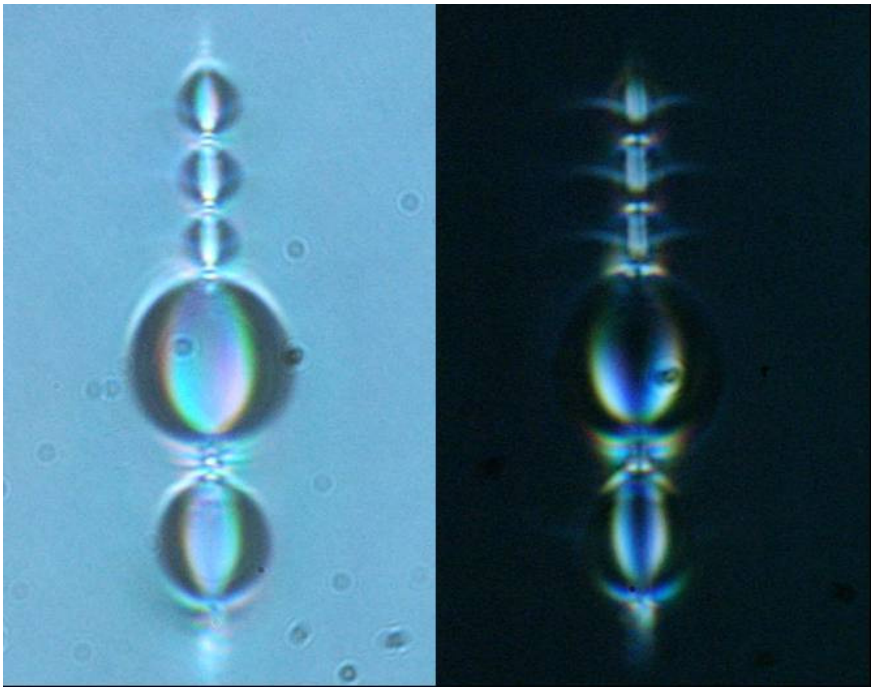
IOP Institute of Physics
Liquids and Complex Fluids Group

NEWSLETTER July 2008

Issue no. 3



Dipolar particles immersed in the aligned nematic liquid crystal 5CB. The nematic director is in the vertical direction. The particles have strong surface anchoring and are viewed with (right) and without (left) crossed polarisers (courtesy T. Wood, University of Edinburgh).

Contents

Chair's report

Welcome
The committee of the Liquids and Complex Fluids Group are pleased to welcome you to the 2008 group newsletter. This newsletter outlines the nature of the group, its interests and relevant activities.

What is the Liquids and Complex Fluids Group?
The Liquids and Complex Fluids Group aims to advance research on the liquid state of matter by fostering collaborations between experimentalists, theorists and computer simulators. Topics range from the structure and dynamics of pure liquids of all kinds to complex fluids such as emulsions, gels, foams, colloids, and liquid crystals, a scope that encompasses both microscopic and mesoscopic length scales from 'simple' liquids to soft condensed matter. The group also has strong interests in synthetic and bio-polymers, with close collaboration with the Polymer Physics and the Biological Physics groups. There are also strong ties with other liquid matter researchers through the Royal Society of Chemistry and the European Physical Society. 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.

A distinctive aim of the group is postgraduate education, particularly via our own graduate winter school, aimed at underpinning the education of the next generation of workers in the field. Another aim is the development of new instrumentation and analysis tools for work on liquids and complex fluids at UK x-ray and neutron sources.

