15 - 17 APRIL 2019

UNIVERSITY OF LEEDS

BRITISH LIQUID CRYSTAL SOCIETY

2019 ANNUAL CONFERENCE

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BLCS
The British Liquid Crystal Society

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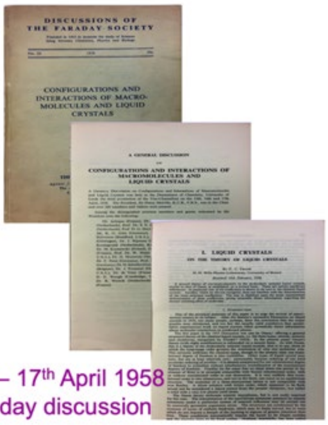
Welcome

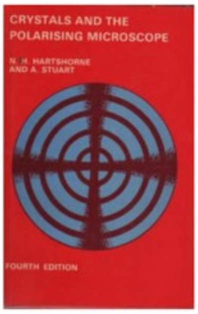
We are delighted and honoured to welcome you to Leeds for the 34th Annual Conference of the British Liquid Crystal Society, and the special Leeds Lyotropic Liquid Crystals Symposium.

After its founding in 1905, the University here is famous for its contribution to X-ray science and Biophysics, being the site for William Bragg and William Astbury. However, it also has a long association with Liquid Crystals too. It was here *precisely* sixty-one years ago, that the Faraday Society, a precursor of the Royal Society for Chemistry, hosted a discussion on Macromolecules and Liquid Crystals. Present at this meeting were Dr George Gray (a junior lecturer at Hull just 5 years after completing his PhD) and Prof Dr Gerhard Meier (from Freiberg, who gave a preview of the Maier-Saupe theory that was to be published the following year). The most cited work from that session was the seminal work by Sir Charles Frank on the elastic theory of liquid crystals, and the *disinclination*s (now disclinations) of the director field. Leeds liquid crystal work began in earnest when crystallographer Prof Norman Holt Hartshorne began using the polarising microscope to interpret the textures of these beautiful materials, writing the first textbook dedicated to Liquid Crystal Textures in 1974. The beauty of the microscopic textures inspired a young student of Hartshorne's to begin a life long devotion to liquid crystals at Leeds from the 1960s to this day. That student was John Lydon, who will continue the tradition that has lasted the thirty-four years of BLCS conferences and make the last presentation. Amongst John's contributions to the field was his seminal work on Chromonic Liquid Crystals, the type lyotropic liquid crystals formed from rigid hydrophoic discs. It is fitting that we precede the annual meeting with a special symposium on Lyotropic Liquid Crystals at which John will also speak. The 1980s and 1990s were a golden age of liquid crystal research at Leeds, when Professors Neville Boden and Richard Bushby were at the forefront of work on discotic liquid crystals worldwide, in particular on their semiconducting and one-dimensional conducting properties. They were the organisers for the BLCS conference the previous occasion it was held here in Leeds, 6th to 8th April 1998. Richard Bushby remains active at Leeds, and will make an invited presentation on the use of liquid crystal droplets as novel chemical and bio-sensors. In 2015, we (Mamatha Nagaraj and Cliff Jones) moved to the Soft Matter Physics Group at Leeds, together with Prof Helen Gleeson. The University has invested in dedicated characterisation and rapid prototyping cleanroom facilities for the group, which has now grown to include six post-doctoral fellows and fifteen post-graduate students. However, liquid crystal activities are not restricted to the Soft Matter Physics group, but in groups across the University, including Profs Steve Evans and Bushby in Molecular and Nano-physics, Dr Arwen Tyler and Prof Michael Rappolt in the School of Food Science and Nutrition, and Profs Andrew Bayly, Nick Warren, Sven Schroder and David York in The School of Chemical Engineering.



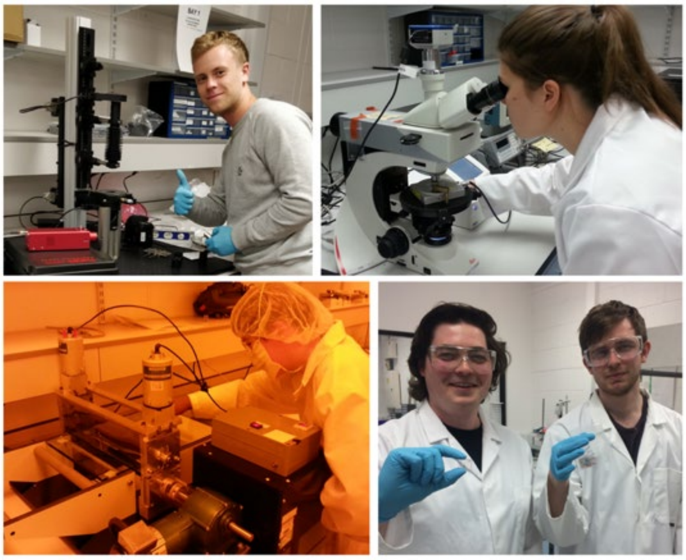
15th – 17th April 1958
Faraday discussion

N. H. Hartshorne (1974)
"Microscopy of Liquid Crystals"
Microscope Publications



N. H. Hartshorne and A. Stuart (1970)
"Crystals and the Polarising Microscope", Edward Arnold and Co.

Including both L3C and BLCS, there are 45 oral presentations; including Plenaries from Ivan Smalyukh (Boulder), Dirk Broer (Eindhoven), Gordon Tiddy (Manchester), John Seddon (Imperial) and Mark Wilson (Durham). We are particularly pleased to have Prof Pratibha from Bangalore become the first female recipient of the Sturgeon Lecture. Indeed, we are proud to have achieved a gender balance of nearly 30% female presenters to male



presenters. Contributors include USA, China, Netherlands, India, Czech Republic, Pakistan and Germany. In addition to hearing the presentation for the 2018 winner of the BLCS Gray Medal, Dirk Broer who was unable to make last year's conference in Manchester, we will also have this year's winner of the Gray Medal, Corrie Imrie from Aberdeen. The Cyril Hilsum Medal this year goes to Linda Hirst from Merced in the USA, and the Young Scientist is Markus Wahle from Leeds. We are sure that you will join us in congratulating these most worthy winners.

We would like to thank and acknowledge the following contributions to the organisation of this conference. Firstly, to Mariam Hussain, who suggested and organised the Leeds Lyotropic Symposium. Taking on such a large responsibility whilst completing her PhD thesis is a great challenge that she has managed admirably. Thanks also to PGR students Nikita Solodkov for the website design and management, and Nina Trbojevic, Pete Wyatt, Rowan Morris and Bart Czubak for help both before and during the conference, and to Faith Bonner, Glenys Bowles and the Meet-in-Leeds team for administrative help. We also wish to thank our sponsors, Merck, SID UK&I Chapter and the UK Fluids Network for their invaluable contributions that have enabled us to invite speakers from around the world.

Thank you for attending and we very much hope that you enjoy the Symposium and Conference as much as we have enjoyed preparing it for you.

Mamatha Nagaraj and Cliff Jones

BLCS 2019 Conference Organisers

Our Sponsors

On behalf of the British Liquid Crystal Society, we wish to thank the generosity of our sponsors, without whom this conference would not be possible:

Merck Chemicals Ltd.

Chilworth Technical Centre,

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Southampton, SO16 7QD, UK

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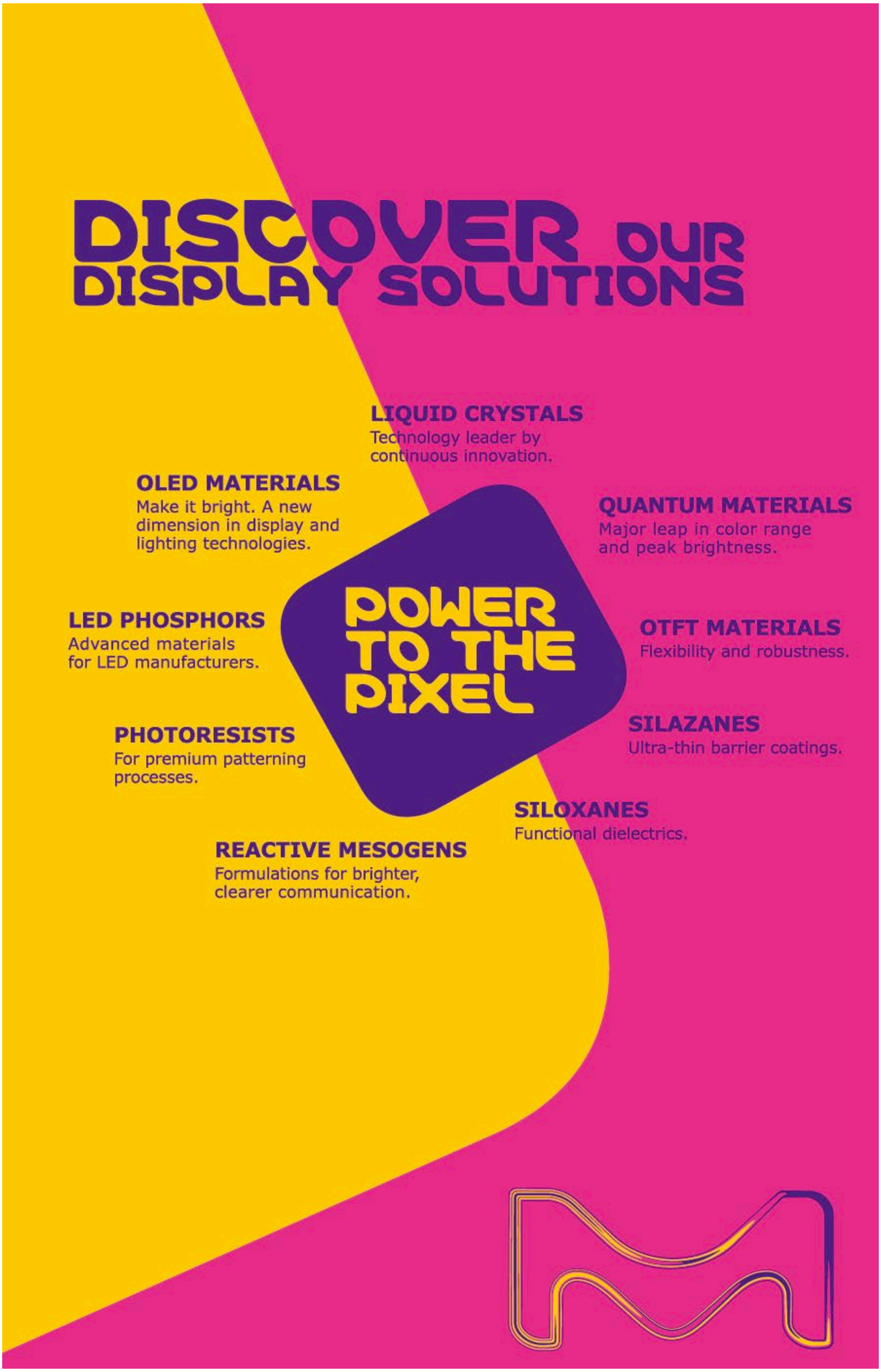


Conference and Venue Information

Organiser Contact Information

All enquiries and issues during the conference, should be directed to:

- BLCS2019@leeds.ac.uk
- **07540 323211**

Registration

The main registration times are between 08:30-09:00 and 11:30-13:40 on Monday 15th April.

The registration desk will also be available on Tuesday and Wednesday mornings from 8:30 for any late registrations and issues.

WiFi Access

Access via Eduroam (i.e. the UK HE institutional Wi-Fi system) is available in the venues being used for this event.

If you do not have access to Eduroam please let us know as early as possible so that either IT assistance or alternative arrangements can be made for you

Fire Alarms and First Aid

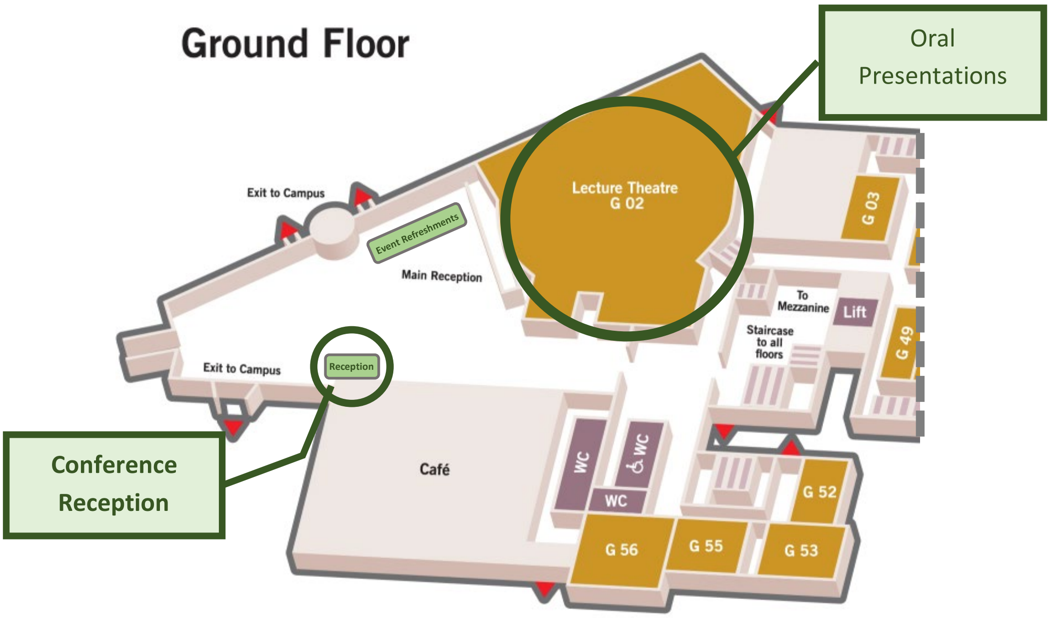
An announcement will be made at the beginning of each day if a planned fire alarm is expected. In the absence of any such announcement, should fire alarm sound you will be directed to your meeting point by conference staff and fire wardens.

