FLUIDS AT LEEDS

The Leeds Institute for Fluid Dynamics (LIFD) is a cross-disciplinary research institute bringing together the expertise of over 300 members of staff, postdoctoral researchers and PhD students with teaching and research interests in fluid dynamics. The institute was established in 2018, and builds on a 50 year interdisciplinary track record of research in fluids. We provide a hub to facilitate world-leading research and education in fluid dynamics and to bring interdisciplinary perspectives to complex flow challenges.

Our objectives focus on four key areas:

**International standing:** To be a world leading centre for Fluid Dynamics, and to continue to build the UK reputation for international excellence in fluid dynamics;

**Collaborative research capabilities:** To enable excellence through collaboration, facilities and support to researchers;

**Strategic partnerships:** To build and maintain partnerships worldwide with end-users, academia, funders and alumni;

**Excellence in training:** To support cross-disciplinary postgraduate level training through MSc, PhD and short courses.

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Over 50% of papers with international collaborators

Over £87M current grants as of June 2021

Researchers from 12 Schools

4 Faculties

Nearly 10% of publications include academic-corporate collaboration

Collaborations in 105 countries

3,405 papers (2015-2020)

49% in Top 10% Journals
FLUIDS IN THE UNIVERSE

We conduct world leading research into fundamental astrophysical fluid dynamics, specialising in theoretical and computational models. Applications of our theories include the modelling of planetary dynamics (planetary dynamos, tidal interactions between planets and stars, planet formation), solar and stellar dynamics (star formation, dynamo theory, magnetohydrodynamic instabilities and turbulence), as well as galactic and extragalactic dynamics on the largest scales involving relativistic fluid dynamics. Our external partners include NASA and the European Space Agency (ESA).

MAGNETIC FIELD GENERATION IN THE EARTH AND PLANETS

Magnetic fields are generated in planets, stars and galaxies. These fields provide unique insight into the dynamics and evolution of astrophysical bodies and help to shield planetary surface environments from solar radiation. The figure shows a simulation of Jupiter’s magnetic field, which is generated by turbulent motion of metallic hydrogen.

A simulation of Jupiter’s magnetic field (red (outgoing) and blue (ingoing) magnetic field in millitesla).
FLUIDS FOR HEALTH

We have major strengths in fluid dynamics relating to cardiovascular disease including advanced facilities for 4D MRI imaging and coupling imaging with CFD modelling to analyse disease mechanisms and predict outcomes of interventions.

Our biomedical flow expertise also includes microfluidic diagnostics for biological flows; drug delivery; microbial dispersion and infection control; and modelling of flows in tissues and tumours. We work closely with pharmaceutical companies and medical imaging industries as well as Public Health England and the NHS to ensure that research outcomes have a real benefit for public health.

IN-SILICO TRIALS REPLICATE AND EXPAND INSIGHTS FROM CONVENTIONAL CLINICAL TRIALS

Using advanced machine learning for image and signal processing, patient – and population-specific models of physiology, computational fluid dynamics and biochemical blood clotting models, we have performed the first large-scale in-silico (computer-based) trial for flow diveters in cerebral aneurysms. With our in-silico trial, we can (i) replicate findings of conventional clinical trials, and (ii) perform virtual experiments and sub-group analyses that are difficult or impossible in conventional trials to discover new insights on treatment performance and failure.

FLUIDS FOR PROCESS INDUSTRY

We bring together understanding of fundamental flow regimes, fluid properties and simulation approaches to tackle challenges in multiple industry sectors. Expertise at Leeds includes: wetting, coating and drying; printing and jetting of complex fluids; formation and transport of sludge and emulsions; cooling and heat transfer; corrosion; thin-film flows, and filtration.

We work closely with industrial partners across a wide range of applications including printing, additive and subtractive manufacturing, novel filtration, electronic displays, magnetic media, instrumentation and power generation.

