated from the Time-Dependent-Ginzburg-Landau (TDGL) equations. These calculations have opened the possibility to investigate important technological LTS and HTS materials. We are also working on the architecture of composite superconducting materials – we are looking to improve their stability through good engineering design of the component parts.

Facilities: Vast range of Computers/Supercomputers in Durham and in the UK

Contact: Prof. Damian Hampshire d.p.hampshire@durham.ac.uk and send your CV.