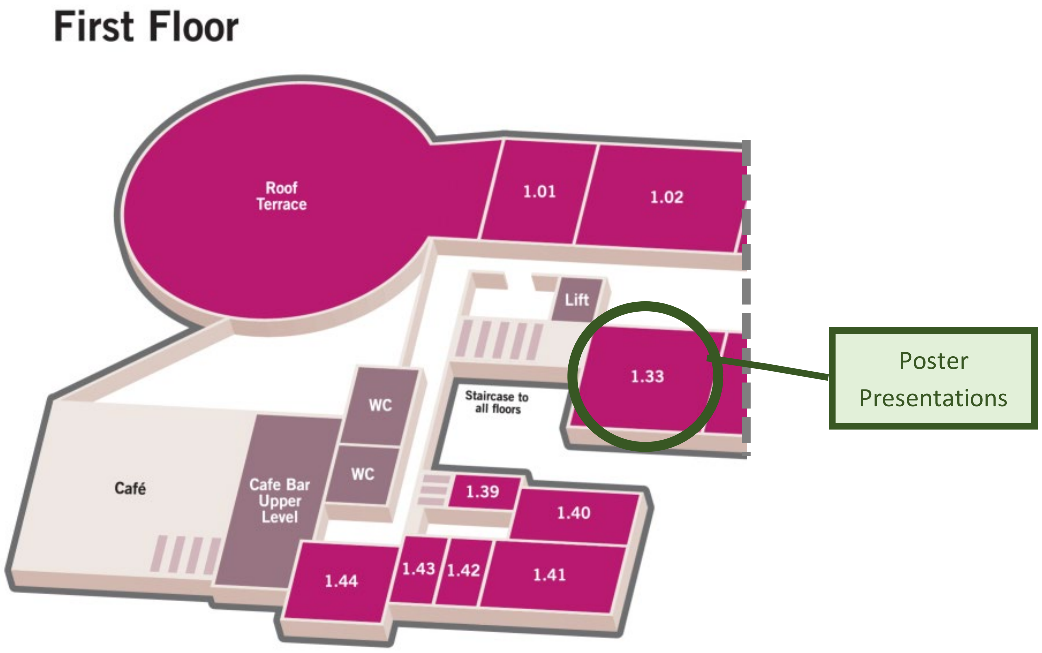
If you require any first aid during your attendance at the event, please contact Mrs Faith Bonner (07540 323211) for assistance or report to the Main Reception desk in the Maurice Keyworth Building.

Venue

The Maurice Keyworth Building is part of the Leeds Business School, the main foyer and associated café of which is usually busy.

All talks will be held in the Lecture Theatre (G.02), the Poster Session is in room 1.33, and all refreshments throughout the day will be provided in the main foyer.

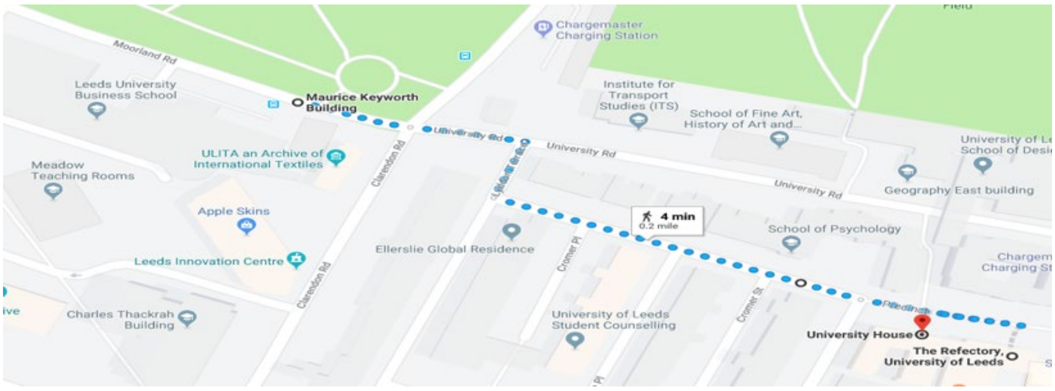




Evening Meals

The venue for both the dinner on Monday 15th and the formal Conference Dinner on Tuesday 16th is University House. Any specific dietary requirements should already have been communicated to us when you registered. And don't worry if you missed the deadline for choosing your preferred options for the formal dinner; the Chef will have made a decision for you based on any restrictions you have identified.

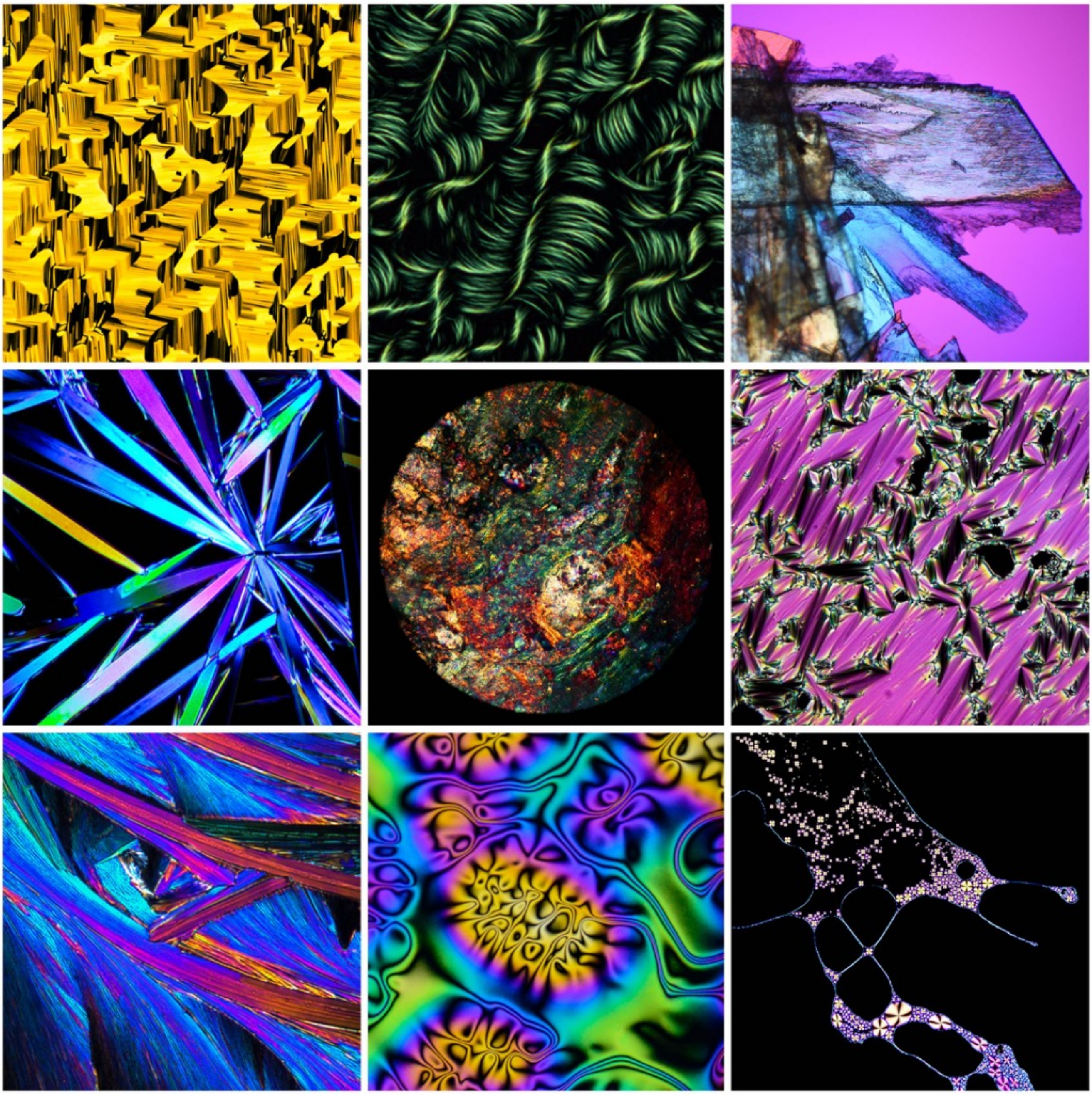
University House is a short walk from the Maurice Keyworth building.



Please ensure you identify yourself at the Conference Reception if you need lift access to the room in University House, which is on the second floor.

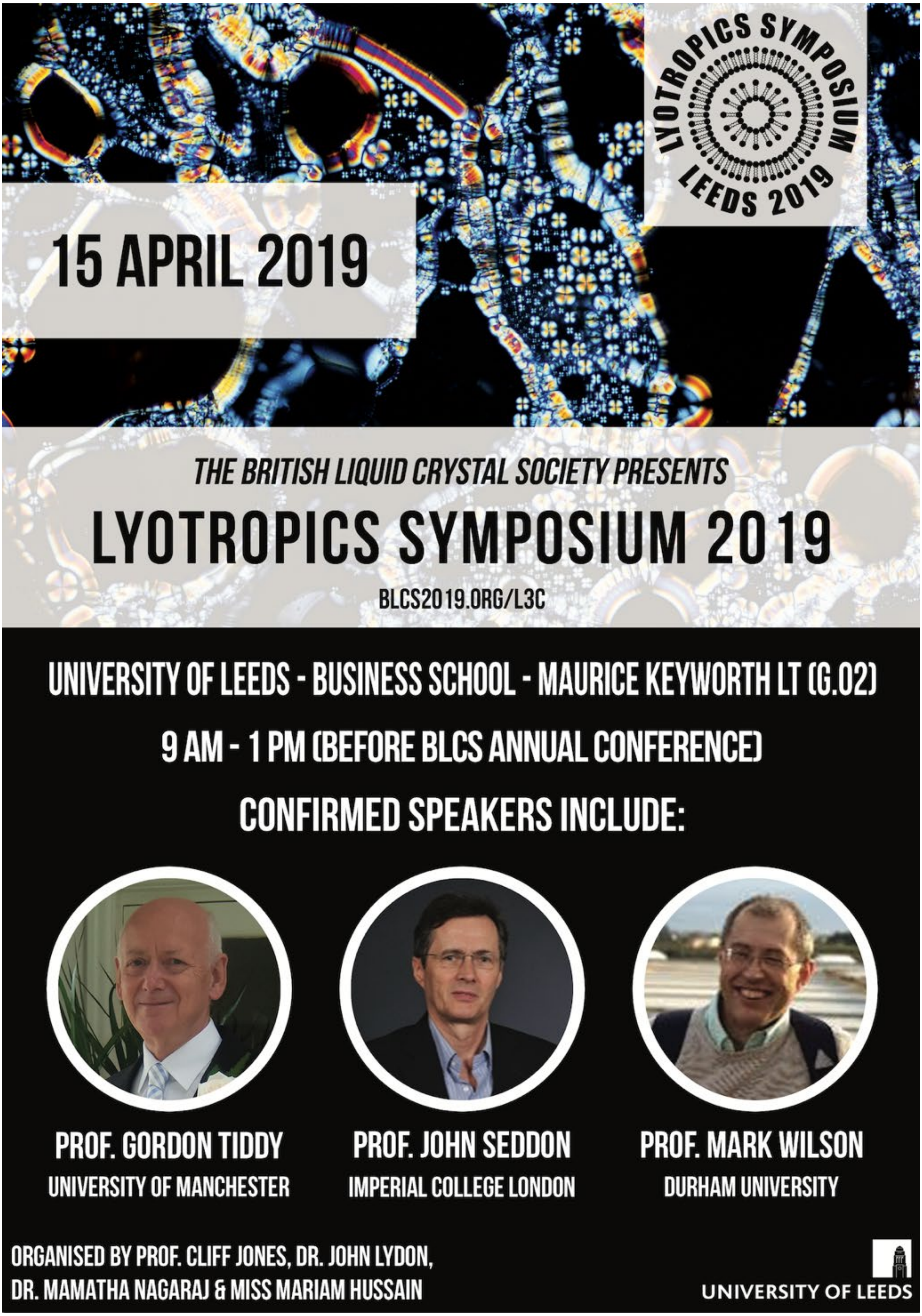
Website Gallery of LC Textures

Selection from Instgram-feed to BLCS2019 Website



Gallery Key

Cool 3D looking texture of an electrically switched bent-core liquid crystal in the smectic-c phase. 🍌 Applying electric fields to liquid crystals changes their orientation and it’s coupling to birefringence allows only specific wavelengths of light to pass through when viewed between crossed polarisers. Photo by Nikita Solodkov (78 likes, 11/04/19)	Self-assembly of filaments in a nematic liquid crystal doped with a bent-core mesogen creating a texture that is reminiscent of fibers in a carpet. Photo by Shajeth Srigengan (92 likes, 11/04/19)	CTAB crystals in water, assembling to form a structure that resembles a dinosaur’s head. 🔬🦖💎 Photo by Nikita Solodkov (152 likes, 11/04/19)
Crystallisation of a supercooled twist-bend nematic liquid crystal mixture, after 6 days at room temperature. 💎🌈🤩 Photo by Nina Trbojević (87 likes, 11/04/19)	View of a small world through a microscope 🌍🔬 The planet like pattern is formed when a responsive polymer is adsorbed onto the surfaces of surfactant-salt complexes, viewed through a cross polarising microscope. Can you find the scary face? 👻 Photo by Mariam Hussain (123 likes, 11/04/19)	Smectic liquid crystal texture that resembles a man riding horseback in the rain, observed through a cross polarising microscope 🔬🐎🌧 Cooling of an RM mixture from the nematic phase produced this colourful and funky smectic texture. Photo by Sarah Whitehouse, Merck Chemicals Ltd (103 likes, 11/04/19)
Supercooling twist-bend nematic liquid crystals to room temperatures often results in uniquely beautiful textures and colour combinations from the crystallisation process. Photo by Nina Trbojević (55 likes, 11/04/19)	Thin layer of a nematic liquid crystal flowing over glycerol. 🌈🔬🤩 Due to the anisotropic nature of liquid crystals, the flow results in a continuously evolving rainbow pattern, when observed through a cross polarising microscope. Photo by Nikita Solodkov (142 likes, 11/04/19)	*"We should show life neither as it is, nor as it should be, but as we see it in our dreams"* (Anton Chekhov, The Seagull). The photograph shows a collection of nematic liquid crystal droplets dispersed in water, viewed through a cross-polarising microscope. The convergence of the boundary around it (accidentally) forms a pattern resembling a seagull's landing. 🐦 Photo by Nikita Solodkov (121 likes, 11/04/19)



LYOTROPICS SYMPOSIUM
LEEDS 2019

15 APRIL 2019

THE BRITISH LIQUID CRYSTAL SOCIETY PRESENTS

LYOTROPICS SYMPOSIUM 2019

BLCS2019.ORG/L3C

UNIVERSITY OF LEEDS - BUSINESS SCHOOL - MAURICE KEYWORTH LT (G.02)

9 AM - 1 PM (BEFORE BLCS ANNUAL CONFERENCE)

CONFIRMED SPEAKERS INCLUDE:

PROF. GORDON TIDDY
UNIVERSITY OF MANCHESTER

PROF. JOHN SEDDON
IMPERIAL COLLEGE LONDON

PROF. MARK WILSON
DURHAM UNIVERSITY

ORGANISED BY PROF. CLIFF JONES, DR. JOHN LYDON,
DR. MAMATHA NAGARAJ & MISS MARIAM HUSSAIN

UNIVERSITY OF LEEDS

Speaker Biographies

Professor Gordon Tiddy

School of Chemical Engineering and Analytical Science, University of Manchesster

Professor Gordon Tiddy spent 29 years employed by Unilever research, where he developed and applied a unique understanding of surfactant phase behaviour, particularly with respect to liquid crystal related structures. In Unilever, many new products were commercialised based on the scientific underpinning which Gordon provided, including detergents, toothpastes and conditioners. In 1996 Gordon left Unilever and took up the chair of Formulation Engineering within the School of Chemical Engineering and Analytical Sciences at the University of Manchester. He now holds an Emeritus chair, but is still research-active with collaborations in the UK and around the World.

