IOP Institute of Physics
Liquids and Complex Fluids Group

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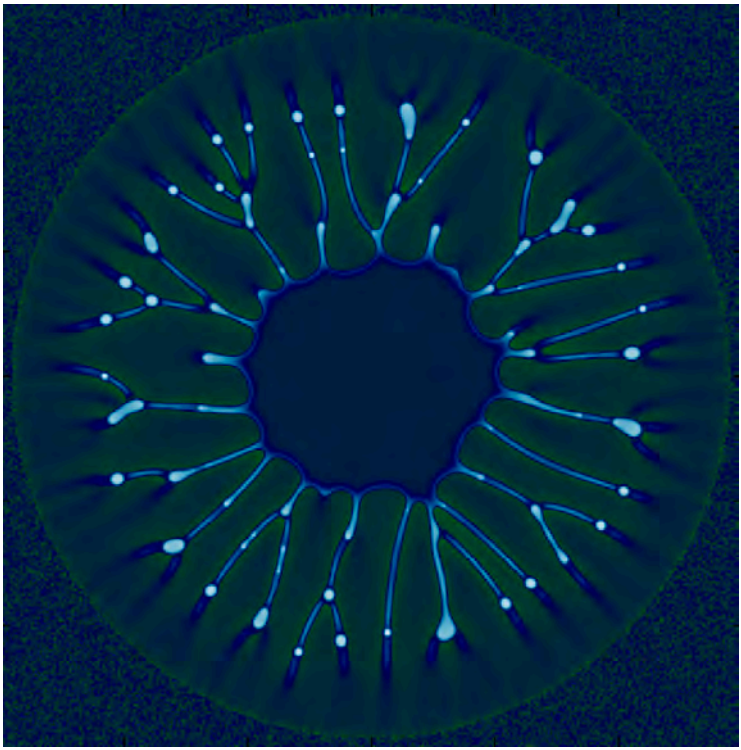

Density distribution of nanoparticles during the evaporation of a drop of suspension from a surface. Image courtesy of A. Archer, Loughborough University.

See http://www.iop.org/activity/groups/subject/lcf/ for further details

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Hon. Secretary's report

Welcome

The committee of the Liquids and Complex Fluids Group are pleased to welcome you to the 2015 group newsletter. This newsletter outlines the nature of the group, its interests and relevant activities across the country.

2015 Group News

This year has been busy for the group as we have been involved in a number of events. First, we have again organised the Advanced School in Soft Condensed Matter "Solutions in the Spring". It was encouraging to see so many graduate students taking part, some for the second or even the third time. The 2014 school was held in Cambridge; a student report on this event can be found on the following pages. Second, the group organised a one-day meeting on *Computer Simulation of Confined Fluids* and a report can be found in this newsletter. Finally, the group sponsored the BSR Annual mid-Winter meeting and a detailed report is included on the following pages.

The 2015 LCFG Soft Condensed Matter school will be held at Loughborough University, from Monday 13 April to Thursday 16 April 2015. Details are available in this newsletter and on the LCFG website. We hope to see many new students, as well as old hands, joining us.

The **LCFG Early Career Prize 2013** was awarded to Dr Anita Zeidler. A report on the prize and associated meeting can be found on pages 8/9.

As group secretary, I particularly wish to thank all of those who have given a considerable amount time organising these activities for the benefit of everyone. I would also like to take this opportunity to remind you all that the Committee always welcomes ideas for meetings, workshops and events. The group is able to organise meetings as well as provide sponsorship for meetings planned by external parties, so do please get in touch if you have an idea for an event likely to be of interest to the community. Contact details of committee members can be found at the end of this newsletter.

Please can I remind students of the Research Student Conference Fund, to which all student members of the Group are eligible to apply. Funding of up to £250 is available for eligible students, and applications should reach the Institute by: 1 March, 1 June, 1 September or 1 December.

I would like to draw your attention to the Group's Early Career Prize 2015, which is advertised on page 8 of this newsletter.

