Superconductivity & Magnetism Group

WARWICK

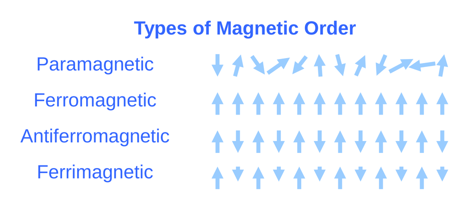
Who we are...

Staff: Geetha Balakrishnan, Paul Goddard, Martin Lees, Don McK Paul, Oleg Petrenko. Technician: Tom Orton. Post-doc: Monica Ciomaga-Hatnean.
Current PhD Students: Mo Saghir, Joel Barker, Daniel Brunt, Jamie Brambleby, Will Blackmore, and Talha Ahmad.

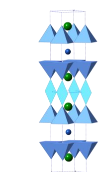
What we do...

The Superconductivity and Magnetism Group has a range of interests that are centred around the properties of Strongly Correlated Electron Systems.

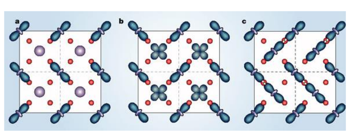
Magnetic materials from simple ferromagnets to systems with complex magnetic structures, frustration, or low-dimensionality.



Intermetallic, pnictide, and oxide superconductors including materials with non-centrosymmetric structures, high transition temperatures, or topological properties.

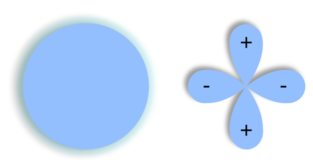


Crystal structure of the cuprate high-temperature superconductor $YBa_2Cu_3O_7$.



Chequerboard Mn^{3+}-Mn^{4+} charge-order in manganites.

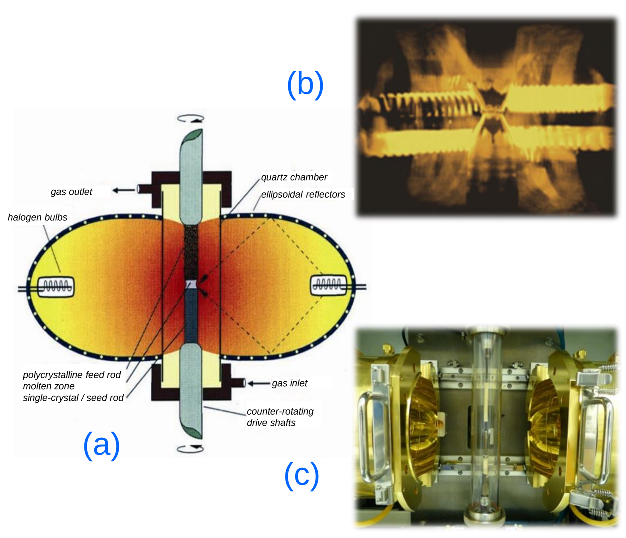
Oxide materials showing colossal magneto-resistance, magnetic field induced changes in structure, charge ordering, and stripe phases.



s- and d-wave superconducting order parameters.

Superconductors, exhibiting exotic properties including multi-band effects, *p* and *d* wave order, or the coexistence of superconductivity with magnetism.

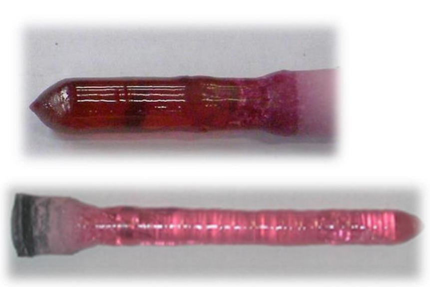
Crystal Growth



Single crystals are grown by various techniques including using mirror image furnaces which melt the samples with heat from intense light.

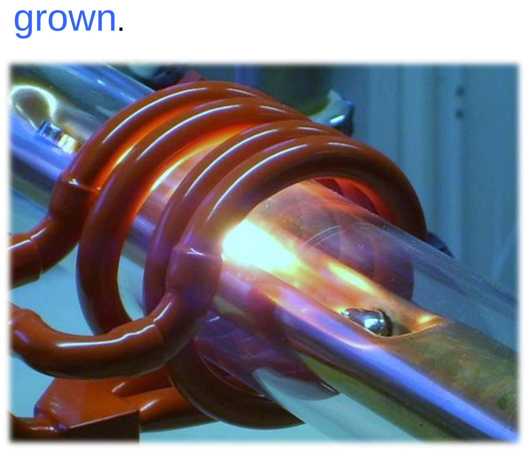
During a crystal growth a molten zone is created between a polycrystalline upper rod and a lower seed crystal. This is called the floating zone technique.

(a) Schematic of a 2 mirror image furnace. (b) Lamp filaments reflected in the mirrors and the molten zone during a crystal growth. (c) Furnace ready for a crystal growth.