Dr Arwen Tyler

School of Food Science and Nutrition, University of Leeds

Dr Arwen Tyler joined the School of Food Science and Nutrition as a University Academic Fellow and Group Leader in September 2016, having previously been a PDRA and a Fellow at Imperial College London. Her research focuses on understanding the lipid molecular features that preferentially drive the formation of various lyotropic lipid phases or tune their sizes and to ultimately develop engineering rules to tailor these structures for particular biomedical and biotechnological applications.

Professor John Seddon

Chemisstry Department, Imperial College, London

John Seddon is Professor of Chemical Physics and Deputy Head of the Chemistry Department at Imperial College London. His research interests lie in the areas of lipid physical chemistry, membrane biophysics and soft matter self-assembly. Since 2013, he has been Secretary of the European Biophysical Societies' Association, which represents 31 national Biophysics Societies, spanning Europe and the Middle East. He has specific interests in the phase behaviour of lyotropic systems including phospholipids, glycolipids, carbohydrate surfactants, and structure of cubic phases, as well as the effect of hydrostatic pressure on the structure and stability of lyotropic crystalline phases. Since 2017, he has been the Chair of the RSC Faraday Standing Committee on Conferences.

Professor Mark WIlson

Department of Chemisstry, Durham University.

Mark Wilson is a Professor in the department of chemistry at Durham University. He mainly carries out research using classical molecular dynamics and Monte Carlo simulation methods to study problems in soft matter chemistry, concentrating on materials that are ordered on the nanoscale, including liquid crystals, colloids, polymers, amphiphilic molecules and proteins. In the field of liquid crystals, he has carried out some of the key atomistic and coarse-grained simulation modelling studies to understand both thermotropic and lyotropic liquid crystals at a molecular level, providing new understanding of both structure and dynamics.

Dr John Lydon

Biological Sciences, University of Leeds

Dr John Lydon started his research career with PhD on single-crystal X-ray structure determination. After his PhD, he spent a post-doc. year in Pittsburgh and then returned to Leeds to help start up the undergraduate course in Biophysics. The work of his colleagues studying the structures of insect cuticle and plant cell walls caused him to form the opinion that many of the self-ordering properties of biological materials are dominated by the presence of transient liquid crystalline phases. He went on to explore this opinion in great detail at Arizona, Unilever, Hull, Glasgow, and Manchester, before moving back to Leeds. He has continued to give lectures about the biological relevance of liquid crystals. His most important work was the pioneering study of chromonic phases, with Terri Attwood. He invented the name but it was to be ten years before the concept was accepted used. Similarly, he characterised discotic phases with John Bunning.

Programme

Monday 15th April 2019

DAY 1	Leeds Liquid Crystal Symposium	Page
08:15	***Registration***	
09:00	**Welcome:** **Cliff Jones** and **Mariam Hussain**	
09:10	Speaker 1: **Gordon Tiddy**, University of Manchester *Lyotropic Liquid Crystals: Surfactants.*	12
09:50	Speaker 2: **Arwen Tyler**, University of Leeds *Inverse Lyotropic Liquid Crystalline Bicontinuous Cubic Phases*	13
10:20	***Break & Refreshments***	
10:40	Speaker 3: **John Seddon**, Imperial College, London *Inverse Micellar Lyotropic Liquid-Crystalline Ordered Phases of Lipids and Surfactants*	14
11:10	Speaker 4: **Mark Wilson**, Durham University *Self-assembled nanostructures and phases formed from conventional and non-conventional amphiphiles: insights from molecular simulations*	15
11:40	Speaker 5: **John Lydon**, University of Leeds *The sickle Cell – a chiral tactoid with a skin*	16
12:00	**Closing Comments**	

Attendees at L3C Symposium are invited to join delegates from the BLCS 2019 conference for lunch, providing an excellent networking opportunity.

L3C: Leeds Lyotropic Liquid Crystals Symposium **Lecture 1**

Title:

Lyotropic Liquid Crystals: Surfactants

Presented by:

Gordon J. T. Tiddy

School of Chemical Engineering and Analytical Science, Faculty of Science and Engineering, The University of Manchester, Oxford Road, Manchester M13 9PL, UK

Lyotropic liquid crystals are formed by dissolution of a solute in a solvent (usually water) at concentrations above the isotropic solution. There are three major classes of lyotropic liquid crystals: polymeric, chromonic and surfactant. Polymeric mesophases are formed by rigid polymers that become ordered due to repulsion forces between the molecules. “Chromonic” mesogens self-associate in solution from inter-molecular attractions to form aggregates which then interact via repulsion forces to give ordered phases. Surfactants, the subject of this contribution, again form self-association aggregates called micelles. These again interact via repulsion forces to give ordered phases.

By far the most common lyotropic mesophases are those formed by surfactants in water. This talk will first discuss the self-association of surfactants via the hydrophobic effect to form micelles of different shapes (spheres, rods and discs). This occurs at a sharp concentration called the critical micelle concentration (cmc). Then we describe how micellar properties such as the cmc and micelle shape are determined by the detailed chemical structure of the surfactant. On increasing surfactant concentration a series of liquid crystal phases form with decreasing surface curvature [cubic (small micelles), hexagonal, (bicontinuous-cubic), lamellar]. A brief description of the forces that determine liquid crystal formation will be given (electrostatic, hydration, steric). All surfactants with water-continuous phases follow this pattern of behaviour.

Surfactants can dissolve in oils (usually with some water) to form reversed micelles. Here the driving forces are attractive and the reversed cmc process is gradual. Otherwise the phases formed (reversed hexagonal etc.) are broadly similar to the water-continuous phases. There is no overall sequence for the occurrence of the mesophases as there is for water-continuous phases.

The liquid crystals described above are in a “liquid-like” state, the only order is that imposed by the micelle surface and the organisation of micelles on a lattice. But there is an important group of structures termed gel phases where short range order occurs in the hydrocarbon chains. These occur because a similar state occurs with alkanes. Linear alkanes with C_n, $n > 20$, do not melt directly to a liquid, but first form a rotator phase (a thermotropic liquid crystal). Long chain surfactants behave similarly; forming layer structures with ordered alkyl chains having rotational freedom. These “gel” phases can also show the usual surfactant properties, for example they are excellent emulsifiers.

In this brief overview it is impossible to include all surfactant properties. Surfactant mixtures, added electrolytes, fragrances, physical properties, rheology, NMR, X-rays, DSC, microscopy all merit attention. The above framework gives a basic description on which other data can be built.

L3C: Leeds Lyotropic Liquid Crystals Symposium **Lecture 2**

Title:

Inverse Lyotropic Liquid Crystalline Bicontinuous Cubic Phases

Presented by:

Arwen I. I. Tyler

School of Food Science and Nutrition, University of Leeds

Lipids exhibit rich polymorphism in water and can adopt phases that may possess 1- (lamellar sheets), 2- (hexagonally arranged cylinders) or 3-dimensional periodicity (cubic phases). One of the most structurally exotic categories of phases adopted by lipids and surfactants are the inverse bicontinuous cubic phases. The most common inverse bicontinuous cubic phases are based on the “diamond”, the “primitive” and the “gyroid” minimal surfaces and are formed by draping a continuous bilayer on such minimal surfaces, resulting in two interwoven yet unconnected, water networks.

Lipid bicontinuous cubic phases have attracted enormous interest as biocompatible scaffolds for use in a wide range of applications including membrane protein crystallisation, drug/bioactive delivery, biosensing and as structure-directing templates for high surface area devices. Additionally, dispersions of such structures as sub-micron sized particles (‘cubosomes’) are candidates for engineered drug delivery systems, where biologically active contents can be encapsulated and later released. Finally, oriented nanostructured films can also be prepared for applications such as substrate-mediated delivery.

One of the major bottlenecks that have hindered exploitation of these structures is an inability to create targeted highly swollen bicontinuous cubic structures with large and tunable pore sizes. In contrast, cubic structures found in vivo have periodicities approaching the micron scale. Here we present an overview of bicontinuous cubic phases, their characterisation and applications as well as our efforts to develop engineering rules to control their structural properties, swelling and functionalisation.

L3C: Leeds Lyotropic Liquid Crystals Symposium **Lecture 3**

Title:

Inverse Micellar Lyotropic Liquid-Crystalline Ordered Phases of Lipids and Surfactants

Presented by: **John M. Seddon**

Chemistry Department, Imperial College London, UK

Lyotropic liquid crystals of 1-, 2-, or 3-dimensional periodicity spontaneously assemble when lipids are mixed with solvent under various conditions of temperature, pressure and hydration. There are two quite distinct types of inverse cubic phases: *bicontinuous* ones based on underlying periodic minimal surfaces, and *discontinuous* ones based on simple or more complex packings of discreet inverse micelles [1].

We have previously shown that by addition of weakly-polar amphiphiles such as diacylglycerols to phospholipids, we can tune the interfacial curvature to be strongly inverse, leading to the formation of a discontinuous cubic phase of spacegroup Fd3m, with a structure based upon a complex close packing of two types of quasi-spherical inverse micelles. We have investigated the effect of hydrostatic pressure on the structure and stability of this phase, and have discovered a number of novel effects [1]. We have also studied the structure of this phase by contrast variation neutron scattering, and have been able to demonstrate that the more weakly amphiphilic diacylglycerol component is preferentially located in the smaller, more highly curved inverse micelles (A.I.I. Tyler, unpublished data).

We have dispersed this bulk Fd3m phase into 'micellosomes' by sonication in the presence of the amphiphilic block copolymer F127, and have used x-ray diffraction to compare their structure to that of the bulk Fd3m cubic phase (A.M. Sartor et al., unpublished data).

Some time ago [2] we discovered a lyotropic phase of space group $P6_3/mmc$, whose structure is based upon a 3-D hexagonal packing of quasi-spherical inverse micelles, in a hydrated mixture of dioleoyl phosphatidylcholine, dioleoyl glycerol, and cholesterol. This phase is expected to have a greater chain packing frustration than the Fd3m cubic phase, and it appears that the cholesterol is able to relieve the chain packing frustration within the hydrophobic region of this phase, allowing the $P6_3/mmc$ phase to form.

We also discovered a novel inverse ribbon phase in the branched-chain polyoxyethylene surfactant system tetradecyloctadecyl-tetraoxyethylene ether ($C_{14}C_{16}EO_4$) in excess water [3]. This phase is stabilised by the application of hydrostatic pressure. The lattice parameters of the inverse ribbon phase were found to vary with pressure, with the structure becoming increasingly distorted away from 2-D hexagonal symmetry ($b/a = \sqrt{3}$) with increasing pressure.

[1] Shearman, G.C., Tyler, A.I.I., Brooks, N.J., Templer, R.H., Ces, O., Law, R.V. and Seddon, J.M.,

Ordered micellar and inverse micellar lyotropic phases. *Liquid Crystals* (2010), **37**, 679-694.

[2] Tyler, A. I. I., Shearman, G. C., Brooks, N. J., Templer, R. H., Ces, O., Law, R. V. and Seddon, J. M, Hydrostatic pressure effects on a hydrated lipid inverse micellar cubic phase. *PCCP* **13**, 3033 (2011).

[3] Shearman, G.C., Tyler, A.I.I., Brooks, N.J., Templer, R.H., Ces, O., Law, R.V. and Seddon, J.M., A 3-D hexagonal inverse micellar lyotropic phase. *J. Am. Chem. Soc.* **131**, 1678 (2009).

[4] Shearman, G.C., Brooks, N.J., Tiddy G.J.T., Sztucki, M., Templer, R.H., Law, R.V., Ces, O. and Seddon, J. M., *Soft Matter* (2011) **7**, 4386-4390.

L3C: Leeds Lyotropic Liquid Crystals Symposium **Lecture 4**

Title:

Self-assembled nanostructures and phases formed from conventional and non-conventional amphiphiles: insights from molecular simulations

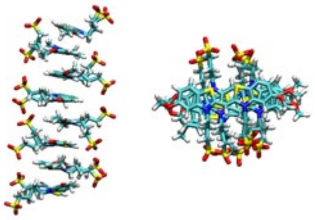
Presented by: **Mark R. Wilson**

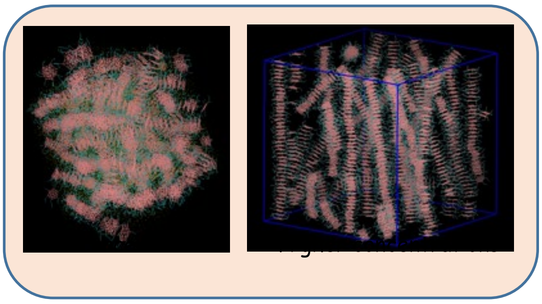
Department of Chemistry, Durham University, Lower Mountjoy, Durham, DH1 3LE

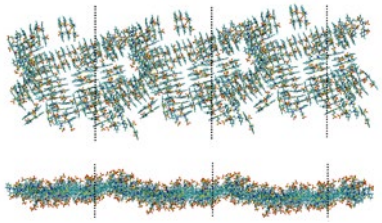
Other authors: Martin Walker and Romnik Thind
Department of Chemistry, Durham University, Lower Mountjoy, Durham, DH1 3LE

Molecular simulation has become a powerful tool for studying the behaviour of amphiphilic molecules. At the "atomistic level", we can use simulation to study and understand the self-assembly process in solution: with simulation providing a link between molecular structure and the shape of aggregates that form. At a (slightly) more coarse-grained level, we can use simulation to predict how aggregates self-organise to form lyotropic liquid crystal phases, and understand how this is influenced by enthalpic and entropic effects, including hydrophobic interactions.