STUDY OF A FREE-FALLING SUCROSE DROPLET DRYING AT HIGH TEMPERATURE

The project aims to model the boiling phenomena of a droplet freefalling at terminal velocity. Through coupling the internal solute diffusion and the phase change at the interface to the external air flow field, the model is able to predict the final morphologies of the dried particle. Understanding the particle structure is useful for the drying process within a Spray Dryer. It also has applications in food powder, chemicals, ceramics and the pharmaceutical industry.
FLUIDS FOR CLIMATE

We tackle the fundamental processes causing past and future changes in local and global climates and their consequences for our planet and society. Expertise at Leeds includes: atmospheric composition; cloud dynamics; aerosols; phase nucleation and statistical comparisons between models and observations. Techniques include laboratory experiments and computer simulations, which benefit from collaboration with the Centre for Environmental Modelling and Computation hosted in the School of Earth and Environment.

A RADICALLY DIFFERENT APPROACH TO MODELLING GEOPHYSICAL FLUID DYNAMICS

LIFD researchers have been involved in the development of a revolutionary new model for geophysical fluid dynamics, which they have applied to study turbulence and mixing in clouds. This Moist Parcel-in-Cell model uses fluid “parcels” to represent the movement of water vapour and cloud droplets and has the potential to radically improve our understanding of the Earth’s water cycle.

FLUIDS IN THE ENVIRONMENT

We have an exceptional track record in fundamental processes related to geophysical and astrophysical flows. Expertise includes: convection in multi-phase flow; atmospheric and oceanic turbulence; non-Newtonian flow and fluid-structure interaction in dynamics of marine ice sheets.

Techniques range from fundamental analysis and statistical methods, to large scale field observation and highly parallel computational simulation. Whilst projects are often fundamental, many benefit from external partner input for example in extreme weather and urban flows.

THE FLUID DYNAMICS OF DISEASE TRANSMISSION

Understanding the transmission of infectious diseases such as COVID-19 is a complex problem linking physics of fluids, microbiology and human behaviour. We have a suite of projects ranging from modelling the influence of ventilation in hospitals and offices, modelling the exposure to droplets as a passenger on a motorbike, through to characterising exhaled breath flows when singing or wearing a mask.

MODELLING THE MULTIPHASE AIR-WATER FLOW ON A SPILLWAY

Complex air-water flows occur in a wide range of industrial and environmental flows. The design of hydraulic infrastructure and in particular reservoir spillways is of importance from a safety and economic perspective. A pressing challenge is to reliably model system behaviour under different flow conditions, for example predicting self-aeration (which results in ‘white-water’). Self-aeration occurs as air is drawn into the water as it starts to descend the spillway which substantially changes the flow behaviour - and associated velocities, pressures and bulk volume - all key for ensuring safe operation.

Fluids.leeds.ac.uk
FUNDAMENTAL FLUIDS

Our substantial research into novel analytical, experimental and numerical methodologies contributes to fundamental knowledge and new techniques for fluid analysis, as well as translating this expertise into application areas. Our strengths include nonlinear dynamics; imaging techniques; and the development of novel CFD tools and numerical algorithms. We develop and modify algorithms for modern computer architectures including multi-core accelerators, GPU and large scale parallel simulation. We have partnerships with software providers and organisations with interests in developing new algorithms and solution techniques to support software for academic and industry users.

TRANSITIONAL FLOW CONTROL
Turbulence is ubiquitous in fluid flows and often undesirable in industrial processes. We are developing a framework to enable a quantitative characterization of the flow transition, prior to the development of turbulence. This framework will make it possible to rank control strategies in order to select the most efficient one at preventing transition to turbulence.

FUNCTIONALITY OF BIOMIMETIC ANTIMICROBIAL SOLUTIONS UNDER FLOW
Natural micro – and nano-patterned surfaces exhibit striking behaviour such as super-hydrophobicity, self-cleaning, wavelength-dependent light management and others that are yet to be discovered. Understanding the performance of these functional surfaces and their synthetic mimics under dynamic flow conditions still remains an open challenging question that we try to address through interdisciplinary research at LIFD.