The Annual General Meeting of the Group will be held in Loughborough in April 2015, traditionally directly after the spring school. This short meeting is the ideal opportunity for you to comment on the present activities of the group, propose improvements, and make suggestions for future events. I would encourage as many members as possible to attend.

The LCFG committee has undergone a regeneration over the past year, with Cait MacPhee, Natasha Rhys, Suzanne Fielding and Matthew Reeves stepping down from committee membership. I would like to thank them all for their hard work. The committee welcomes Paul Clegg and Adam Hughes as new members. We are currently holding elections for a student and an ordinary group member. If you are interested, please contact me directly.

Edo Boek, Hon. Secretary,
Liquids and Complex Fluids Group

Reports on recent group events

LCFG / STFC Advanced School in Soft Condensed Matter 2014: 'Solutions in the Spring'

Matthew Reeves and Natasha Rhys

Student representatives for the IoP Liquids and Complex Fluids Group

The Advanced School in Soft Condensed Matter 2014 was held at Homerton College, Cambridge, between the 11th and 14th April. The school was organised by the IOP Liquids and Complex Fluids Group, with sponsorship from the STFC Centre for Molecular Structure and Dynamics. The eighth in the series, 'Solutions in the Spring' provides an opportunity for postgraduates from across the UK to come together and share their research, as well as to hear stimulating lectures and participate in workshops conducted by

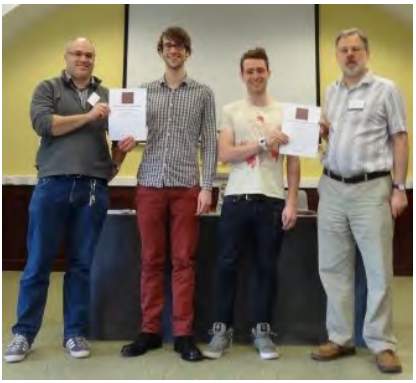
a variety of renowned academics in the field.

This year's school was unmistakeably themed on 'colloids', with Daan Frenkel (Cambridge) opening the proceedings with an entertaining introductory lecture before making way for Paddy Royall (Bristol) to go in to greater detail about the theory and application of colloid physics. Brent Murray (Leeds) complemented Paddy's lectures by expanding in to the realm of food-grade systems, and exploring some of the concepts and challenges that are currently relevant to industry. Murray's workshop invited the students to scientifically analyse the contents of ice cream in order to establish the number of unique phases, with the winning group happy to receive a prize of Wall's Magnums!

Other topics covered included 'biomolecular solutions' delivered by Sylvia Mclain (Oxford), who highlighted the multi-faceted approach required for solving biomolecular problems including protein structure and folding. Andrew Archer (Loughborough), Mike Allen (Warwick) and Edo Boek (Imperial) lectured about mesoscale computational simulations and the theory behind such approaches, with the advantages and disadvantages with respect to soft matter clearly outlined.

The social programme this year allowed for plenty of networking and relaxation between lecture sessions. On the first day of the school, an intense couple of hours were had as the students tried to match each other up with a prepared list of short descriptions (see picture on the left).

The poster sessions were well attended, with Daniel Toolan (Sheffield) and Adam Churchman (Leeds) jointly winning the poster prize (see picture below). The school wrapped up with punting down the River Cam followed by an evening meal at La Mimosa.



Feedback from the event was extremely positive, underlying the importance of the yearly meet-up to the professional and personal development of the participating postgraduates. Our thanks go to this year's organisers on the IOP Liquids and Complex Fluids Committee.

Computer Simulation of Confined Fluids

Mike Allen

On 8 December 2014, LCFG held a joint one-day meeting with the Royal Society of Chemistry's Statistical Mechanics and Thermodynamics Group, on the subject of "Computer Simulation of Confined Fluids". Two invited talks were given, by Jesper Schmidt Hansen (Roskilde) and Jürgen Horbach (Düsseldorf); there were 11 contributed talks and the meeting was attended by about 35 people in total. The venue was the 17th floor of The Shard, in London, where Warwick Business School has a teaching facility, which they make available to other University of Warwick departments. The meeting was a great success, and we look forward to organizing other events with RSC-SMTG in the future. Details of the event are available at www.warwick.ac.uk/csc/events/confluid/

British Society of Rheology

Annual mid-Winter Meeting: "Active and Complex Fluids"

Durham, 17-18 December 2014.