This talk provides examples showing how simulation can be used to unravel the structure of complex aggregates. We show results for both conventional and non-conventional amphiphiles; concentrating on the interesting structures that arise from the self-assembly of chromonic mesogens.







References

1) R. Thind, M. Walker, M. R. Wilson. Molecular simulation studies of cyanine-based chromonic mesogens: spontaneous symmetry breaking to form chiral aggregates and the formation of a novel lamellar structure. *Adv. Theory Simul.* (2018), 1800088 (1-8).

2) M. Walker, M. R. Wilson. Formation of complex self-assembled aggregates in non-ionic chromonics: dimer and trimer columns, layer structures and spontaneous chirality. *Soft Matter* (2016), 12, 8588.

3) A. Akinshina, M. Walker, M.R. Wilson, G. J. T. Tiddy, A. J. Masters, and P. Carbone. Thermodynamics of the self-assembly of non-ionic chromonic molecules using atomistic simulations. The case of TP6EO2M in aqueous solution. *Soft Matter* (2015), 11, 680.

4) M. Walker, A. J. Masters, M. R. Wilson. Self-assembly and mesophase formation in a non-ionic chromonic liquid crystal system: insights from dissipative particle dynamics simulations. *Phys. Chem. Chem. Phys.*(2014), 16, 23074.

5) Molecular Order in a Chromonic Liquid Crystal: A Molecular Simulation Study of the Anionic Azo Dye Sunset Yellow. Fatima Chami and Mark R. Wilson, *J. Am. Chem. Soc.* (2010), 132, 7794.

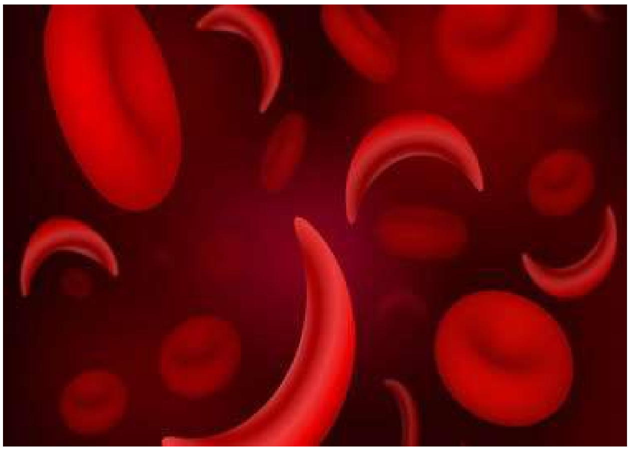
L3C: Leeds Lyotropic Liquid Crystals Symposium **Lecture 5**

Title:

The sickle Cell – a chiral tactoid with a skin

Presented by: **John E. Lydon**

Biological Sciences, University of Leeds, Leeds, LS2 9JT



Over the last century and a half, tactoids have been encountered repeatedly in both living and in organic systems. A notable early example is the discovery by Zocher1, in 1925, of Zeppelinshaped droplets separating out of suspensions of vanadium pentoxide1. They have subsequently been observed in many colloidal lyotropic sols of linear polymers including those of tobacco mosaic virus, synthetic polypeptides and cellulose nanocrystals2.4. In living systems, similarly-pointed droplets are seen in the silk-producing glands of insects and spiders - but, by far the best-known example is the aberrant form of red blood cells found in patients suffering from sickle cell anaemia. These tactoids, however, do not have a pure Zepellin-shape with cylindrical symmetry. They are curved like the blade of a sickle - and this is seen as a consequence of the chirality of the cell contents. Under certain circumstances it is energetically favourable for the twist in a structure to relax into a gyre - where the straight-line axis of twist becomes a corkscrew shape of a gyre. It suggests that the curve of the sickle cell can be regarded in this way - giving an interesting geometrical converse to the way in which curved molecules can give rise to helical assemblies in twist-bend structures.

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BLCS
2019
LEEDS

15 - 17 APRIL

THE BRITISH LIQUID CRYSTAL SOCIETY

ANNUAL CONFERENCE 2019

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UNIVERSITY OF LEEDS - BUSINESS SCHOOL - MAURICE KEYWORTH LT (G.02)

INVITED SPEAKERS INCLUDE:

PROF. DICK BROER
EINDHOVEN UNIVERSITY
OF TECHNOLOGY

PROF. PRATIBHA R.
RAMAN RESEARCH
INSTITUTE BANGALORE

PROF. IVAN SMALYUKH
UNIVERSITY OF
COLORADO BOULDER

STARTS AFTER NEW LYOTROPICS (L3C) SYMPOSIUM

ORGANISED BY PROF. CLIFF JONES AND DR. MAMATHA NAGARAJ

UNIVERSITY OF LEEDS

Plenary Speakers

Professor Ivan I. Smalyukh

University of Colorado, Boulder, USA

Ivan I. Smalyukh is a professor at the Department of Physics at CU-Boulder, which he joined in 2007. He is also a founding fellow of Renewable Sustainable Energy Institute (a joint institute of CU-Boulder and NREL) and Materials Science Engineering Program. Prior to CU-Boulder, Smalyukh did his postdoctoral and PhD studies at the University of Illinois at Urbana-Champaign and Kent State University, respectively, as well as was a visiting scholar at the University of Pennsylvania. Smalyukh also held a visiting professor position at the Newton Institute (University of Cambridge, UK) and at the Max Planck Institute (Stuttgart, Germany), as well as held Paris Sciences Char and CNRS Chair positions at ESPC and University of Paris Sud, respectively (both in France). Smalyukh's research focuses on soft condensed matter, materials and biological systems, including liquid crystals, colloids, polymers, bacteria, gels, biomaterials and their photonic, electro-optic and energy-related applications. He published >180 peer-refereed articles, including 5 in Nature and Science, and has an h-index of 49. He is an elected fellow of the American Physical Society. He received many awards, including the Bessel and Glenn Brown Awards, NASA iTech award and Mid-Career Award of ILCS, the PECASE Award from the Office of Science and Technology of the White House and the GSoft Award from the American Physical Society.

Professor R Pratibha

Raman Research Institute, Bangalore, India

R. Pratibha is presently an Emeritus scientist at the Raman Research Institute, India. She joined RRI after receiving Ph.D in the field of Liquid Crystals and served as a faculty member with final designation being Professor and Co-ordinator of the Soft Matter Group, until December 2018. During her tenure at RRI, she has been a visiting researcher in many research institutes including Groupe des Materiaux Organiques, Institut de Physique et Chimie des Materiaux de Strasbourg, Liquid Crystal Institute, Kent State University, Tokyo Institute of Technology, Liquid crystal materials research centre. Some of Pratibha's earlier significant research includes observation of high strength defects, saturn rings and coexistence of two nematic phases in mixtures of rod-like and disc-like nematogens, the observation of a new type of TGB phase (UTGB*) with a three dimensionally modulated structure and an enhanced type II character. More recent prominent research is related with in-depth studies on several bent-core liquid crystals (BCLCs) and observation of the biaxial smectic A phase and formation of lattice disclinations composed of striking striped patterns in mixtures of rod-like and bent-core molecules. Her most recent interests are in ordered self-assembly of nano materials in liquid crystals, anisotropic physical gels and unconventional liquid crystal-fibre assemblies with possible potential in soft matter photonics.

Professor Dirk J. Broer, Winner of the 2018 Gray Medal

Institute for Complex Molecular Systems, Eindhoven University of Technology, Netherlands

Dirk J. Broer has worked the better part of his career at Philips Research (Eindhoven, Netherlands) which he joined in 1973. He worked on a manifold of research topics such as vapor phase polymerization, optical data storage, telecommunication and display optics. In 1990/1991, he worked at DuPont Experimental Station (Delaware, USA) on nonlinear optics and vapour phase deposition of piconjugated polymers. In 1990, in line with his Philips research into liquid crystal materials, Broer obtained his PhD degree at Groningen University. From 2003 to 2010 he was senior research fellow and vice president at the Philips Research Laboratories. Borer has been a part-time professor at Eindhoven University of Technology since 1996. In 2010, he was appointed as fulltime professor at TU/e to chair the research group functional organic materials and devices. In 2013 he was appointed as Distinguished Professor at South China Normal University, China.

Prize-winning Speakers

Professor Corrie Imrie, Winner of the 2019 Gray Medal

The School of Natural and Computing Science, University of Aberdeen

Corrie Imrie received a BSc degree in Chemistry (1984), and a PhD under the supervision of Geoffrey Luckhurst (1988) both from the University of Southampton. He was as a Fellow of the Royal Commission for the Exhibition of 1851 (Southampton), an AFOSR Research Fellow in Frank Karasz's group at the University of Massachusetts (Amherst) and since 1992 been at the University of Aberdeen. He has been awarded the British Liquid Crystal Society's Young Scientist Prize (1993), and Cyril Hilsum Medal (2011), and the International Liquid Crystal Society LG Display Award (2012). He was part of the team awarded the 2017 Luckhurst-Samulski Prize (T&F). He served as Chair of the British Liquid Crystal Society between 2007 and 2009, and is the Editor of the journal Liquid Crystals.

Professor Linda Hirst, Winner of the 2019 Cyril Hilsum Medal

University of California Merced, USA

The recipient of the 2019 Cyril Hilsum Medal for independent contributions to liquid crystal science and technology over the past ten years is Professor Linda S. Hirst of University of California Merced, USA. Hirst received her Ph. D. in Experimental Physics, in December 2001, from the University of Manchester, where she studied liquid crystal materials. She spent three and a half years as a postdoctoral researcher in the Department of Materials Science at the University of California, Santa Barbara, working on biomolecular self-assembly. After serving for three years as a faculty member in the Physics Dept at Florida State University, she joined the faculty at UC Merced in 2008. She is a member of the board of directors of the International Liquid Crystal Society and the author the textbook "Fundamentals of soft matter science" (CRC press 2012).

Dr Markus Wahle, Winner of the 2019 Young Scientist Award

School of Physics and Astronomy, University of Leeds

The 2019 BLCS Young Scientist Award goes to Markus Wahle of Leeds University. Wahle received his BS degree in chemistry from Paderborn University, Germany, in 2010 and obtained his PhD in physical chemistry under the supervision of Prof Heinz-Siegfried in 2017. His PhD research focused on optical and electrooptical effects in microstructured optical fibres and photonic crystal fibres filled with liquid crystals. He is currently a Postdoctoral Research Fellow in the Soft Matter Physics Group at the University of Leeds in a joint project with Merck KGaA for the development of new liquid crystal-based devices.

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BLCS AGM			
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BLCS 2019

Oral Presentations Abstracts

Session 1:	**COLLOIDS I**	**Plenary 1**
Title:	**Nematic colloidal crystals and micro-motors powered by light**	
Presented by:	**Ivan I. Smalyukh,** University of Colorado, Boulder, CO 80309, USA Department of Physics; Soft Materials Research Center and Materials Science and Engineering Program, Department of Electrical, Computer, and Energy Engineering; Renewable and Sustainable Energy Institute, National Renewable Energy Laboratory.	

Man-made nano- and micro-motors are key to many future applications. I will describe highly reconfigurable self-assembly of colloidal micro-motors that exhibit a repetitive rotation when immersed in a liquid crystal and powered by a continuous exposure to unstructured ~1nW light. A monolayer of self-assembled azobenzene molecules defines how the liquid crystal's optical axis mechanically couples to the colloidal particle's surface, as well as how they jointly rotate as the light's polarization changes. The rotating particle twists the liquid crystal, which, in turn changes polarization of the light traversing it. The resulting feedback mechanism spontaneously yields a continuous opto-mechanical cycle and drives the unidirectional particle spinning, with handedness and frequency robustly controlled by polarization and intensity of light. I will discuss how this may enable new forms of active matter and self-assembled machines.

Session 1:	**COLLOIDS I**	**Oral 1**
Title:	**Enlightening Colloidal Crystals for Photonics**	
Presented by:	**Dwaipayan Chakrabarti,** School of Chemistry, University of Birmingham	
Other authors:	Andreas Neophytou, School of Chemistry, University of Birmingham	

Photonic crystals provide an exciting platform to control the flow of light, increasingly finding applications, for example, in optical communications, lasers and sensors.[1] Spherical colloidal particles dispersed in isotropic liquids have long been envisaged as building blocks for photonic crystals, often involving templating.[2,3] In recent years, dispersions of spherical colloidal particles in nematic liquid crystals formed by elongated molecules have shown great promise for new discoveries, with applications especially in photonics.[4,5] Here I will talk about optimal design of open colloidal crystals, which could be directly self-assembled from elongated patchy particles, for them to have superior photonic properties compared to those formed by their spherical counterparts.[6] The designer colloidal particles, considered in our computational study, have a soft repulsive spherocylindrical core, with an attractive patch on each of the hemispherical caps. Our study predicts the crystal structures for the designer colloidal particles and reveal that two of the polymorphs - the cubic and hexagonal tetrastack structures - both possess photonic band gaps. Finally, we explore a two-stage hierarchical self-assembly strategy for the colloidal particles, exploiting a hierarchy of interaction strengths for patch-patch interactions,[7] to realise these colloidal crystals via self-limiting formation of tetrahedral clusters at the intermediate stage.

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Session 1:	**COLLOIDS I**	**Oral 2**
Title:	**Self-assembly of fractal liquid crystal colloids**	
Presented by:	**Nikita V. Solodkov,** University of Leeds	
Other authors:	Jung-uk Shim and J. Cliff Jones, University of Leeds	

In a world governed by symmetry and invariance principles, complex mathematical concepts often realise themselves in seemingly simple physical systems[1]. Nematic liquid crystals are anisotropic fluids that self-assemble into vector fields, which are governed by geometrical and topological laws. Consequently, particulate or droplet inclusions self-assemble in nematic domains through a balance of topological defects and elasticity. Here, we use double emulsions of water droplets inside radial nematic liquid crystal droplets to form various structures, ranging from linear chains to three-dimensional fractal structures[2]. The system is modelled as a formation of satellite droplets, distributed around a larger, central core droplet and we extend the problem to explain the formation of fractal structures, as shown in Figure 1. We show that a distribution of droplet sizes plays a key role in determining the symmetry properties of the resulting geometric structures. The results are relevant to a variety of inclusions, ranging from colloids suspensions to multi-emulsion systems. Such systems have potential applications for novel switchable photonic structures as well as providing wider insights into the packing of self-assembled structures.