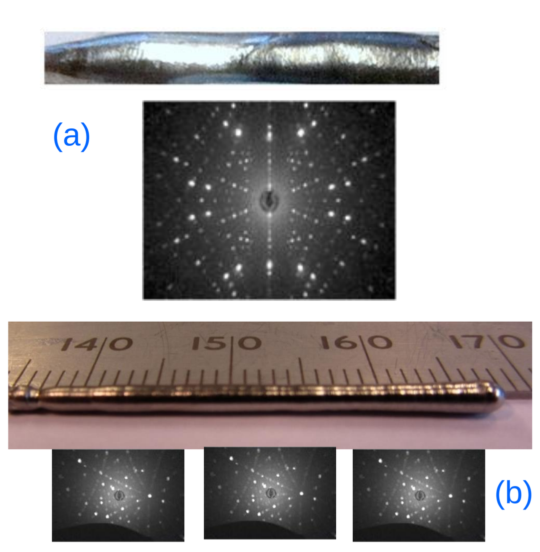


Single crystals of (a) ruby and (b) the frustrated magnetic system $SrEr_2O_4$.

Single-crystals up to 100 mm in length and 10 mm in diameter of oxides, borides, and carbides, with melting points up to 3000 °C can be grown.



Melting an intermetallic superconductor inside the r.f. coil in our induction furnace.



Single crystals and the x-ray Laue patterns of the superconductors (a) Ru_7B_3 and (b) $Nb_{0.18}Re_{0.82}$.

Powder and single-crystal x-ray diffraction, along with electron microscopy, are used to investigate the composition and structure of materials. The x-ray Laue method is used to investigate the quality of crystals and align them for experiments.

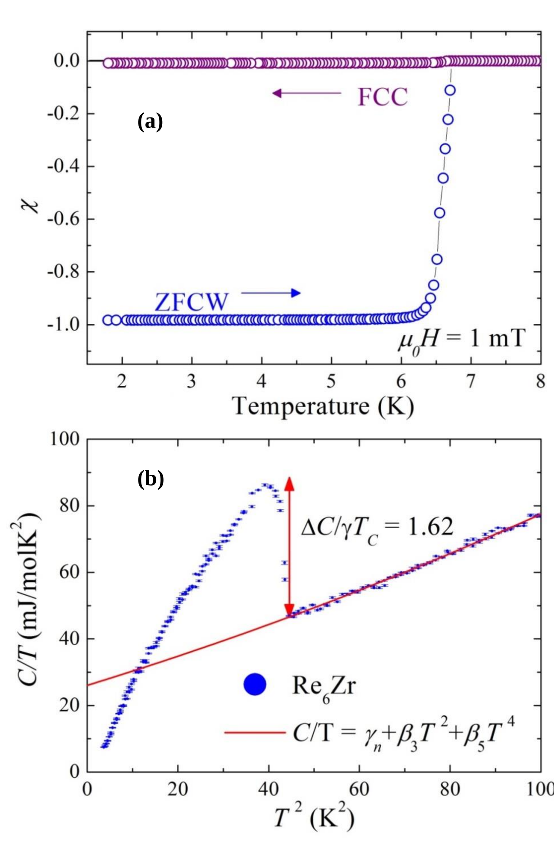
In Our Laboratories

We have a suite of state-of-the-art apparatus for measuring the physical properties of samples at temperatures from 0.05 up to 400 K and in applied magnetic fields up to 17 T.

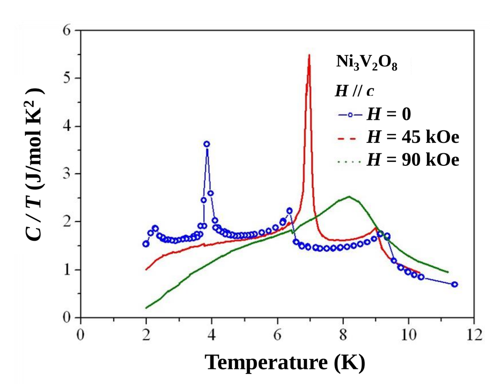
Measurements in higher magnetic fields or at lower temperatures are performed at central facilities such as the National High Field Magnet Laboratory in the USA, or in collaboration with colleagues at locations throughout the world.

Our 12 tesla Oxford Instruments Vibrating Sample Magnetometer.

We perform electrical transport measurements, including ac and dc resistivity, Hall effect, and thermopower studies.



Temperature dependence of (a) the dc susceptibility and (b) the heat capacity of the non-centrosymmetric superconductor Re_6Zr, showing the onset of superconductivity at 6.76 K and the change in the electronic response from the normal to the superconducting state.



Specific heat versus temperature data for $Ni_3V_2O_8$, a frustrated magnetic system. The complexity of the system is apparent from the number of peaks that show where phase transitions occur.