DYNAMICS OF HYDROGEN RETENTION AND RELEASE IN NUCLEAR WASTE
The growth, retention and release of trapped gases within soft sediments is important in many natural and engineered systems, such as the behaviour of methane in reservoir beds. It is also critical to understanding hazards associated with nuclear waste sludges. In particular, we work with Sellafield Ltd (the U.K.’s largest nuclear site operator) to study the dynamics of hydrogen bubble networks and their release in corroded nuclear cladding. This will result in the safe transfer and storage of thousands of cubic metres of waste in a multimillion-pound operation.

FLUIDS FOR CLEAN ENERGY

Our research ranges from reacting flows in internal combustion engines, through to mixing problems in nuclear waste, fluid-structure interaction in wind energy, and multiphase flows in oil and gas fields. Academic expertise includes: engine combustion and tribology; aerodynamics and shape optimisation; heat transfer; and turbidity currents.

Our external partners include nuclear industries with interests in suspensions, multiphase flows and mixing; fuel industries on combustion, lubrication and production; and the aerospace industry on heat transfer problems.

LEFT TO RIGHT: 3-D x-ray CT image of nuclear waste simulant and (i) extracted pore scale bubble network. (ii) Gas transport through inter-bubble network.
Our EPSRC Centre for Doctoral Training (CDT) in Fluid Dynamics tackles fundamental and applied problems providing students from a wide range of academic backgrounds with the opportunity to undertake cutting-edge, multidisciplinary research.

Students undertake an integrated 4-year MSc and PhD combining theoretical, experimental and numerical training with a strong programme of professional development and a research project with cross-disciplinary supervision. The programme was launched in 2014 and will support at least 10 students per year until 2023.

INTERNATIONAL PHD OPPORTUNITIES

We welcome enquiries from international PhD candidates who are interested in carrying out their doctoral studies in Leeds. We offer a vibrant research environment which attracts students from over 170 countries.

Many of our students can align their studies with the CDT, enabling access to taught courses and professional development alongside their PhD. Students are supported through the Leeds Doctoral College which offers a wide range of training, personal development and peer support.

Opportunities are available across Engineering, Mathematics, Environmental Sciences, Physics and Biomedical Sciences.

MSC PROGRAMMES

Our 1 year MSc programmes offer the chance to build in-depth knowledge in a discipline area, and all include a substantial research dissertation component. We have several MSc programmes at Leeds which develop aspects of fluid dynamics including:

• Advanced Chemical Engineering
• Advanced Mechanical Engineering
• Aerospace Engineering
• Chemical Process Engineering
• Climate and Atmospheric Science
• Energy and Environment
• Exploration Geophysics
• Mathematics
• Petroleum Production Engineering
• River Basin Dynamics and Management with Geographical Information Systems

STUDYING IN LEEDS

The University of Leeds is one of the largest universities in Britain with over 38,000 students and more than 7,000 staff, including over 2,000 academic and academic-related staff.

We offer excellent facilities to support your studies including state-of-the art laboratories, high performance computing and a wide range of library and support services such as language support.

The campus is just a 10 minute walk from Leeds city centre which offers a wide range of social, retail, sporting and cultural activities. The city is within easy reach of the beautiful Yorkshire countryside enabling access to outdoor activities, the coast, market towns and the historic city of York.
BECOME A VISITING RESEARCHER

Our LIFD Fellows scheme aims to attract distinguished scholars from around the world to work with researchers at Leeds. LIFD Fellows are normally invited to spend 1-3 months in Leeds and are supported with up to £3000 to assist with expenses. We invite applications for LIFD Junior Fellows and LIFD Senior Fellows twice a year. We also welcome visiting researchers at all career stages, including PhD students, who are hosted by the academic departments involved with LIFD.

ACADEMIC FELLOWSHIPS IN LIFD

A fellowship is a prestigious award offering flexible and independent research funding to explore large scale and challenging research ideas. We are keen to support scholars from around the world who are interested in applying for an externally funded fellowship to join the University of Leeds.