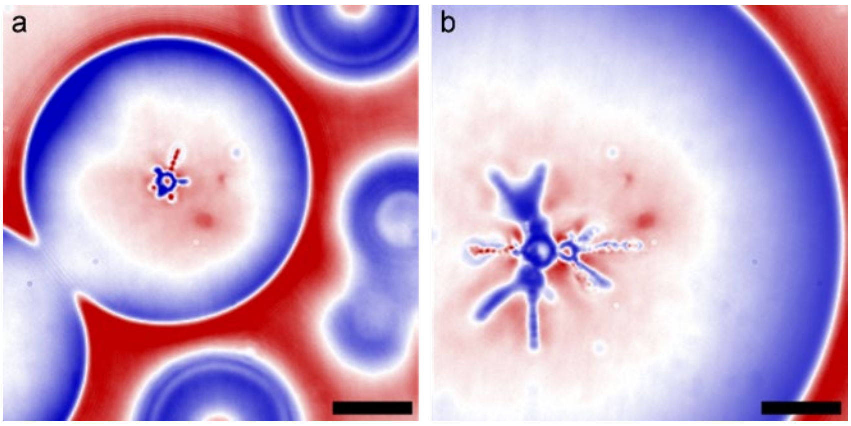

Figure 1 – Confocal microscopy images of radial nematic droplets with (a) octahedral satellite packing and (b) tetrahedral fractal satellite packing. Individual inclusions are made up of water droplets with normal boundary conditions and are separated by hyperbolic defects. Scale bar: 10 μm.

Acknowledgements:

We thank Stephen Webb, Sarah Needham and Dave Clarke of the Central Laser Facility, Harwell Science Park, for help with the confocal microscopy; Liam Hunter for his assistance with creation of microfluidics devices. This work was supported by a Merck iCASE studentship for N.V.S. and an Advanced Fellowship in Manufacturing from the EPSRC for J.C.J. (EP/L015188/2).

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[1] Gross, D. J. The role of symmetry in fundamental physics. Proc. Natl Acad. Sci. USA. 1996, **93**, 14256.

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Session 1: COLLOIDS I **Oral 3**

Title:

Novel Liquid Crystal Behaviour of Gold Nanoparticles Coated with a Room-Temperature Chiral Discogen

Presented by: **Huanan Yu,** Department of Chemistry, University of Hull
Other authors: Georg H Mehl, Department of Chemistry, University of Hull, Hull
Feng Liu, Wentao Qu, Department of Materials Science and Engineering, Xi'an Jiaotong University, Xi'an, China

Well-defined hybrid systems composed of liquid crystals (LCs) and nanoparticles (NPs) or nanorods (NRs) have been widely reported. Their physical and optical properties are intimately related to the 2D and 3D organisation of such materials.[1,2] The properties are strongly affected too by the chemical structure of the attached organic ligands attached to the NPs or NRs. Hence a careful design of the organic corona affecting the self-assembly of NPs or NRs to realize chemical control of the composition in hybrid system is critical. Research on these hybrid materials has in past concentrated mainly on the NPs or NRs doped LC systems[3,4] and relatively few reports on the LC phase behaviour of modified NPs[5], let alone the of chiral features in LC functionalized NPs, resulting thus in more complicated macroscale LC structures, are available.

Here, we report the synthesis and investigation of the phase behaviour of a NPs-LC hybrid system, that is designed using an intrinsically chiral discogen with a single, stable and wide temperature range. The mesogens, based on the pentaalkynylbenzene core, are attached to the surface of gold NPs via alkylthiol spacers, designed to achieve room temperature LC behaviour. The properties of the modified gold NPs were characterized by TEM, NMR, DSC, UV/Vis and OPM studies as well as GISAX. The properties will be discussed and compared to structurally related materials.

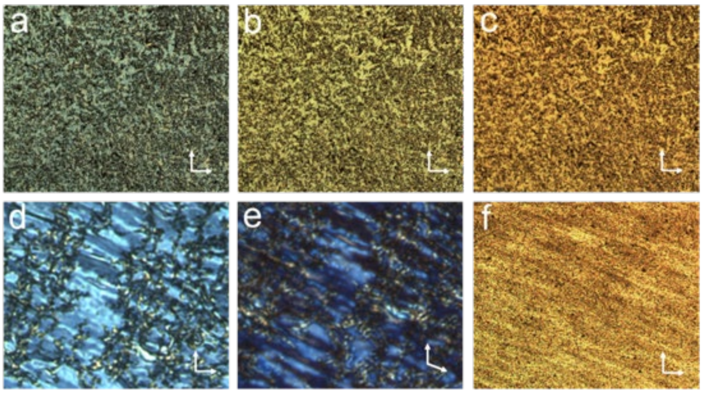

Figure 1. OPM micrographs of gold NPs coated with chiral discogens: (a) 86.5 °C (crossed polarizer), (b) 63.5 °C) (c) 37.8 °C ; (d) 79.0 °C; (e) 79.0 °C (polarizer 110°), (f) 37.8 °C (after compression) .

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Session 2: **NOVEL COMPOUNDS** **Plenary 2**

The 2019 Gray Medal

Title:

Liquid crystal dimers: from the intercalated smectic phases to the twist-bend nematic and smectic phases

Presented by: **Corrie Imrie,** University of Aberdeen

Liquid crystal dimers consist of molecules containing two mesogenic units linked *via* a flexible spacer, most commonly an alkyl chain, and can be broadly divided into two classes: symmetric in which the two mesogenic units are the same and non-symmetric in which they differ [1]. Their transitional properties are strongly dependent on the length and parity of the flexible spacer. This behaviour is most commonly accounted for in terms of how the spacer controls the average shape of the molecule such that even-membered dimers are essentially linear whereas odd-members are bent. We will see how the study of non-symmetric dimers led first to the discovery of intercalated smectic phases [2, 3]. Following this the focus of interest switched to the search for the biaxial nematic phase and here molecular bend was the key structural feature [4, 5]. These studies dovetailed with the discovery of the twist-bend nematic phase [6, 7], and more recently, twist-bend smectic phases have also been identified [8]. Structure-property relationships in these phases will be reviewed.

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Session 2:	NOVEL COMPOUNDS	Oral 4
Title:	**Heliconical Nematic and Smectic Phases Exhibited By Non-Symmetric Liquid Crystal Dimers: The CB6O.m Series**	
Presented by:	**Rebecca Walker,** University of Aberdeen	
Other authors:	Damian Pociecha (University of Warsaw), Miroslaw Salamonczyk (University of Warsaw), Chenhui Zhu (Lawrence Berkeley National Laboratory, Advanced Light Source) Ewa Gorecka (University of Warsaw), John MD Storey (University of Aberdeen), and Corrie T Imrie (University of Aberdeen).	

The twist-bend nematic phase, N_{TB}, is presently the focus of intense research activity for a number of reasons but perhaps primarily because it is the first example of spontaneous chiral symmetry breaking in a fluid with no spatial ordering. It is widely believed that the key structural requirement for the observation of the N_{TB} phase is a bent molecular shape and indeed theory predicts that the N_{TB} phase is formed for just a narrow range of molecular curvatures.[1] In his seminal 2001 proposal on the existence of the N_{TB} phase, Dozov also used symmetry arguments to predict the existence of heliconical smectic phases.[2] However, the overwhelming majority of N_{TB} phases either crystallise or vitrify upon cooling and only rarely are N_{TB}-smectic or N_{TB}-B transitions observed.

We are at an early stage in establishing and understanding how these bent molecules will pack into smectic phases and the properties such phases will exhibit. It has been reported recently that bent achiral liquid crystal dimers can form heliconical smectic phases such as, for example, the smectic C_{TB} phase in which the director forms a helix in which it is tilted with respect to the helical axis.[3]

In order to begin to develop our understanding of how these bent dimeric structures need to be modified to form smectic phases, here we report a series of achiral asymmetric dimers with an odd number of atoms in the spacer, the CB6O.*m* series – illustrated in *Figure 1* – which form twisted structures in nematic as well as in lamellar phases: the heliconical nematic (N_{TB}) phase and a new variation on the heliconical tilted smectic C (SmC_{TB}) phase.[4]

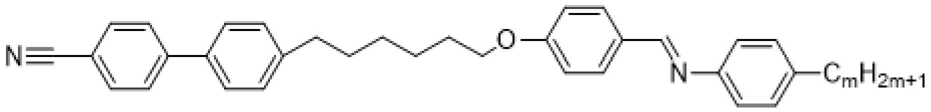

Figure 1. *General structure of the CB6O.m series.*

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4. a) Walker, R., Pociecha, D., Strachan, G., Storey J.M.D., Gorecka, E. and Imrie, C.T. *Submitted.* 2019. b) Salamonczyk, M., Vaupotic, N., Pociecha, D., Walker, R., Storey, J.M.D., Imrie, C.T., Zhu, C. and Gorecka, G. *Submitted*. 2019.

Session 2: **NOVEL COMPOUNDS** **Invited 1**

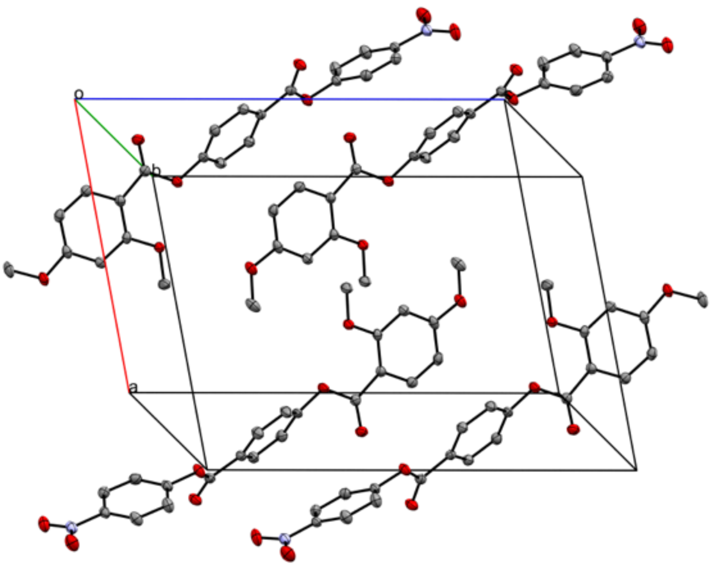
Title:

Calamitic Materials Exhibiting Two Nematic Phases: Discovery of a Splay Nematic Phase

Presented by: **Richard J. Mandle,** University of York

Recently we reported wedge-shaped liquid crystals which exhibit two nematic phases separated by a weakly-first order phase transition. [1] Subsequent analysis of one of these materials (*RM734*) reveals the lower temperature nematic phase to be a splay modulated nematic phase (N_S). [2] When approaching the N_S-N phase transition, the splay nematic constant is unusually small and goes towards zero. Analogous to the transition from the uniaxial nematic to the twist-bend nematic phase, this N_S-N is driven by instability towards splay orientational deformation, resulting in a periodically splayed structure.

This talk presents an overview of this newly discovered phase of matter, from its initial observation at York to efforts aimed at understanding how molecular structure governs its incidence and properties.



The unit cell of RM734 ($P\bar{1}$ space group) displayed with a thermal ellipsoid model (50% probability) as obtained by X-ray diffraction on single crystals grown by vapour diffusion of cyclohexane into ethyl acetate.

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Session 2: **NOVEL COMPOUNDS** **Oral 5**

Title:

Liquid crystal trimers and tetramers exhibiting twist-bend nematic behaviour

Presented by: **Ewan Forsyth,** University of Aberdeen

Other authors: Corrie T. Imrie and John M. D. Storey, University of Aberdeen

The twist-bend nematic phase, N_{TB}, is the most recently discovered nematic phase. It was first predicted by Meyer[1], then later independently by Dozov[2]. The N_{TB} phase is observed for molecules that have an overall bent structure, with the director tilted at an angle ϴ relative to the helical axis to form degenerate helices which form an achiral nematic phase.

The overwhelming majority of twist-bend nematogens are liquid crystal dimers consisting of molecules containing two mesogenic units linked through a flexible spacer. If an odd-number of atoms connect the two mesogenic units then the prerequisite bent-shape is achieved. The most studied liquid crystal dimers exhibiting the twist-bend nematic phase belong to the CBnCB series[3-4], in which two cyanobiphenyl units are linked by an alkyl spacer. Recently higher oligomers, both covalent and hydrogen bonded and containing various mesogenic units have also been shown to exhibit the N_{TB} phase[5-7].

Here we report the synthesis and characterisation of novel liquid crystal trimers and tetramers based on biphenyl or benzylideneaniline liquid crystal groups. To maintain an overall bent structure the flexible spacers between the aromatic mesogens are of odd parity.