2008 Group News

The Liquids and Complex Fluids group is now approximately two years old and we continue to be increasingly active and dynamic in providing a wide variety of events that we hope will be of interest to our members: conferences, one-day meetings, workshops and the post graduate winter school (see 'Forthcoming activities' below). In 2007 we have hosted large international meetings (such as 'Confined Fluids' at Coseners House, Abingdon) and smaller one day workshops (such as 'Simulations' at the IoP in London). Over the next few years these events will cover all the major areas of interest to our membership - experiment, theory and simulation: biological, chemical and physical. The committee hopes you will enjoy attending as many as you can and we will be pleased to hear of suggestions for future events from any member. Details of forthcoming meetings for 2008 and 2009 are included in the newsletter. As group chair on behalf of the entire group, I particularly wish to thank all those on the committee, and others, who have given a considerable amount time organising these activities for the benefit of everyone. Many thanks! We hope that as many members as possible will take full advantage of their group membership by attending as many meetings and workshops as they can, take advantage of bursaries available and nominate deserving individuals for our group prize.

The postgraduate 'Winter School', held at Jesus College, Cambridge in Jan 2008, continues to be a centrepiece of the group activities. As the report later in the newsletter shows, this very successful activity makes our group very attractive to a significant number of new young members. We hope that this initial contact will lead onto further participation by these members. Can I warmly encourage all graduate students to come to the next school in January 2009 in Leeds? Again, we are pleased to report that we have EPSRC support for a number of postgraduates whose work falls under the EPSRC remit. There is also support for LCFG group members, who can also apply for travel funding support. Places are already going fast, so book early to avoid disappointment! Both the last two years have been over subscribed.

I would also draw members attention to the AGM to be held at Hinsley Hall, Leeds, on Wednesday 7th Jan 2008 at 1.30pm. This short meeting is the ideal opportunity for members 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. At the last AGM, in Jan 2007, a number of committee members were re-elected, in accordance with IoP procedure. In this respect, as well as returning committee members, I would like to warmly welcome a new LCFG committee member, Edo Boek from Schlumbeger Cambridge Research. Edo has already become an active participant of the group helping to organise LCFG meetings. We hope he finds his time with us enjoyable and productive. I would also like to extend a warm thank you to Wilson Poon, who has stepped down as a member of the Committee. We

are grateful for his many contributions over the years, and for his enthusiastic lectures presented at the inaugural Winter School.

I look forward to meeting as many of you as possible at the group activities through the year.

Stuart Clarke, Chair,
Liquids and Complex Fluids Group

Annual General Meeting

Notice is hereby given that the Annual General Meeting of the Liquids and Complex Fluids Group will be held at 1.30apm on 7th Jan 2009 at Hinsley Hall, 62 Headingley Lane, Leeds, LS6 2BX. Please put this date into your diaries.

If you are interested in joining the Liquids and Complex Fluids Group Committee and would like more information about its work, or if you have any issues you would like to be raised at the annual general meeting, please contact the Honorary Secretary Cait MacPhee, (cait.macphee@ed.ac.uk). Nominations for committee members are invited and should be made to the Honorary Secretary before 7th December 2008.

Reports on recent group events

LCFG/EPSRC Winter School 2007

The Groups second Winter Postgraduate School, 'Solutions in the Snow' was held at Jesus College, Cambridge University, from 6th – 10th January 2008. This was a particularly successful event and the group warmly thanks everyone who played a part, particularly the 50 students and lecturers.

This School was the second in a three-year rolling programme to enable students in the field to get a firm grounding in all the key topics that underpin research in liquids and complex fluids (theoretical, experimental and computer simulation) through a series of lectures given by established specialists in the relevant field. We were particularly pleased that the School has grown significantly since last year; indeed we were obliged to turn students away having reached the maximum attendance.

Feedback on the 2008 school has been very positive. We are particularly pleased that all eligible students who replied have indicated that they intend to come to the next school (which will be held at Hinsley Hall, Leeds, Jan 5th – 8th 2009). As well as complimentary comments about the lecturers, the attendees particularly enjoyed meeting and networking with each other – such as the 'Scientific Speed Dating' where students had two minutes to tell another student about their work. This aimed to enhance their skills at presenting their work efficiently and effectively and also to get to know what their contemporaries are working on. The Cambridge College provided a beautiful setting and students enjoyed the 'Scientific Treasure Hunt' around the University Colleges including Newton's Rooms, and the original Cavendish Laboratory where the electron was discovered. A number of other new initiatives at the winter school this year included after dinner speakers in the evenings and we thank Peter Olmsted (Leeds) and Professor Mark Warner (Cambridge) for some beautifully illustrated and illuminating talks. The winner of the poster prize, part sponsored by '*Soft Matter*', was Mathius Kolle of Cambridge. Well Done Mathius!