Peter Olmsted

I had the pleasure of attending the 2014 British Society of Rheology mid-Winter meeting in Durham this December, organized by Suzanne Fielding. Every year this meeting has a specific theme, and the focus of this year's meeting was on active fluids, with the particular aim of enhancing collaboration between the active fluids and complex fluids communities. The first day focussed on active materials, in which energy sources within objects and swimmers in fluids, rather than pressures or boundary driven flows, lead to fascinating inter-actions and patterns. Increasingly this area is incorporating non-Newtonian fluids (e.g. when swimming in bodily fluids), which leads to non-trivial interactions and of course interesting rheology. The

`applications' of non-Newtonian rheology in interactions and collective behaviour is a fruitful counterpart to structure formation and rheology in passive filled materials such as fibre-reinforced composites and nanoparticles in polymer melts.

Ray Goldstein's (Cambridge) keynote lecture kicked off the pre-Holiday fest with a tour through a world of interesting fluid mechanics issues in cytoplasmic streaming (in plant cells), complete with wonderful historical anecdotes stretching back a few centuries. Vincent Martinez from Edinburgh studied how flagella swim in non-Newtonian fluids; for highly entangled solutions their helix speed departs from the Newtonian result, which they attributed to the nm-width helix exploring the microviscosity between the polymer mesh.

Ramin Golestanian's (Oxford) keynote lecture divided active matter into mechanically and chemically active matter, and culminated in a dramatic demonstration of the effects of long-range interactions induced by chemically active swimmers, which lead to unexpected clustering and phase diagrams. The was followed by Rhoda Hawkins' (Sheffield) invited lecture about how the splay instability in active materials leads to motion in active droplets. This was followed by talks from Armando Maestro (Cambridge) and Joakim Stenhammer (Edinburgh) about synchronization of colloidal rotors and phase behaviour of active Brownian particles.
The final active session was led by Ignacio Pagonabarraga from Barcelona, whose keynote lecture addressed Lattice Boltzman models for interacting squirmers, in which he showed how squirming activity can lead to clustering and phase separation-like behaviour. Alex Morozov spoke about swimming of waving sheets in viscoelastic liquids, Thomas Montenegro-Johnson stood in for Eric Lauga from Cambridge and spoke about cooperation and interactions among cilia in "Kupfer's Vesicle", and Tyler Shendruk (Oxford) described a computational method for using multiparticle collision dynamics to study active polar and nematic materials.

The second day saw a return to more "traditional' rheological topics. Professor Gareth McKinley from MIT was awarded the BSR's Gold Medal, and gave a typically masterful and scholarly lecture on the roles of extensional rheology in breakup of droplets and fluids, which spans phenomena such as sprays, sneezing, combustion, and atomization. On the way he demonstrated how "fractional calculus" can usefully model materials that interpolate between solids (stress proportional to strain or mathematically the zeroth order time derivative of strain with respect to time) and fluids (stress proportional to the first time derivative of strain). Such a materials was said to have a "springpot", to interpolate between spring and dashpot. Gareth played some rare audio recordings in which Scott Blair discussed the inceptions of the (US) Society of Rheology and the British Society of Rheology.

This was followed by Oliver Harlen's lecture on modeling droplet breakup in inkjet printing, in which droplets are a problem, rather than the feature of McKinley's lecture. David Hoyle presented a comprehensive study of necking instabilities in extension which generalizes and updates the familiar Considère criterion to the dynamic realm. The final session of the conference has a clear lecture from Ivo Buttinonoi (ETH Zürich) about rheology and shear banding in 2D colloidal monolayers at the air water interface, another exceptionally clear talk from Claire McIlroy from Leeds about elastic effects on coatings of fibers, and culminated with the Vernon Harrison Award Winner, Nafiseh Badieh from the University of Swansea, who spoke about linking structure and rheology infibrin-thrombin gels (which is crucial for blood clotting).