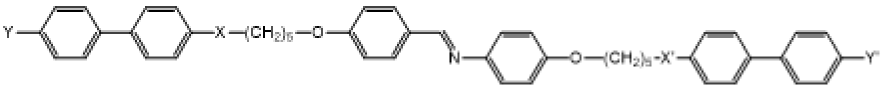

Figure 1: Structural skeleton of synthesised liquid crystal trimers containing biphenyl or benzlideneanaline mesogenic units. (Y, Y' = CN or OMe; X, X' = CH_2 or CO)

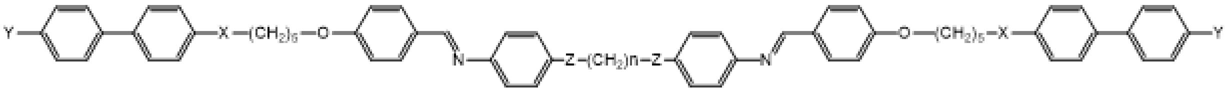

Figure 2: Structural skeleton of synthesised liquid crystal tetramers containing biphenyl or benzlideneanaline mesogenic units. (Y = CN or OMe; X = CH_2 or CO; Z = CH_2 or O)

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Session 2: NOVEL COMPOUNDS **Oral 6**

Title:

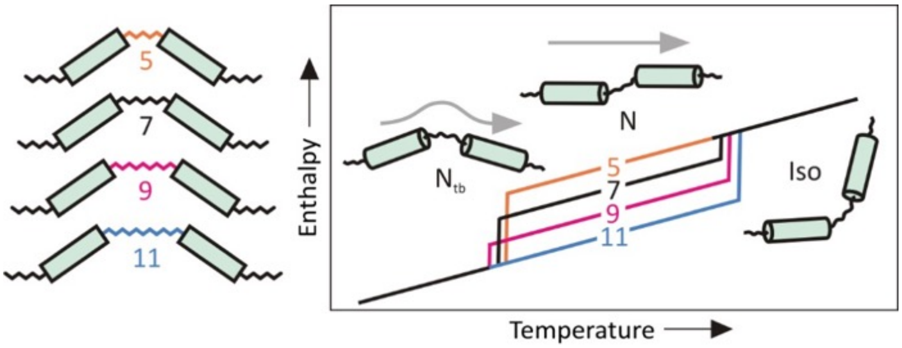
Study of the Twist Bend Nematic Phase by Modulated DSC and Circular Dichroism

Presented by: **Warren Stevenson**, University of Sheffield

Other authors: Xiang-bing Zeng [a], Goran Ungar[a,b] , Christopher Welch[c], Georg H. Mehl[c]
[a] Department of Materials Science and Engineering, University of Sheffield
[b] School of Materials, Xi'an Jiaotong University, China
[c] Department of Chemistry, University of Hull

For several years the transition between the conventional nematic (N) and twist bend nematic (N_{tb}) has been a highly topical subject of research. The novelty of the latter phase lies in its unique helical structure, wherein bent achiral molecules tilt at an angle to the pitch axis but lack long-range positional order.[1-3] The molecular-scale details of the phase, and how they change with temperature, are still widely debated.

In this presentation we explore the N and N_{tb} phases in bent achiral dimers using modulated DSC (MDSC) and circular dichroism. From MDSC findings, in combination with conformational energy calculations, we construct a molecular model relating the enthalpies of the N_{tb}-N and isotropization transitions to the twisting energy of the spacer chain between mesogens.[4] In the model the spacer is least twisted in the N_{tb} phase creating an angle between mesogens. As the N phase is approached the molecules twist further to bring the mesogens closer to parallel. Circular dichroism experiments show decreasing chirality in the N_{tb} phase as the temperature is raised, providing experimental support of our model.



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Session 2:	**NOVEL COMPOUNDS**	**Oral 7**
Title:	**A systematic study of bent-core calamitic dimers**	
Presented by:	**Sam Gorman**, University of Aberdeen	
Other authors:	Professor John M. D. Storey, Professor Corrie T. Imrie, University of Aberdeen	

The most extensively studied liquid crystal phase is the uniaxial nematic phase (N_U), characterised by its uniform electron density, a phase director oriented parallel to the long axis of the molecules and the absence of positional order. Investigations as to how mesogens with an overall bent-molecular curvature facilitate nematic ordering resulted in the discovery of a new nematic phase, the twist-bend nematic (N_{TB}) phase in which the director forms an oblique helicoid maintaining a constant tilt angle to the helix with the director undergoing twist and bend deformations[1]. Studies of structure property relationships of the N_{TB} phase have identified molecular curvature and a low bend elastic constant[2] as prerequisites to its formation. Materials which have been observed to exhibit the phase include dimers with odd parity spacers[3,4], rigid bent-core mesogens[5], and dimers comprising of calamitic moieties bonded to rigid bent-cores[6]. Here we describe a series of liquid crystal dimers comprising of methoxybiphenyl or cyanoterphenyl calamitic units connected to a series of rigid aromatic cores via an alkoxy spacer. The aromatic cores were varied through the use of meta and para substitution to evaluate the impact of a rigid bent-core on mesogenic behaviour. Additionally, both ester and imine linkages were used to evaluate their impact on the clearing temperatures of this class of materials and nitrile, n-butyl and propoxy terminal groups were used to investigate their influence on mesogenic behaviour. The materials studied have been observed to show both N_U and N_{TB} phases, with the dimers of more extended cores exhibiting either glassy nematic phases or smectic phases.

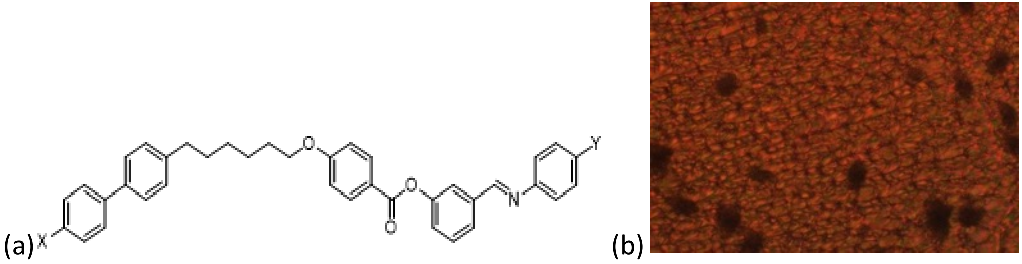

Figure 1: (a) General structure of bent-core calamitic dimer where X = -OMe or -PhCN and Y = -CN, -C_4H_9 and –OC_3H_7. (b) Polarised light micrograph of MeOB6OPCHNBN exhibiting the characteristic rope like texture of the N_{TB} phase.

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Session 3:	**DEVICES** **The 2018 Gray Medal**	**Plenary 3**
Title:	**Reactive mesogens: One principle - infinite possibilities**	
Presented by:	**Dirk J. Broer,** Institute for Complex Molecular Systems, Dept. Stimuli-responsive Functional Materials and Devices, Eindhoven University of Technology.	

Since their development in the 80's of last century, reactive mesogens (RM's) form a versatile class of soft matter materials that have find their way to a wealth of applications. The frozen-in molecular order of the polymer networks that they form upon polymerization brought a new dimension into liquid crystal technologies. Initially developed for their use as low shrinkage, low thermal stress coatings, the RM's demonstrated their function especially in optical applications. The large, temperature-stable and adjustable birefringence was adopted by the display industry for many purposes, varying from viewing angle enhancement to optical-retarder based 3D imaging optics. Presently, advanced optical applications for augmented reality and astronomy lenses are drawing much attention as well as their use to stabilize special liquid crystal effects for smart windows and dedicated display types.

The use of RM's for soft robotics applications is nowadays studied by many academic and industrial institutes. Triggered by heat, light or humidity the polymers change shape, surface structure or porosity. At Eindhoven University, we developed self-sustaining oscillators, cilia based micro-transport devices and haptic surfaces. Films deform from a flat to a complex, but pre-designed, shape with prospects to light-triggered origami and self-folding plastic elements. A completely new development relates to coatings that switch their surfaces from flat to corrugated with a preset topography. Or in a different design from dry to wet by controlled secretion of liquid. Properties that enable controlling properties as friction, grip, lubrication, stick, soil rejection, particle manipulation, etc.

The lecture will discuss part of the history next to our newest developments in responsive liquid crystal polymer materials, giving a preliminary view on the future of RM's with advanced applications in the fields of oscillatory films, smart coatings, soft robotics and haptics.

Session 3: **DEVICES** **Invited 2**

The 2019 BLCS Young Scientist Award

Title:

Liquid Crystals for Optical Devices: From Fibres to Lenses

Presented by: **Markus Wahle**, School of Physics and Astronomy, University of Leeds

This talk will feature several optical devices based on liquid crystals (Figure 1), on which I worked during my PhD at Paderborn University, Germany, and in my current postdoc at the University of Leeds. First, photonic crystal fibres filled with nematic liquid crystals will be discussed and how these can be used for tuneable for wave mixing sources [1]. Next, I will show that PCFs can be infiltrated with the more complex blue phase and that this can be utilised to measure the Kerr constant from transmission spectra [2]. The blue phase also plays a key role for polarisation-insensitive two-dimensional diffraction gratings [3] produced using a self-assembly technique called nanosphere lithography. Finally, I will discuss my current postdoc work on manufacturing polarisation-independent optical devices such as gratings and lenses [4] based on the embossing of reactive mesogens.

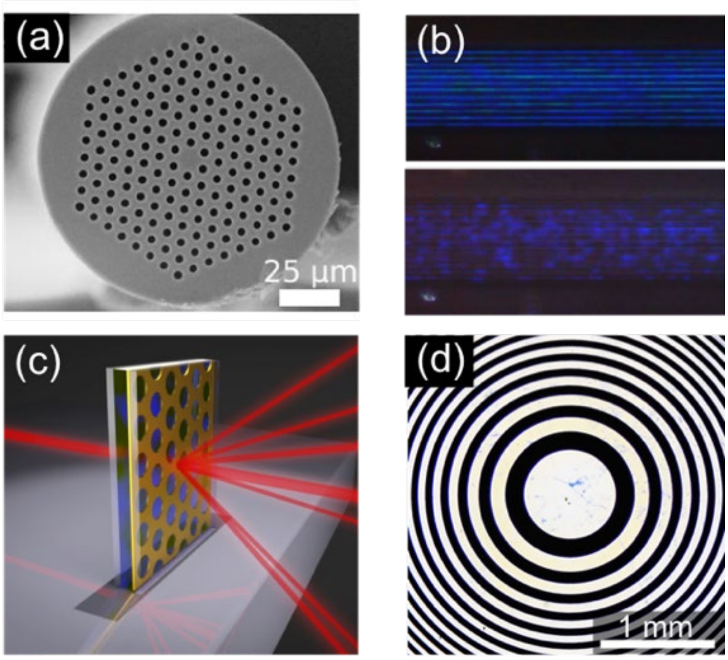

Figure 1. (a) Cross section of a photonic crystal fibre (PCF). (b) Transmission perpendicular to the fibre axis of a PCF filled with blue phase in BP I (top) and BP II (bottom). (c) Schematic of a switchable 2D diffraction grating based. (d) Polarisation optical micrograph of a two-level Fresnel zone plate embossed in reactive mesogen.

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Session 3:	**DEVICES**	**Oral 8**
Title:	**And now for something completely different: Woodburytype**	
Presented by:	**Susanne Klein,** Centre for Fine Print Research, UWE Bristol, UK	
Other authors:	Damien Leech, Walter Guy, Centre for Fine Print Research, UWE Bristol, UK	

Woodburytype, invented by Walter B. Woodbury and patented in 1863, was the first commercially successful mechanical printing process for the permanent reproduction of photographic quality pictures and today is still unsurpassed in producing continuous tone images of the highest quality. Woodburytype was made commercially obsolete by the introduction of Halftone to the printing industry which allows the printing of text and images at the same time and does not require the complex production methods or the time-consuming trimming and tipping-in of the images.

In Woodburytype contrast and greyscale are generated by a relief of pigmented gelatine. In contrast to traditional printing methods where the ink is driven into the paper by pressure, the gelatine layer sits on top of the paper surface. The pressure of the printing press has to be carefully tuned to achieve a reliable release from the printing plate without chasing the ink into the substrate. Substrate surface chemistry and paper porosity are parameters which have to be controlled for a successful release and these also influence contrast and greyscale in the printed image.

Present day Woodburytype practitioners use photographic paper avoiding paper treatment described in some historical recipes. The grades used have a completely sealed surface which does not allow air trapped between plate and paper to escape, generating air bubbles in the final print. Historic documents show that in the 19th century commercial print companies, Goupil for example, were producing several thousand prints per day. This is in stark contrast to today’s very low success rate, with yields reported between 15 to 20%.

In our research we use an Albion platen press as our printing platform, where pressure is controlled by adjusting the packing within the press. The pressure is quantified using compression load cells. A range of different papers, supplied by St. Cuthbert’s Mill and John Purcell Paper, were tested for their suitability for the process. Contrast and greyscale were recorded as a function of the degree of absorption of the ink by the paper and as a function of compatibility of ink and surface chemistry. Contrast and greyscale are objectively determined by measuring optical density with the Konica Minolta Spectrodensitometer FD-7/FD-5 mounted on the ColorScout A+. Correlating optical density with the actual parameters of the printing process will allow the user to choose an image appearance suited to the image content and desired artistic expression.

Applying the gelatine layers via ink jet allows the addition of active layers like liquid crystal layers. We will report first results.

Session 3: **DEVICES** **Oral 9**

Title:

A grating-aligned shock-resistant ferroelectric liquid crystal electro-optic shutter with sub-millisecond response times

Presented by: **Peter J.M. Wyatt**, University of Leeds

Other authors: James Bailey (Dynamic Vision Systems LTD.), Mamatha Nagaraj (University of Leeds),
J. Cliff Jones (University of Leeds)

Ferroelectric liquid crystals (FLCs) were a highly promising research subject for the display industry in the 1980s and 1990s, due to their sub-millisecond switching times and inherent bistability. The Surface Stabilised FLC[1] seemed suited as an alternative to nematic-based liquid crystal displays (LCDs). Uniform alignment of the tilted smectic layers of the FLC must be retained even after mechanical shock to the display. However smectic liquid crystals are susceptible to shock induced flow, rendering them unsuited for large area displays. These fast switching speeds still remain desirable, for instance allowing frame sequential colour in projector display applications. Liquid Crystal on Silicon (LCoS) spatial light modulators based on FLCs are commercially successful and are less sensitive to shock, but new shock-insensitive modes are still important to develop.

A simple but novel geometry for FLC electro-optic shutters is presented, based on low-amplitude, low-pitch surface-relief gratings and interdigitated electrodes (IDEs) to controllably align the FLC **c**-director. The gratings are surface treated to induce a homeotropic, or vertical, alignment to the FLC layer normal, **k**, which is parallel to the substrate normal. Such alignments are shown to exhibit greater shock stability due to the initial alignment of the smectic layers relative to the direction of the induced liquid flow. The surface-relief grating provides a preferred orientation for the **c**-director to which it returns after a mechanical shock or electrical addressing, seemingly self-healing. When addressed with IDEs, sub-millisecond response times are obtained. This relatively simple geometry has led to a working prototype that demonstrates both resistance to mechanical shock as well as sub-microsecond switching times. Improvements are suggested that will help optimise the device for use in LCoS spatial light modulators, high-speed adaptive optics and head-mounted displays for virtual/augmented reality.