We have magnetometers to study the ac and dc magnetic response of superconducting and magnetic materials. Specific heat can be used to observe either structural, magnetic, or electronic phase transitions.

All these measurements can be carried out as a function of temperature and magnetic field, but also sometimes under high pressure.

Neutron Scattering & μSR

Central facilities such as ISIS in the UK, the ILL in France, or the PSI in Switzerland provide neutrons or muons which we use to study our samples.

Powder and single-crystal neutron diffraction, including techniques such as small angle neutron scattering (SANS) and studies with polarized neutrons, are used to investigate the crystallographic and magnetic structure of materials.

ISIS

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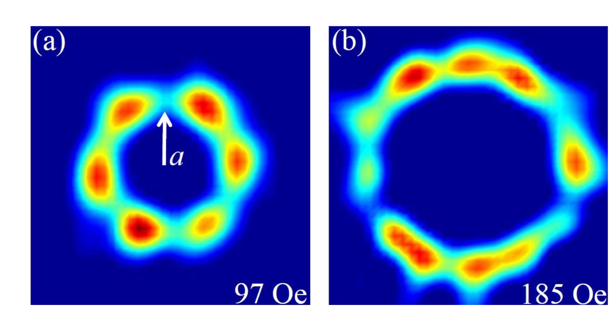
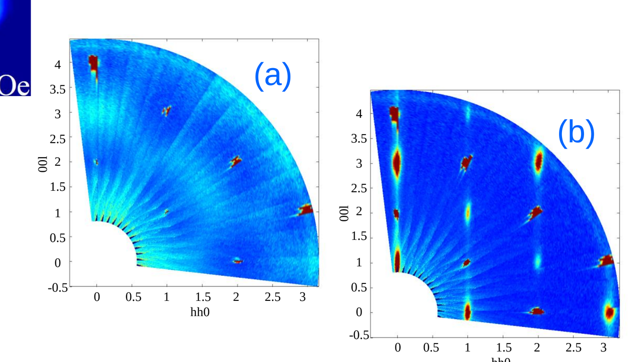


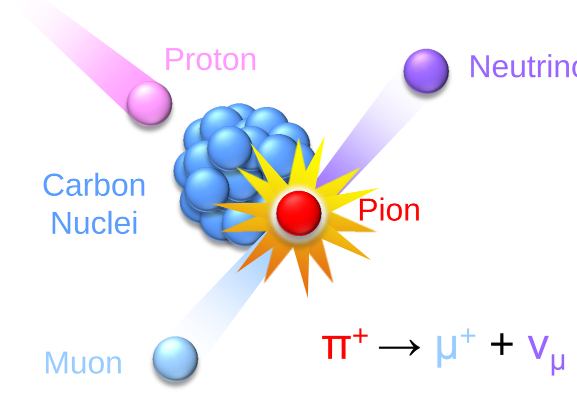
SANS study of the FLL in the two-band superconductor CaAlSi. The data collected using D22 at the ILL show a rearrangement of the magnetic flux lines within the sample as the applied magnetic field is increased.



A neutron diffraction study of the magnetic correlations in spin ice $Dy_2Ti_2O_7$ using the PRISMA spectrometer at ISIS. (a) In zero-field at 50 mK the material is in a short-range order spin ice state; (b) in a field of 1.5 T, there is a coexistence of long- and short-range magnetic order.

As well as studying long-range magnetic order, neutrons are also used to study short-range order or the magnetic correlations in materials that do not order down to very low temperature.

Inelastic neutron scattering is used to investigate the nature of spin and lattice excitations in our samples, while muon spectroscopy allows us to study magnetic fluctuations, the mixed state in superconductors, and very small ordered moments.



A high energy proton collides with a carbon nucleus. A 100% spin-polarised muon is produced from the decay of the resulting pion.

1986 – Today

1986 Superconductivity and Magnetism Group formed by Don Paul, Geetha Balakrishnan, and Andrew Boothroyd (now at Oxford Univ.)

Ph.D. students are listed along with their year of graduation

1990 Our single crystal growth programme begins

1992 Dr Laurence Caves

1992 Martin Lees joins the Group

1995 Oleg Petrenko joins the Group

1996 Dr Jason Gardner

1997 Dr Suzy Coad

1997 Dr Lieh-Jeng Chang

1997 Dr John Martin

1999 Dr Alistair Campbell

2002 Tom Orton joins the Group

2002 Dr Emma Chung

2002 Dr Nicky Bancroft

2003 Dr Simon Levett

2005 Dr Sonya Crowe

2006 Dr Jenny Wooldridge

2007 Dr Nicola Wilson

2009 Dr Catherine Fleck

2010 Dr Dan O'Flynn

2012 Dr Pabitra Biswas

2013 Paul Goddard joins the Group

2013 Dr Michael Smidman

2013 Dr Olga Young

2014 Dr Robert Cook

2014 Dr Natalia Parzyk

http://go.warwick.ac.uk/supermag