PhD students and post docs with appropriate interests are strongly encouraged to come to the 2009 school in Leeds. We are pleased to be able to offer a limited number of free places to students with research interests falling under the EPSRC remit, arising from EPSRC support for the school, and to LCFG members. In addition members of the LCFG are also encouraged to apply for student travel bursaries (please see the IoP website for the on-line application form). More details of the school, grants and application forms are on the group website.

Again the speakers will be leaders in their fields - Matthew Turner (Warwick) on 'Membranes', Tom Mcleish (Leeds) on 'Rheology', Jacob Klein (Oxford) on 'Confined Fluids' and Nigel Wilding (Bath) on 'Simulation Approaches' – it looks like being a great event!!

Stuart Clarke
Cambridge

International Workshop - Recent Advances in the Understanding of Confined Fluids: From Superfluids to Oil Reservoirs

Fluids confined in small spaces are ubiquitous in the natural and industrial world, and are of great interest both for their fundamental physical properties and their practical importance. For example, understanding the mechanisms of interfacial phase transitions such as wetting, layering, roughening and surface freezing and melting and the effects of confinement on bulk transitions such as superfluidity, condensation, freezing and liquid crystalline ordering constitute major challenges. As a result, confined fluids are very topical, and are being studied extensively by a broad range of physicists, chemists, biologists, geologists and engineers.

The event was co-sponsored by the Liquids and Complex Fluids Group of IoP, in association with the EPSRC, the Centre for Molecular Structure and Dynamics (Science and Technology Facilities Council), Schlumberger Cambridge Research, and SoftComp, and held at Cosener's House in Abingdon on the 9th-11th of

January 2008. There were 62 participants including 25 graduate students and young scientists.

In the workshop we addressed a number of important contemporary questions concerning the fundamental properties of classical and quantum fluids in confinement. The meeting was very timely; there have been a number of recent advances in this area, deriving from major developments in experiment, theory and computer simulation. Some of the main scientific topics addressed included: Quantum Fluids, Simple Classical Fluids, Molecular and Complex Fluids, Solid-Liquid Interfaces, Phase Transitions, Crossing Length- and Time-Scales.

By general consensus, the Workshop was a tremendous success, with an extraordinarily high standard of presentation and discussion. We had excellent participation from young researchers, and many of our participants asked me to thank our sponsors. The meeting was also enhanced by the wonderful facilities and staff at the Cosener's House.

Neal Skipper
University College London

Group Prize

The Liquids and Complex Fluids Group Prize was this year awarded to Dr Dirk Aarts of the University of Oxford. Below, Dirk provides a flavour of his research. We would like to take this opportunity to congratulate the many exceptional candidates nominated for the award.

Interfaces are ubiquitous in nature and have attracted the interest of scientists for many centuries. Besides a fundamental drive much research in interfaces is motivated by technology and industry, where understanding interfacial behaviour is of key importance. We aim at a better understanding of interfaces by studying colloidal interfaces, for example emerging in fluid-fluid phase separating colloid-polymer mixtures. Here, the attractive depletion interaction may lead to a phase coexistence between a colloidal gas (poor in colloids, rich in polymers) and a colloidal liquid (rich in colloids, poor in polymers), which has all the characteristics of a molecular system, albeit with an interface characterized by an ultralow interfacial tension. As a result the thermal energy may displace the interface over distances up to a micrometer enabling us to directly observe the 'Brownian motion' of the interface, i.e. its thermal capillary waves, by means of a laser scanning confocal microscope.