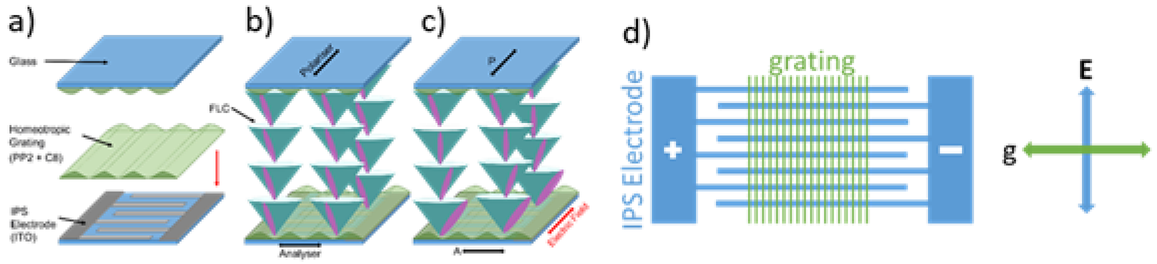

Figure 1: A schematic diagram of the prototype devices' geometry. a): the orientation of the gratings with respect to the in-plane electrodes. b): the device in the OFF/dark state, with no applied electric field, where the **c***-director is homogeneously aligned through the cell. c): the device with a sufficiently strong electric field applied to rotate the* **c***-director 90° through the cell. On removal of this field, the device will relax back to the homogeneous* **c***-director alignment shown in the middle diagram. d): A 2D schematic diagram representing the orientation of the IDE w.r.t. the grating vector,* ***g****. This geometry allows an in-plane electric field,* ***E****, to be applied perpendicular to the rest-state of the FLC* **c***-director, resulting in* **c***-director reorientation within the smectic layer, shown in c).*

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Session 3:	DEVICES	Invited 3
Title:	**Large-scale topological defect arrays for multistable diffraction gratings**	
Presented by:	**Francesca Serra,** Dept. Physics and Astronomy, Johns Hopkins University	
Co-author:	MinSu Kim, Dept. Physics and Astronomy, Johns Hopkins University	

Defect arrays in liquid crystals are interesting for colloidal self-assembly and for optical applications such as tunable gratings. Recently, Orihara and colleagues were successful in controlling instabilities in nematic liquid crystals to obtain large, electric field- induced arrays of umbilical defects by using patterned electrodes [1]. However, it is difficult to control the regularity of the defect array without direct intervention such as manipulation with optical tweezers.

We investigate the role of the geometry of the electrodes on the geometry of the umbilical defect array [2]. We show that the size of the electrodes not only influences the regularity of the array but also the spacing between the defects. We identify the combination of parameters that guarantee the regularity of the defect array and a strategy to create very large-scale arrays by a slight modulation of the electrode conductivity.

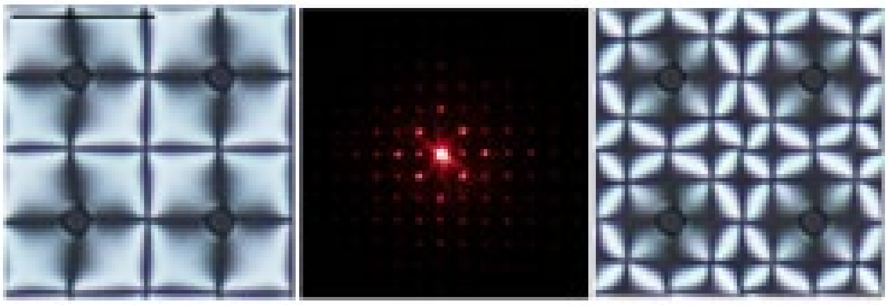

Figure 1: array of topological defects, which has two stable states (left and right). In the center, the diffraction pattern of the array on the left. Scale bar 40 μm.

We then explore the use of a micro-pillar array in combination with the applied electric field. The micro-pillar array imposes a preferred length-scale on the system which may or may not be compatible with that dictated by the instability. The competition between the two length-scales leads to a global rotation of the nematic director to better accommodate the defects. This bistable, tunable structure can then be used as a switchable diffraction grating. The system can be optimized in terms of response speed, threshold voltage and efficiency by choosing the appropriate size of the micro-pillar and a liquid crystalline material with high birefringence.

This platform, which combines topography and applied field for the control of defect, can be expanded to more exotic geometries to design multi-stable tunable gratings.

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Session 4:	**SURFACTANTS AND LYOTROPICS**	**Invited 4**

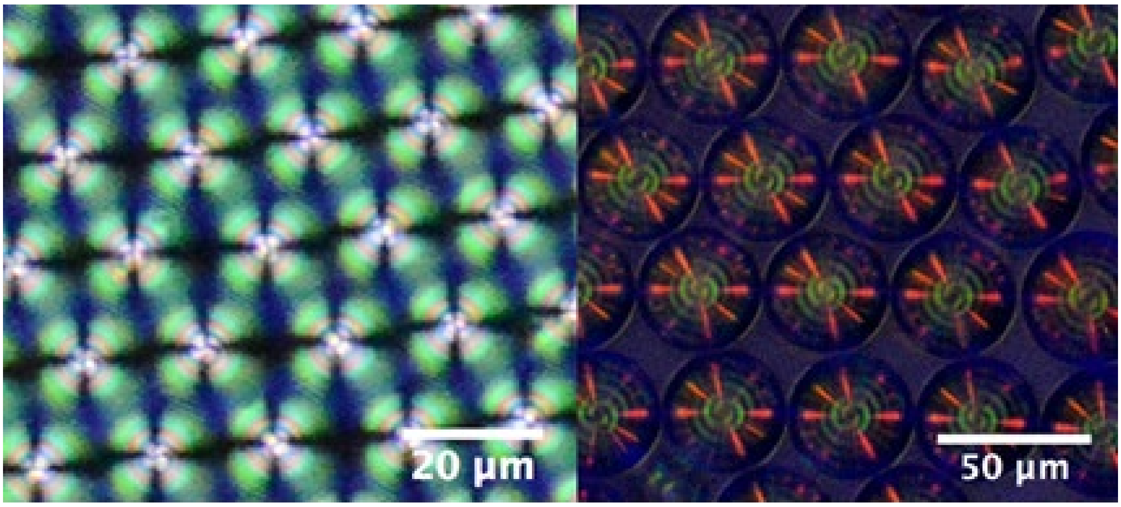
Title:

Phospholipid-coated Liquid Crystal Droplets

Presented by: **R. J. Bushby,** University of Leeds

Other authors: P. Bao, D. A. Paterson, S. Peyman, J. C. Jones, J. Sandoe, S. D. Evans, H. F. Gleeson, University of Leeds

Because very small changes at the surface can switch the anchoring of a liquid crystal, liquid crystals are good candidates for creating biosensors. However, to make this happen, we need to forge a link between 'the world of liquid crystals' and 'the world of biology'. One way of doing this is to use liquid crystal droplets coated with a phospholipid monolayer. Work at Leeds on phospholipid-coated surfaces, droplets and bubbles is long-standing. We will discuss two pieces of work which extend our previous studies to phospholipid-coated liquid crystal droplets and (more generally) we will discuss the potential of liquid crystals for medical applications. The first piece of work is mainly the work of Daniel Paterson and this tries to address the fundamental question of what controls the anchoring at the liquid crystal/phospholipid interface.[1] The second is mainly the work of Peng Bao and demonstrates the use of microfluidically-produced phospholipid-coated droplets to 'sense' a model antimicrobial peptide from the venom of the North African scorpion *Scorpio maurus palmatus.*[2]



Microfluidically produced, monodisperse liquid crystal droplets. (Left) Transmission mode, crossed polariser image of a nematic phase, homeotropically anchored with a DOPC/DOPE coating. (Right) Reflection mode, crossed polariser image of a chiral nematic phase, planar anchored with PVA.

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Funding: EPSRC EP/P024041/1

Session 4:	**SURFACTANTS AND LYOTROPICS**	**Oral 10**
Title:	**Manipulating Liquid Crystals Using Surfactants: A Molecular Perspective**	
Presented by:	**Zeynep Sumer,** Department of Chemical Engineering, University College London	
Co-author:	Alberto Striolo, Department of Chemical Engineering, University College London	

The aim of this work is to quantify from the molecular level how surfactant adsorption on cylindrical LC bridges and spherical droplets controls orientational order. The study is carried out using the popular Dissipative Particle Dynamics (DPD) simulation method. In the systems considered, LC droplets or bridges are dispersed in water. Three different surfactants are modelled with short, moderate, and long tail lengths, respectively. All surfactants adsorb at the LC-water interface. Particular attention is focused on the 'anchoring' of the surfactants on the LC structures.

It is found that the length of the surfactant hydrophobic tail determines the effectiveness by which the LC order is affected. Short tails are not as effective as long ones. Surfactants with long tails affect the LC order, but, in agreement with experiments, predominantly within a short distance from the interface. For these surfactants, the surface density at the LC-water interface is an important knob that can be used to control the order of the LCs. The simulations show that, as the effective LC-surfactant interactions change, so does the distribution of the surfactants at the interface.[1]

To aid experimental advancements, theoretical calculations have been conducted to quantify molecular driving forces responsible for the collective behaviour of LC molecules within micrometer-size spherical droplets. When the surfactants have hydrophobic tail of sufficient length, they cause deviations from the spherical symmetry of LC droplets. Increasing the concentration of these surfactants enhances such phenomenon. The results presented could be helpful for designing novel surface-active compounds to develop advanced optics and/or sensing devices based on LCs.

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Session 4:	**SURFACTANTS AND LYOTROPICS**	**Oral 11**
Title:	**Calculating the scission free energy of wormlike micelles using dissipative particle dynamics simulations**	
Presented by:	**Charlie Wand,** School of Chemical Engineering and Analytical Science, University of Manchester	
Other authors:	Paola Carbone and Andrew Masters, School of Chemical Engineering and Analytical Science, University of Manchester	

Wormlike micelles (WLM) can be formed by surfactant systems at moderate concentrations. These are long, flexible structures that share many features with traditional polymeric systems, but an important difference is that they can break and reform. Thus, they are often thought of as 'living' polymers. This similarity to polymers forms the basis of a theoretical description developed by Cates and co-workers[1] that relates the microscale structure to the macroscopic properties of these complex fluids. One key parameter is the scission free energy, that is, the change in free energy upon breaking a cylindrical micelle into two hemispherical caps (see Figure 1). This can be directly related to the mean micelle length and mean aggregation number.

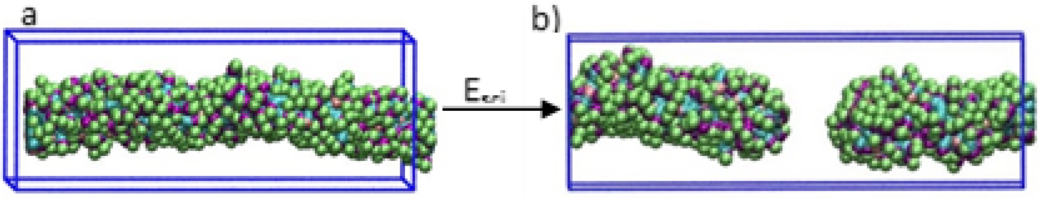

Figure 1 The scission free energy (E_{sci}) is the change in energy from breaking a wormlike micelle (a) into two wormlike micelles with hemispherical caps (b).

The rheological properties of wormlike micellar systems are heavily dependent on many factors including surfactant composition and temperature. In addition, for ionic surfactants such as sodium laureth sulphate (SLES) considered here, the salt concentration is particularly important and the measured viscosity can change by orders of magnitude with salt concentration[2].

Here we use Dissipative Particle Dynamics simulations (DPD) to calculate the scission free energy. We employ a simulation protocol developed by Wang *et al*[3]. Briefly, we simulate an infinitely long micelle and calculate the scission free energy using umbrella sampling and the weighted histogram analysis method (WHAM). The reaction coordinate chosen is the number of tail beads in a denoted scission region which has been shown to give a robust calculation of the scission free energy. From these simulations we are investigating how the salt concentration and surfactant attributes (head group size, alkyl tail length) affect the scission free energy. We find that E_{sci} increases with increasing salt content indicating longer micelles are present, in agreement with previous literature results[2,3]. However, upon increasing the alkyl chain length from C12 to C16, a 4-fold increase in E_{sci} and a qualitatively different potential of mean force is observed.

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3. Wang H., Tang X., Eike D. M., Larson R. G. and Koening P. H., Scission Free Energies for Wormlike Surfactant Micelles: Development of a Simulation Protocol, Application, and Validation for Personal Care Formulations, *Langmuir,* 2018, **34** (4), 1564-1573

Session 4:	**SURFACTANTS AND LYOTROPICS**	**Oral 12**
Title:	**The aqueous phase behaviour of linear alkylbenzene sulphonate / polycarboxylate polymer systems**	
Presented by:	**Mariam Hussain,** School of chemical and Process engineering; and, School of Physics and Astronomy, University of Leeds	
Other authors:	Mamatha Nagaraj, School of physics and astronomy, University of Leeds Olivier Cayre and Andrew Bayly, School of Chemical and Process engineering, University of Leeds	

Linear Alkylbenzene Sulphonate (NaLAS) surfactant, is often combined with polycarboxylate polymers that act as anti-redeposition agents and viscosity modifiers for use in detergent products. In this work, we investigate the interactions of the NaLAS surfactant with polycarboxylate-water dispersions at various concentrations, at a temperature of 50°C. We observe multiple effects of polymer on the anisotropic and non-isotropic surfactant structures, depending upon the region of the phase diagram being observed, as shown in Figure 1. At low surfactant concentrations, increasing the polymer concentration induces phase separation or the formation of lamellar structures. At higher concentrations, polymer changes the nature of the lamellar phase, inducing the onset of an additional lamellar phase that has a lower d-spacing, which is determined using synchrotron SAXS experiments. This is in contrast to the previously observed, higher d-spacing, lamellar phases that are induced by salting out electrolytes.^{2}H-NMR shows that the sizes of the multilamellar vesicle structures increase with polymer concentration. This is the first time that ^{2}H-NMR has been used to probe the diffusion and anisotropy of D_2O within the bilayers of the vesicles for such a system. The change in vesicle size, coupled with the various transformations induced by the increase of polymer concentration, is likely to be a result of depletion flocculation. Furthermore, we show how the unique rheological behaviour of this system influences its structural changes. Understanding these phenomena is paramount to the processes involved in the formulation of washing powder and other detergent products to maximise their effectiveness and customer satisfaction.