The stimulating meeting also had room for a poster session, with the Best Poster Award (sponsored by TA Instruments) going to Elsen Tjhung (Montpellier) for work performed while at Edinburgh, on a simple model for cell crawling. Finally, a Special Award was presented to Nick Hudson for his long and distinguished service to the British Society of Rheology. In his 25 years on council, he has been responsible for managing publications, particularly Rheology Abstracts.

Photo Caption (right): Prof. Gareth McKinley (MIT) receiving the BSR Gold Medal from Prof. Rhodri Williams (Swansea)

Forthcoming events

Advanced School in Soft Condensed Matter: “Solutions in the Spring”

Organised by the IOP Liquids and Complex Fluids Group with support from STFC, and Biological Physics, and Neutron Scattering Groups

13–16 April 2015, Loughborough University, Loughborough, UK

This will be the 9th in our very successful annual series of advanced schools. Confirmed lecturers include

- Daniel Bowron (ISIS) - Neutron Scattering and Disordered materials
- Ingo Dierking (Manchester) - Liquid crystals
- Rhoda Hawkins (Sheffield) - Biophysics
- Alexei Likhtman (Reading) - Polymer physics

Formal announcement and deadlines to follow soon

Group Prize:

LCFG Early Career Award 2013 – by Mike Allen

The group awards a biennial prize to an exceptional scientist in the early stage of their career, working in the broadly defined area of Liquids and Complex Fluids.

The recipient of the LCFG Early Career Award for 2013 was Dr Anita Zeidler, of the University of Bath. Dr Zeidler's work uses neutron scattering, with isotope substitution, to make significant contributions to our understanding of the fundamentals of the structure of liquids and glasses. Her current focus is on the behaviour of materials under extreme conditions of high pressure and high temperature, including water and geological fluids. The properties of these fluids are important for understanding the best practice for processing the greenhouse gas CO_2.

The prize was presented to Dr Zeidler by the current LCFG Chair, Professor Mike Allen, in February 2014, with the congratulations of the LCFG committee. A one-day meeting on "Structural Transformations in Amorphous Materials" was held in Bath in May 2014, focusing on some of the areas in which Dr Zeidler works. A report on this meeting appears elsewhere in this newsletter.

Previous winners of the LCFG Early Career award were James Adams (University of Surrey) and Dirk Aarts (University of Oxford).

LCFG Early Career Award 2015

We are now inviting nominations for the LCFG Early Career Award **2015.** The Council has defined “Early Career Awards” as applying to those individuals in the first 12 years of their career (allowing for career breaks), e.g. following the award of a first degree. Those eligible for IoP awards should be members of the Institute. For more information, please see the group website at

http://www.iop.org/activity/groups/subject/lcf/index.html

As chair of the Liquids and Complex Fluids group, I encourage everyone to consider suitable nominees for this award. It is a great opportunity to raise the profile of the individual's research, and the area of liquids and complex fluids in general. The group usually arranges a meeting, or a session within a larger meeting, at which the award winner is invited to present their recent results.