Besides shining new light on the nature of fluid interfaces, we have shown that

such thermal noise plays an important role in hydrodynamic processes such as droplet coalescence and pinch-off. Recently, we have also demonstrated that the fluctuations play a critical role in the static problem of complete wetting.

Dirk Aarts, University of Oxford, winner of the 2008 Liquids and Complex Fluids Group Prize.

By considering typical length- and timescales of colloidal interfaces it becomes evident that colloidal systems are most compatible with microfluidics. Here, fluids are manipulated at a micro- or even nanoscopic scale, which raises new questions about the behaviour of liquids at increasingly small scales. Colloids can be used to answer such questions and at the same time microfluidics opens up a host of exciting opportunities to study the dynamic and static behaviour of fluid interfaces in confinement. We are currently focusing on a number of hydrodynamic instabilities, such as the Saffman-Taylor instability which occurs whenever a high viscosity fluid is displaced by a low viscosity one. Static problems, dealing with wetting and capillary condensation are also being targeted. For us in the lab it is an exciting time to be studying these issues: Experimentally, the combination between microfluidics, real space microscopy and colloidal model systems proves to be flexible and adequate. Theoretically, the experimental observations lead to challenging fundamental questions, in particular on the role of the ubiquitous fluctuations. Therefore, the timing of the prize couldn't have been better – it is the strongest possible encouragement and I feel deeply honoured.

Dirk Aarts
University of Oxford

Bursaries

The IoP provides support to students to contribute toward attendance at conferences through the Research Student Conference Fund (RSCF). Students may apply to receive up to £250 from the RSCF during the course of their PhD. Students may apply more than once up to a total of £250. Applications may be submitted directly to the IoP at any time but are considered on a quarterly basis. Applications should reach the Institute by: 1 March, 1 June, 1 September or 1 December. A decision will be made within eight weeks of the closing date. For further information, see the IoP website.

http://www.iop.org/activity/grants/Research_Student_Conference_Fund/page_26535.html

Forthcoming events

The committee encourages members to attend the variety of group conferences, workshops and schools organised by the group. In addition we welcome members' suggestions for further meetings or other activities. Please contact any member of the committee.

Phase separation and mixing

3 - 5 September 2008
Trinity College Cambridge

The meeting aims to address the important areas of phase separation and mixing in its many forms, and bring together workers interested in a wide range of systems, including polymers, colloids, emulsions, gels and lipid membranes, and those workers using a variety of novel techniques, such as optical tweezers and microrheology.

For more information see:
http://www.psm2008.org

Liquids and Complex Fluids Group Winter School Solutions in the Snow

5–8 January 2009
Hinsley Hall, University of Leeds, UK

In 2009 the lecturers and topics are:

- Matthew Turner (U Warwick): Biophysics
- Tom McLeish (U Leeds): Polymer Physics
- Jacob Klein (U Oxford): Complex Fluids at Surfaces and Interfaces
- Nigel Wilding (U Bath): Computer Simulations in Complex Fluids

For more information see
http://www.iop.org/activity/groups/subject/lcf/Winter_School/page_6569.html

Biological and Soft Matter

6 - 8 April 2009
University of Warwick, UK

Organised by the Liquids and Complex Fluids, Biological Physics and Polymer Physics Groups of the Institute of Physics.

Details of this meeting will be posted on the IoP website.

Faraday Discussion 144: Multiscale Modelling of Soft Matter

20 – 22 July 2009
University of Groningen, The Netherlands

Molecular modelling has become a standard element in the armoury of a chemist. The severe time and length scale limitations imposed by traditional methods (~10 nm or smaller, < 1 microsecond) has led in recent years to the development of techniques for multi-scale modelling (~100 nm or larger, > 1 microsecond).