Fellowship opportunities are available for all career stages, from recent PhD graduates through to senior Professors. Eligibility varies by scheme, career stage, discipline and country; however there are a wide range of schemes from UKRI and EU funders that align to fluid dynamics disciplines. We offer support to applicants to prepare exciting and competitive fellowship proposals, as well as mentoring and guidance to develop your career in Leeds if your proposal is successful.

CONFERENCES, MEETINGS AND SUMMER SCHOOLS

Within LIFD we offer a wide programme of seminars, lectures, conferences and training events aimed at both academic and industry audiences.

Our flagship LIFD Research Programme is a two week workshop that will run every two years to gather leading international experts in a specific area of fluid dynamics. Through a series of lectures and workshops this meeting aims to advance the science and understanding of specific fluid challenges and build new collaborative partnerships.

The LIFD summer school will run annually, focusing on a different area of fluid dynamics each year. Primarily aimed at graduate students, this concentrated one week course will develop both core discipline skills and share the current research advances in the discipline.

The Institute also runs a series of high-profile events for stakeholders including LIFD Colloquia, the LIFD John Fox Annual Lecture and a series of international Fluids webinars in partnership with the Journal of Fluid Mechanics, DAMTP at Cambridge and the UK Fluids Network.

We are keen to partner with the international fluids community to organise events that actively support researchers across the diversity of fluids research. LIFD will support the organisation and promotional aspects of these meetings, enabling academic collaborations to focus on the scientific content of the meeting. Please talk to us if you are interested in collaborating with LIFD to organise a conference or meeting, or chairing one of our Research Programmes or Summer schools.
## WORK WITH US
### INDUSTRY ENGAGEMENT

Partnerships with industry, policy makers and end-users are critical across our research portfolio, enabling definition of relevant research projects and facilitating impact into guidance, policy and practice. We are one of the founding members of the EPSRC funded UK Fluids Network, and actively engage with the fluid dynamics community across the UK, and internationally. We use industry facing study groups, workshops and sandpit events to explore challenges, and we have a range of mechanisms for collaborative working with external partners, offering different timescales, costs and complexity.

<table>
<thead>
<tr>
<th>STUDENT ROUTES</th>
<th>GRANTFUNDED</th>
<th>DIRECT SUPPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry led UKRI grant schemes</td>
<td>Consultancy</td>
<td>Undergrad/MSc projects</td>
</tr>
<tr>
<td>Cost share scheme for industry driven R&amp;D projects, typically 2-3 years with a dedicated research associate.</td>
<td>Short term with retention of IP, but relatively high cost. Good for short focused projects.</td>
<td>Short term (3-6 months), low risk, low cost, ideal way of building a relationship and exploring an idea.</td>
</tr>
<tr>
<td>Innovate Funding</td>
<td>Research Grant Partner</td>
<td>Strategic Partnership</td>
</tr>
<tr>
<td>Industry led grant schemes focusing on strategic R&amp;D and in partnership with academia.</td>
<td>Academic led projects, with industry partner in-kind or small value. Low risk, but over longer timescale. Good for building relationships.</td>
<td>Long term approach, usually where there are multiple connections or projects. Supported through a partnership agreement.</td>
</tr>
<tr>
<td>Direct Funded Research</td>
<td>Fully Sponsored PhDs</td>
<td>Co-funded PhDs</td>
</tr>
<tr>
<td>Lower cost than consultancy, developed in partnership with academic. Usually allows retention of IP.</td>
<td>Similar to co-funded, but enables stronger partner steer and retention of IP.</td>
<td>Ideal for underpinning research to support new ideas. Cost share with research council via CDT or CASE schemes. Typically 3-4 years.</td>
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OUTREACH

PUBLIC ENGAGEMENT AND OUTREACH

Inspiring the next generation is a key mission for LIFD. Fluid dynamics underpins almost everything in our lives, yet is often a hidden discipline in our school curriculum. Our researchers work closely with end-user partners to inspire curiosity and show how fluid dynamics affects the world around us. We are particularly interested in engaging school-age children through interactive hands-on activities, and collaborating with existing and new partners on the development and delivery of exciting outreach.
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For further information on postgraduate study at the
University of Leeds please visit http://www.leeds.ac.uk/

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