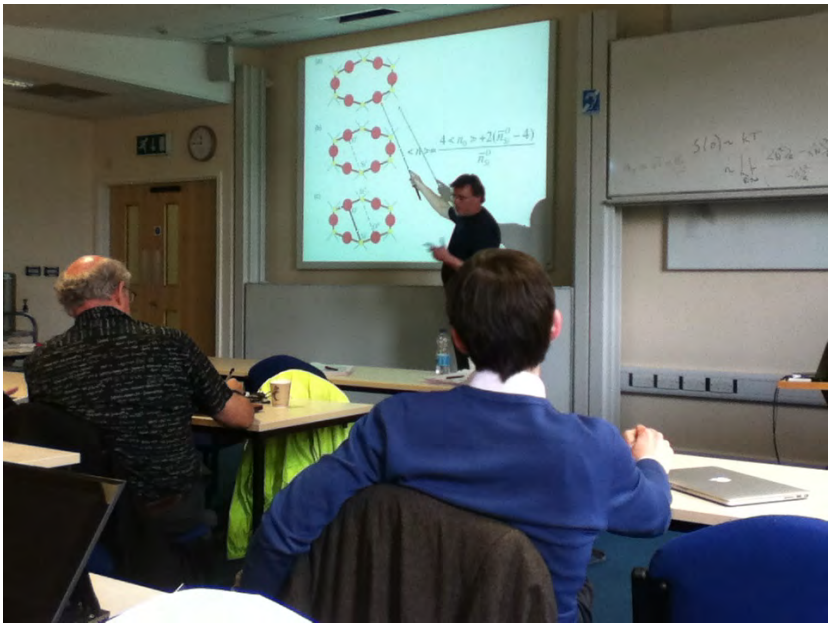
Report on the Structural Transformations in Amorphous Materials Meeting

Anita Zeidler

Physics Department, University of Bath, Bath, BA2 7AY

As part of receiving the IoP Liquids and Complex Fluids Early Career Award, I was invited to organise with Andrew Archer (Loughborough) a one-day meeting that was held at the University of Bath on the 29th May 2014. The meeting brought together experimentalists and theoreticians who are interested in the structural transformations that occur in amorphous materials, and the changes that are induced to their physical properties. The meeting welcomed around 50 participants from all around the world.

Before lunch, Mike Thorpe (Arizona State) gave a brief history of glass structure, Mark Wilson (Oxford) discussed network-forming materials in 2- and 3-dimenstions, and Stephen Elliott (Cambridge) explained how and why crystallisation occurs in phase-change memory alloys on the picosecond timescale. After lunch, Chris Tulk (Oak Ridge) compared methane clathrate hydrates with amorphous ice, Stefan Klotz (Paris) covered the recrystallisation of ices under pressure, and I described how silica transforms into an octahedral glass under pressure. Several excellent posters were also presented. The discussions were lively, and several new collaborative ventures were formed.



Mark Wilson caught between 2 and 3 dimensions

In the following, we will catch up on the activities of two LCFG group members. First, we present a contribution by one of our previous award winners from 2009, Dirk Aarts. Then we will continue with a contribution from Peter Olmsted, who has recently moved from Leeds to Georgetown (USA). Both have provided a summary of their current research interests below.

Research in the group of Dirk Aarts

Over the last five years part of my research has focused on the behaviour of colloidal liquid crystals, which I would like to highlight here. Colloidal liquid crystals have the typical colloidal advantage: the individual 'molecules' making up the liquid crystalline phases can be directly visualised and they move slowly enough to be studied at the single particle level. We have been using a wonderful colloidal system made up of (for us harmless) virus particles, namely *fd* virus, which has well-defined dimensions –set by nature–, a very large aspect ratio, and a controllable stiffness. Such systems shine light on packing and confinement problems, where the anisotropic nature of the particles adds to the complexity, and they allow to address fundamental questions about the applicability of continuum theories at microscopic scales. In order to address such questions, however, it turned out that although the bulk phases of these systems have been relatively well characterised, the elasticities of the nematic phase, for example, had not yet been determined. Traditional techniques using e.g. magnetic fields are difficult, but the coupling between geometry and particle orientation can actually be used to measure elasticity ratios [1]. It turned out that depending on the stiffness of the individual virus particles the splay-to-bend elasticity ratio is either around 1 or around 20. We then used this knowledge in exploring the effects of superconfinement [2], where confinement was down to a couple of rod lengths. For elasticity ratio 1 it was possible to write down analytical expressions for the elastic energy for rectangular confinement. This enabled us to determine the extrapolation length, which is the interplay between anchoring strength and elasticity. Microscopic numerical calculations furthermore suggested the existence of higher-energy metastable states with internal defects, which were indeed seen experimentally. We are currently exploring more exotic confinement geometries, which are experimentally challenging, computationally puzzling, and mathematically appealing!