The following themes will be included in the discussion:

- Polymers: including microphase separation and self-assembly
- Colloids: including the prediction of phases and phase diagrams
- Mesophases: including liquid crystals, novel phases, self-assembled structures and the links between molecular structure and bulk properties
- Membranes: including collective processes in lipid and surfactant systems
- Methodology for multiscale simulations: including methods for moving between scales and for bridging different time and length scales

For more information see: www.rsc.org/FD144

Further meetings of possible interest to members:

Faraday Discussion 141: Water - From Interfaces to the Bulk

27 - 29 August 2008
Heriot-Watt University, Edinburgh, United Kingdom
See: www.rsc.org/FD141

European Materials Research Society Fall Meeting

15-19 September 2008
Warsaw University of Technology, Poland
See: http://www.e-mrs.org/meetings/fall2008/

Jülich Soft Matter Days 2008

11-14 November 2008
Gustav-Stresemann-Institut, Bonn, Germany
E-mail: jsmdays@fz-juelich.de
See: http://www.fz-juelich.de/iff/jsmd2008/

British Society of Rheology Midwinter Meeting - "Rheology and Microstructure"

15 - 16 December 2008
School of Mathematics, University of Leeds, U.K.
See: http://innfm.swan.ac.uk/bsr/conf/view_page.php?page_id=38&conf=35

de Gennes Discussion Conference

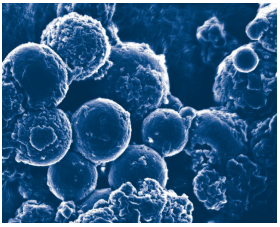
2 - 5 February 2009
Chamonix, France
See: http://www.degennesconference.fr/

Faraday Discussion 143: Soft Nanotechnology

15 - 17 June 2009
The Royal Society, London, UK
See: www.rsc.org/FD143

Thermodynamics 2009

22 - 25 September 2009
Imperial College, London
See: http://www.thermodynamics2009.org/



Event Preview: Phase Separation and Mixing Conference

Biologists, Physicists and Chemists: Come Forth and Mix

A three day conference entitled 'Phase Separation and Mixing' will be held on 3 – 5 September 2008 at Trinity College, Cambridge. This meeting, jointly organised by the Liquids and Complex Fluids Group (of the Institute of Physics), the Colloid and Interface Science Group (of the Royal Society of Chemistry) and the Colloid and Surface Chemistry Group (of the Society of Chemical Industry), aims to address important areas of phase separation and mixing in its many forms.

In particular, the event will bring together workers interested in a wide range of systems, including polymers, colloids, emulsions, gels and lipid membranes and those workers using a variety of novel techniques such as optical tweezers and microrheology.

Leading international and national speakers from academia have been invited to present on a wide range of key and prominent subjects, including the following topical areas;

- Biological Systems
- Theory of Colloid Behaviour
- Phase Separation in Thin Films
- Experimental Studies of Colloid Phase Behaviour
- Morphological Control Using Phase Separation
- Bulk Behaviour

The programme for the conference is available on the website at www.psm2008.org. Contributions for poster presentations are currently still being accepted and further information can be gained by contacting Faye Héran, the Conference Organiser directly on 020 7470 4908 or via email to faye.heran@iop.org. Poster abstracts should be a maximum of 300 words in length and may include up to three references; figures are not permitted. Please read the guidelines provided on the website prior to submission.

Organising Committee
Dr Alex Routh, University of Cambridge, UK
Dr Stuart Clarke, University of Cambridge, UK

IOP Institute of Physics

Liquids and Complex Fluids across the UK

Focus on Schlumberger Cambridge Research

Schlumberger is the leading oilfield services company: we bring our specialist skills to help with each stage of petroleum exploration and production. Many of the services that we offer involve complex fluids, and much work at Schlumberger Cambridge Research (SCR) is directed at understanding these fluids in order to improve their performance. Examples include drilling fluids, cement and fracturing fluids.

Drilling fluids are pumped around a well as it is drilled. They lift the rock cuttings to the surface and are viscous, preferably with a yield stress, to prevent cuttings sinking to the bottom of the well. Suspended barite particles give the fluid a high density, so that hydrostatic pressures within the well prevent its closure by earth stresses. Fluid tends to leak from the wellbore into surrounding porous rock, but solid particles (e.g. clays) and polymer microgels suspended within the drilling fluid create a low permeability filter cake at the rock surface [1], preventing deep invasion of filtrate into the rock pores.

When the well has been drilled, a steel tube (casing) is lowered into it, and cement is pumped into the gap between the casing and the rock face, sealing the rock. The cement displaces drilling fluid: it is therefore important to control the cement rheology and density in order to avoid viscous fingering or buoyancy-driven instabilities.

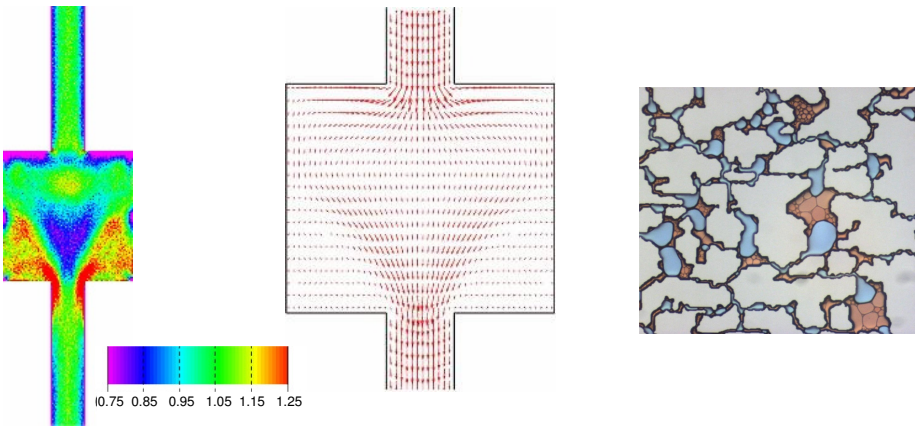
If the permeability of the reservoir is small, the rate of production of petroleum is low. One way to increase production is to pump a viscous fracturing fluid at high pressure into the well. The fluid creates a fracture in the rock. Sand particles, suspended in the fracturing fluid, are pumped into the fracture and hold the two sides of the fracture apart when the pressure is released. The packed bed of sand forms a high-permeability channel running hundreds of metres from the wellbore into the reservoir, and petroleum production is enhanced. The rheology of the fracturing fluid plays a major role in ensuring that proppant particles are carried far into the fracture.

Sometimes the chemistry of the fluids is important in its own right, e.g. drilling fluids must be formulated so as not to cause clay-rich shales to swell [1]. However, in general the fluid chemistry is chosen in order to provide the required mechanical properties, and the rheology of particle-laden fluids and pastes is a major concern of our laboratory. Often it is advantageous to design fluids with a yield stress, but if thixotropic gels become too strong, the pressure required to re-start flow after a period of rest can be excessive.

Some thixotropic fluids flow into rock pores but are difficult to remove after gelation. This may be useful: gelled fluids can block highly permeable rock formations, thereby ensuring that remedial treatments (e.g. acids) enter only other formations where the permeability is to be enhanced. Flow of complex fluids in porous media is therefore an important concern, as is the effect of rock surface wettability. Experiments in micro-models (figure 1) allow us to view the flow. Experiments in rock cores allow macroscopic variables (e.g. pressure gradients, saturations) to be measured, and core experiments combined with NMR allow both imaging (e.g. of inhomogeneous saturation) and flow measurement via measurement of diffusion propagators [2].

The recent introduction of thixotropic fluids based on surfactant micelles occasioned a major effort to characterize their rheology [3,4]. This can be modified if non-uniform shear rates within the rock pores cause migration and non-uniform concentration of micelles [4,5].

A laboratory such as SCR must also keep a watchful eye across a wide range of topics that are (or may become) relevant to the oilfield industry. Examples include rheometry of soft solids [6-8], and streaming potentials [9].