More information can be found in the publications below; this also lists my collaborators from within Oxford (chemistry, physics and mathematics), within the UK, and within Europe, who are gratefully thanked for all their help.

[1] O.J. Dammone, I. Zacharoudiou, R.P.A. Dullens, J.M. Yeomans, M.P. Lettinga, D.G.A.L. Aarts, *Confinement induced splay to bend transition of colloidal rods*, Phys. Rev. Lett. 109, 108303 (2012)

[2] Alexander H. Lewis, Ioana Garlea, José Alvarado, Oliver J. Dammone, Peter D. Howell, Apala Majumdar, Bela M. Mulder, M. P. Lettinga, Gijsje H. Koenderink and Dirk G. A. L. Aarts, *Colloidal liquid crystals in rectangular confinement: theory and experiment*, Soft Matter (2014)

Research in the group of Peter Olmsted

GEORGETOWN UNIVERSITY

Institute for Soft Matter Synthesis and Metrology, Department of Physics

Georgetown University

Washington, DC

It's now been nearly a year since I left the UK after 20 years to return to USA, and I'm still getting used to the reverse culture shock! This week I got to experience pre-Halloween madness for the first time in 20 years. Whew!

I had a great time at Leeds in the Polymers and Complex Fluids Group in Physics, which later morphed into the Soft Matter Physics Group. I arrived while Tom McLeish was there, and thoroughly enjoyed the stimulating scientists in Leeds, the lively Soft Matter community in the North (Bradford, Durham, Manchester, Sheffield, Unilever, Hull, etc), and UK science generally. However, it was time to take up a new challenge, and this arrived in the form of the opportunity at Georgetown, which I availed myself of in January of this year.

Georgetown is most known as an excellent undergraduate university with Jesuit values, that has extremely strong programs in Law, Business, Public Policy, International Affairs, as befits its location in the nation's capital. [They also have a good, nationally-ranked, basketball team from time to time!]. The strongest traditional sciences have been in Medicine. In 2012, however, Georgetown benefitted from a large capital grant from the National Institute of Science and Technology (NIST) in Gaithersburg, Maryland, which led to a brand new Science Building, and the creation of the **Institute for Soft Matter Synthesis and Metrology (ISM)**, which would underpin current strengths and future growth in Soft Matter in Georgetown. Part of this new effort included hiring new staff, and I arrived, as well as simulator Professor Emanuela Del Gado from ETH Zürich. Together with other new and current faculty, we are now tasked with growing the science program and creating a new Soft Matter focus in the mid-Atlantic Region.

The Soft Matter effort includes three experimentalists in Physics (Jeff Urbach, Dan Blair, Ed Van Keuren), studying rheology, structure formation in soft matter in flow, nanoparticle synthesis, biopolymers, silk, active materials, emulsions, and neuron growth, among others. Del Gado simulates gels, glasses, cement, and cell monolayers as functional materials; and I continue to work on a mix of biophysics (membranes, proteins, and probably a move into active matter), and traditional soft matter dynamics (polymers, surfactants, liquid crystals). Chemistry `Softies' include Dick Weiss, who makes all manner of gelling materials and surfactant systems, Jong-In Hahn, who is

studying protein organization and structure at interfaces, and Steve Metallo, a disordered protein person. We are likely to hire another Soft Matter chemist in the near future. At the moment there are no formal Biological members of the ISM, but this will change soon, I'm sure! I have already found lots of interesting areas of common interest with local biologists, as well as medics in the Medical School.

The new building came with lots of shiny new equipment, including scanning probe and optical microscopies, AFM, STM, ITC, DSC, plasmon resonance, standard and confocal rheology, traction force microscopy, a 3D dynamic light scattering kit, and a clean room for nanofabrication. It houses Physics, Biology, and Chemistry across three floors, and all labs are tightly intertwined so that full chemical analysis and biological facilities (cell culture, protein prep, etc.) are available to all scientists. Rather than divide the science disciplines on different floors, we are jumbled together in a marvellous mixture; my hallway features, in order, a physicist (me), four biologists, three chemists, three physicists, and offices for physics and chemistry graduate students, as well as laboratories for all three disciplines.