(a) (b) (c)

Figure 1. Computed concentrations of viscoelastic surfactant solution (VES) flowing (top to bottom) through an expansion and contraction [5], (b) measured VES velocities (after smoothing) [5]. (c) Distribution of air (blue) and oil (red) in a micromodel with geometry based on the pore space of a sandstone.

Finally, it is worth mentioning the other major scientific themes at SCR:

- Geophysics, based around seismic data acquisition and interpretation.

- Chemistry, e.g. fluid analysis downhole at high temperature and pressure.
- High Reynolds number multiphase flow, e.g. for flow measurement.
- Drilling and wireless telemetry, e.g. data collection downhole during drilling.

I thank my colleagues Valerie Anderson, Louise Bailey, Edo Boek, John Crawshaw, Edmund Fordham, Gerry Meeten, Silke Sheppard and Mikhail Stukan for their help in preparing this note.

John Sherwood,
Schlumberger Cambridge Research.

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7. A.J.W. ten Brinke, L. Bailey, H.N.W. Lekkerkerker, G.C. Maitland, Rheology modification in mixed shape colloidal dispersions. Part II: mixtures. Soft Matter, 4 (2008) 337-348.
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For further background reading on oilfield services, see recent issues of Oilfield Review: http://www.slb.com/content/services/resources/oilfieldreview/english.asp?

Liquids and Complex Fluids in the EU

Focus on Lisbon

Research in liquids and complex fluids in the Lisbon area is carried out by a number of groups, theoretical as well as experimental, based at Lisbon's three public universities and at Lisbon Polytechnic Institute. Together these comprise more than 30 permanent staff, plus a fluctuating population of occasional collaborators, MSc and PhD students, and postdocs.

Liquid crystals (*Centre for Condensed Matter Physics, Lisbon University, and the Centre for Theoretical and Computational Physics,*)

Research in this area encompasses small-molecule liquid crystals, polymer liquid crystals and liquid crystal colloids, studied by experiment and theory. Experimental investigations are focussed on the structure and dynamical behaviour of mesophases, using polarising Optical Microscopy, Digital Scanning Calorimetry, X-ray diffraction and NMR. Of particular interest are instabilities and patterns in liquid crystal cells; an understanding of the mechanisms at the origin of the biaxial nematic phase; the molecular dynamics of smectic and columnar phases; the electro-optical characterisation of new mesophases, especially those with technological applications; the development of new types of LC aligning substrates with confirmed technological applications. Recent hightlights include the identification of a biaxial nematic phase in an organosiloxane tetrapode (see figure 1), as well as structural and molecular ordering and dynamics investigations in liquid crystal dendrimers. This effort includes the actual synthesis of some of the compounds studied.

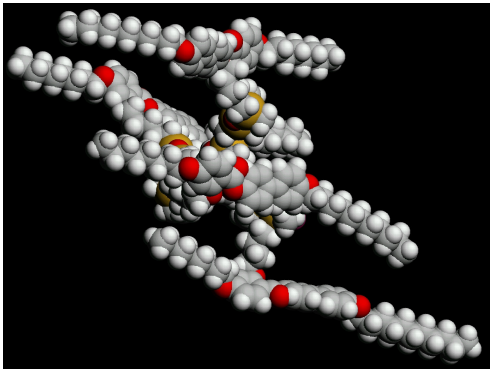

Figure 1. Siloxane tetrapode molecule, the building block of the thermotropic biaxial nematic phase (courtesy of C. Cruz, CFMC).

The theory/modelling work is centred on inhomogeneuos liquid crystals. New efficient finite-element methods with adaptive meshes have been developed to solve the Euler-Lagrange equations of the Frank and de Gennes free energies of non-uniform nematics, in various geometries and spatial dimensions. Highlights include a geometrically-controlled twist transition of a nematic confined by a sinusoidal grating with and without electrical field; a generalisedWenzel's law

for the effective contact angle of nematic droplets on rough substrates; the effective interaction between colloidal particles, or a colloidal particle and an interface immersed in liquid crystals; and the deformation of soft colloids in smectic membranes. Another, up till now separate, strand is density-functional theory of both symmetric and hybrid-anchored liquid crystal films.

Polymers and elastomers (*Centre for Condensed Matter Physics, Lisbon University; Centre for Materials Research, New University of Lisbon*; *and Institute for the Science and Engineering of Materials and Surfaces, Lisbon University of Technology*)

The main lines of research in polymers and elastomers are: theoretical and experimenttal investigations of structure-viscoelasticity relationships and constitutive equations for liquid crystalline polymers; computational fluid dynamics and rheology of low molecular mass and polymeric liquid crystals; the development of novel rheological techniques (rheo-NMR, rheo-optics, electro-rheology); and last, but certainly not least, the synthesis and characterisation of novel liquid crystalline polymers and elastomers from cellulose derivatives and from polyurethane, and the investigation of high added-value technological applications of these materials, e.g., controllable transparency windows for architectural and automobile applications. In addition to the above techniques atomic force microscopy, polarising optical microscopy and small-angle light scattering are also used.

Recent highlights include the observation of very regular and reproducible shear-

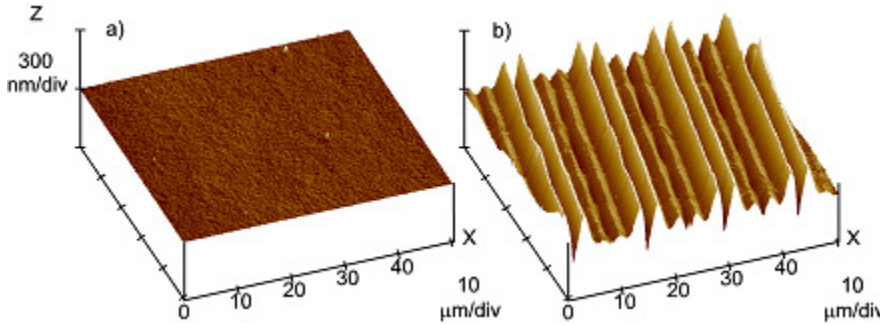

Figure 2. AFM images of a UV-irradiated urethane/urea film, before (left) and after (right) being subjected to a plane-stress uniaxial deformation (courtesy of P. Brogueira, ICEMS).

induced surface textures on urethane/urea elastomer films (see figure 2); rheological studies of several mesomorphic materials based on cellulose derivatives (APC and HPC); and the original identification of noise as a

fundamental cause of damping effects in the transient shear flow of tumbling nematic liquid crystals.

Further areas of active research include the study of fluid interfaces, the structure and properties of liquid foams, theoretical and simulation work investigating dipolar fluids, and research into the physics of biological systems focussing on protein folding and the relationship between protein folding, misfolding and disease using computer modelling and simulations.

Paulo Teixeira
School of Engineering, Lisbon Polytechnic Institute
and Centre for Theoretical and Computational Physics, Lisbon University

For more information see:

- Centre for Materials Research, New University of Lisbon, Polymeric and Mesomorphic Materials group:

  http://campus.fct.unl.pt/polinova/MPM%20Group.htm

- Centre for Condensed Matter Physics, Lisbon University, Liquid Crystals group:

  http://cfmc.cii.fc.ul.pt/research/clrmn/

- Centre for Theoretical and Computational Physics, Lisbon University, Condensed Matter Physics and Physics of Biological Systems groups:

  http://cftc.cii.fc.ul.pt/investiga.htm

- Centre for Structural Chemistry, Lisbon University of Technology, Statistical Mechanics and Experimental Thermodynamics group:

  http://cqe.ist.utl.pt/research/group3.php

- Institute for the Science and Engineering of Materials and Surfaces, Lisbon University of Technology, Advanced Testing and Evaluation of Materials group:

  http://www.icems.ist.utl.pt/advanced/advanced.html

- Membrane Separations and Processes group,

  http://www.icems.ist.utl.pt/chemistry/memb.html

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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.

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