The blend of experimental and theoretical interests is almost ideal, and there are any number of interesting projects to keep all of us working together. The DC area is blessed with many nearby institutions with strong Soft Matter groups. NIST is 35 minutes away in Gaithersburg, MD (its neutron facility, which I'm sure many in the UK have used, has several in situ neutron-flow instruments), and we have already started collaborations with them; the National Institute of Health is 20 minutes away in Bethesda; Johns Hopkins University is an hour away in Baltimore; the University of Maryland is 30 minutes away in College Park; and a bit farther afield are Delaware and the University of Pennsylvania (2 hours by train), which both have vibrant and strong soft matter efforts. A number of years ago Dan Blair at Georgetown initiated the Mid-Atlantic Soft Matter Meetings (MASM), which rotate twice-yearly among the local institutions. This ensures lots of opportunity to cross-fertilize, much like we did for many years with the Polymer IRC across Sheffield, Leeds, Durham and Bradford. A unique, and hopefully fruitful challenge will be to marry science with the very strong Public Policy and International Affairs programs at Georgetown. Indeed, this was a leading reason to come here, since very few other universities offer such direct possibilities for influencing major policy makers, as well as translating our accessible science to a very wide and hopefully appreciative (!) public.

The DC area is wonderful to live in, with lots of cultural events of all sorts just outside our door. If you do come through DC on your way to NIST, NIH, or a conference nearby, be sure to let us know and do stop by! We also hope to host events in the near future, so keep and eye out for them as well. In the meantime, I miss Black Sheep Ale, Wensleydale Blue, Yorkshire Gold, and other Yorkshire delights, so do be sure and bring some if you pass through ☺.

Group committee

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Members of the committee welcome suggestions and comments from group members to help facilitate the running and development of the group at any time.

What is the Liquids and Complex Fluids Group?

The Liquids and Complex Fluids Group aims to advance research into the liquid state of matter, complex fluids, and soft condensed matter by fostering collaborations between experimentalists, theorists and computer simulators working in these fields. Its scope encompasses both structure and dynamics from microscopic to mesoscopic and macroscopic length scales in systems ranging from simple liquids to all kinds of complex fluids and soft materials such as polymers, emulsions, gels, foams, colloids, liquid crystals, and their biological counterparts. The group correspondingly enjoys close links with the Polymer Physics and Biological Physics Groups of the IOP. Other topics covered include liquid mixtures and solvation phenomena, liquids and glasses under extreme conditions, confined liquids and fluids at interfaces, the glass transition and arrested states of matter (including the structure of glasses and amorphous solids), crystal growth in liquids, and self-assembly from solution.

This highly interdisciplinary field has industrial links to the pharmaceutical, petroleum and plastics, food and personal care industries, among others. The physical realisation of many ideal model systems is of interest to physicists interested in statistical mechanics, liquids, elasticity, flow behaviour and rheology, and non-equilibrium phenomena. Nevertheless, liquids and complex fluids are topics that are poorly covered in the traditional undergraduate curriculum so a distinctive aim of the group is postgraduate education, for example, via graduate schools aimed at the exposition of basic ideas that cut across the sub-disciplines of the field. Another aim is the development of new instrumentation for work on liquids and complex fluids at UK supported X-ray and neutron sources together with sophisticated data interpretation tools. The Group therefore benefits from interactions with the Neutron Scattering Group where appropriate. Collaboration with other liquid matter researchers is strengthened through links with the Faraday Division of the Royal Society of Chemistry (the interests of many physical and theoretical chemists encompass the topics covered by our group) and through co-operation with the Liquids Board of the European Physical Society.

This newsletter is also available on the web and in larger print sizes

The contents of this newsletter do not necessarily represent the views or policies of the Institute of Physics, except where explicitly stated.

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