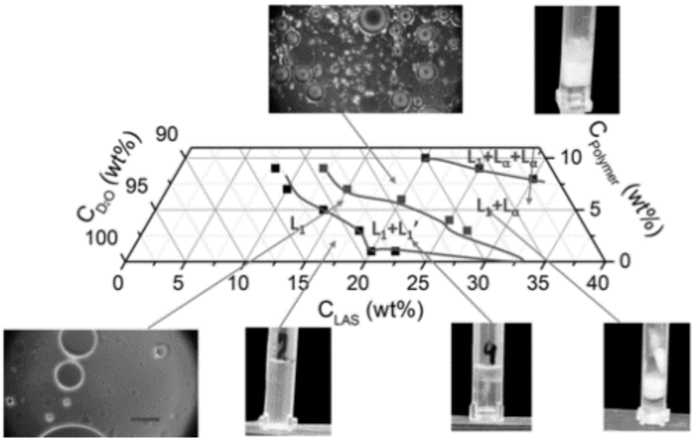

Figure 1: Ternary phase diagram of the NaLAS-polycarboxylate polymer-water system at 50°C; the phase transitions were determined by centrifugation and cross-polarised microscopy. L_1 represents the low density lamellar phase, L_1' is the high density isotropic phase, L_α is the high density lamellar phase and L_α' is the low density lamellar phase.

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Session 4:	**SURFACTANTS AND LYOTROPICS**	**Oral 13**
Title:	**Interactions between lipid bilayers and antimicrobial peptoids**	
Presented by:	**Vanessa J. Woodhouse**, Department of Physics, Durham University	
Other authors:	Elizabeth H. C. Bromley, Durham Physics, Mark R. Wilson, Durham Chemistry	

Antimicrobial resistance is a significant threat to world health, so the discovery and development of novel antimicrobial molecules is becoming increasingly important. One such class of molecule is peptoids, synthetic derivatives of peptides where the side chains are appended to backbone amide nitrogen atoms rather than the alpha-carbons. Peptoid antimicrobial activity is attributed largely to their ability to selectively disrupt and destroy bacterial cell membranes via a variety of mechanisms.[1] Cell membranes are lyotropic liquid crystals consisting of lipid bilayers with various embedded proteins and other organelles. Though highly complex they can be modelled in their simplest form as unilamellar lipid vesicles.

We have investigated the interactions between peptoids with strong *in-vivo* antimicrobial activity and lipid vesicles of varying composition designed to mimic different cell types. The peptoids undergo distinct secondary structural changes upon binding to the vesicles which can be observed via circular dichroism spectroscopy, while changes in the vesicles are characterised by dynamic light scattering. We have observed that the extent and nature of the interactions varies with lipid composition. We have also studied the effect on peptoid structure as the lipids undergo a phase transition from the gel to fluid phase.

To study these interactions computationally we have modified the General Amber Force Field (GAFF) to accurately capture the backbone torsional preferences of peptoids. Using Hamiltonian replica exchange molecular dynamics we are able to sample over the high energy barriers between structures and visualize the structural preferences of the peptoids in water and octanol. Further work into developing a coarse-grained model for peptoids compatible with the Martini lipid model will allow us to gain insight into the membrane disruption mechanism of the peptoids. Developing these techniques will aid in the rational design of peptoids for antimicrobial applications.

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Session 5:	**DEVICE THEORY**	**Oral 14**
Title:	**Spontaneous topography in thin liquid crystal films on patterned surfaces**	
Presented by:	**Tim Atherton,** Tufts University, Massachusetts, USA	

Isotropic fluids such as water in contact with a substrate form droplets or films depending on the wettability of the surface. Patterned surfaces can be used to sculpt nonspherical droplet topography if the volume of the fluid droplet is sufficiently small, e.g. by including a hydrophilic region within a hydrophobic background. Above this critical volume, the fluid forms a continuous film with a flat upper interface. In a film of isotropic fluid, therefore, the top and bottom interfaces are decoupled and the air-fluid interface at the top bears no trace of any patterning on the substrate.

Liquid crystals are similarly controllable by surface patterning, but in contrast to isotropic fluids are also able to sustain elastic distortions across the thickness of a film. For most liquid crystals, however, elastic forces are small relative to forces due to the surface tension of the air-LC interface, and hence an air-LC interface also tends to remain flat regardless of the substrate below it.

In this work, a remarkable situation is presented where surface topography **does** spontaneously emerge: a thin hybrid-aligned liquid crystal film on a patterned surface. The substrate is prepared with a spatially varying pattern that promotes planar anchoring and locally imposes the in-plane component of the director; the upper air-LC interface imposes vertical alignment. The film is cooled through the nematic-smectic transition, where twist and bend deformations incompatible with the smectic order are expelled from the liquid crystal and the corresponding elastic constants diverge. This expulsion of bend is shown to be sufficient to distort the air-LC interface. Recent experimental work testing these theoretical predictions will also be presented.

Session 5:	**DEVICE THEORY**	**Oral 15**
Title:	**A Model for Squeezed Coalescence of Nematic Droplets**	
Presented by:	**Joseph R. L. Cousins,** Department of Mathematics and Statistics, University of Strathclyde.	
Other authors:	Stephen K. Wilson and Nigel N. Mottram, Department of Mathematics and Statistics, University of Strathclyde David Wilkes and Leo Weegels, Merck KGaA, Darmstadt, Germany KY Lin, Merck Performance Materials, Taiwan	

Liquid crystal devices (LCDs) are ubiquitous in modern day life, and faster and more accurate manufacture of these devices is required to meet increasing global demand. The optimisation of the manufacturing process generally involves attempting to reduce manufacturing time by increasing flow velocities and filling speeds. However, implementing such changes runs the risk of causing deformation to the director structure which is crucial to the display.

A common process of filling the liquid crystal layer in LCDs used by display manufacturers is the One-Drop-Filling (ODF) process. In the first stage of the ODF process, a bottom substrate is coated with an alignment layer in order to correctly orient the liquid crystal layer within the cell. Droplets of liquid crystal are then dispensed onto the bottom substrate and are allowed to equilibrate. In vacuum, a top substrate is then lowered at a constant speed onto the droplets, squeezing them, causing them to coalesce, and eventually creating a continuous thin film of liquid crystal within the cell. Finally, the cell is cured and sealed to make it ready for use in LCDs. Although this method is an efficient way to fill liquid crystal cells used in LCDs, it is known that it can cause deformation to the director structure within the liquid crystal cells known as "ODF mura" (as shown in Figure 1(left)) which, in turn, can affect the optical performance of the final display.

We propose a model for the squeezed coalescence of droplets during the squeezing stage of the ODF process to provide insight into the formation of this ODF mura. This model assumes that the timescale for changes in the shape of droplets due to surface tension is much longer than that of squeezing, and so the effects of surface tension can be neglected. This assumption allows the calculation of the spreading behaviour of multiple squeezed droplets to be determined by geometrical methods using conservation of volume.

We obtain implicit expressions for the droplet boundary speed of multiple squeezed coalescing droplets which allow us to make direct comparisons with experimental photographs of the ODF mura (as shown in Figure 1(left) and (right)). Specifically, the deformation to the director structure at any point is assumed to be proportional to the droplet boundary speed as it passes over that point. The deformation to the director structure calculated shows a remarkable similarity to experimental photographs of the ODF mura. Motivated by the success of this model we further investigate the flow and director within squeezed coalescing droplets using Ericksen-Leslie continuum theory and compare the evolution of the director to further experimental results.

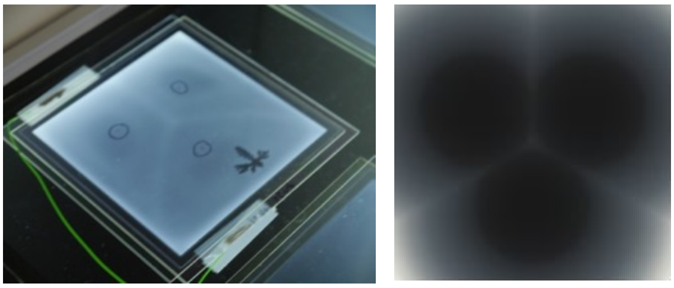

Figure 1. Experimental photograph of ODF mura (left) model of deformation to the director structure (right).

Session 5: **DEVICE THEORY** **Oral 16**

Title:

Defect dynamics of bistable latching

Presented by: **Sophie A. Jones,** University of Leeds

Other authors: Prof Sally E. Day and Dr F. Anibal Fernandez, UCL; Prof J. Cliff Jones, University of Leeds

The zenithal bistable device is a bistable nematic device which includes a surface relief grating giving two mutually stable director alignments. The high tilt state is known as the continuous (C) state, and the low tilt as the defect (D) state due to the $\pm {}^1/_2$ disclinations at the top and bottom of the grating grooves (see Figure 1). Latching between the states can be achieved through application of bipolar pulse waveforms. The polarity of the trailing pulse chooses the latch state: negative for continuous, positive for defect. This polar response is critical to latching between bistable states and is a result of the flexoelectric effect.

Due to the scale of the defects and the fast switching speeds, the precise mechanism for latching is not observable through experimental techniques. In this paper we explore the defect dynamics during latching in either direction using computational modelling.

QLC3D[1] is a three dimensional finite element model to solve the Q-tensor field in small scale LC devices. It has been used previously to model nematic bistability[2,3]. In this work it was used to model a 5 µm ZBD operating in VAN/HAN (homeotropic surface opposing the grating). LC values were taken from Spencer *et al.*[4], which represent Mixture B from Jones *et al.*[5]

We find good agreement of the modelled device performance to that of experiment. In defect-to-continuous latching, the defects are annihilated by meeting on the sidewall, as expected. In continuous-to-defect latching, we find unique defect dynamics which help to illuminate previously unexplained experimental behaviour. This includes the nucleation of a second generation of latching defects.

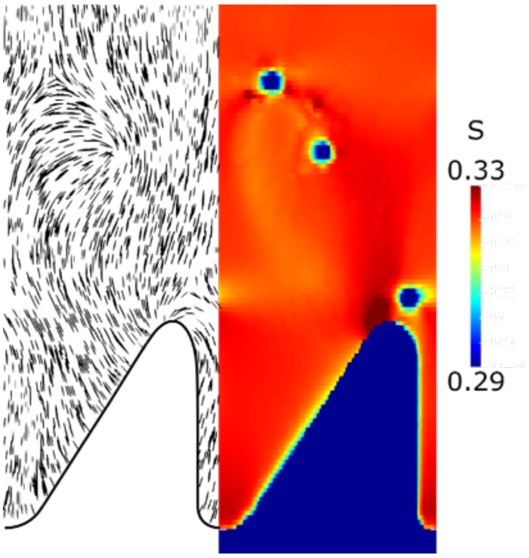

Figure 1: Director configuration and map of order parameter for second-generation defect nucleation, as seen on application of a 2.5 ms, 12.5 V bipolar latching pulse.

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Session 5: DEVICE THEORY **Oral 17**

Title:

Programming Emergent Symmetries with Saddle-Splay Elasticity

Presented by: **Doug Cleaver**, Sheffield Hallam University, UK

Other authors: Yu Xia, Dae Sook Kim, Shenglan Chen and Shu Yang, U Penn, USA
Andrew DeBenedictis and Tim Atherton, Tufts University, USA

Multi-state switchability is highly desirable in optoelectronic devices. For liquid crystal (LC) based devices, the stability of any configuration is achieved through a balance between imposed interactions and the LC's orientational elasticity. In most cases, the latter acts to resist deformation.

By combining surface topography and chemical patterning, here we exploit the effects of saddle-splay orientational elasticity, a property that, despite being intrinsic to all LCs, is routinely suppressed. Utilising theory and continuum elastic calculations, we identify experimental conditions for which, even using generic, achiral LC materials, spontaneously broken surface symmetries develop.

We further demonstrate a multi-stable device in which a weak, but directional, applied field switches between spontaneously-polar surface state domains (Figure 1). Our approach of manipulating surfaces is simple and scalable, yet powerful. By generalising beyond slab-geometry confinement, we envision creating ever more exciting behaviours for low-field and fast-switching optoelectronic devices, beyond current technologies.

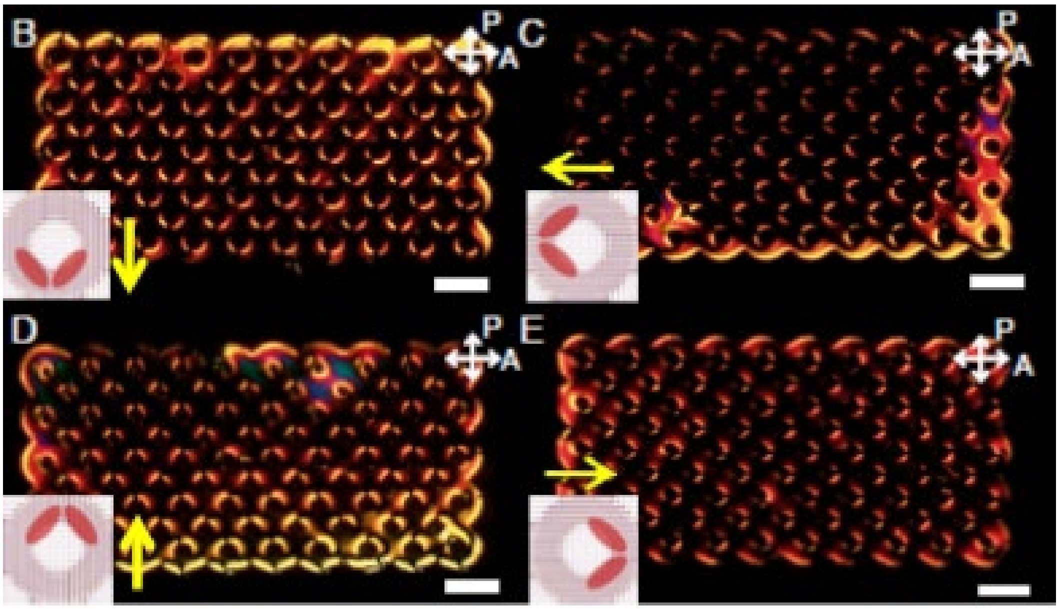
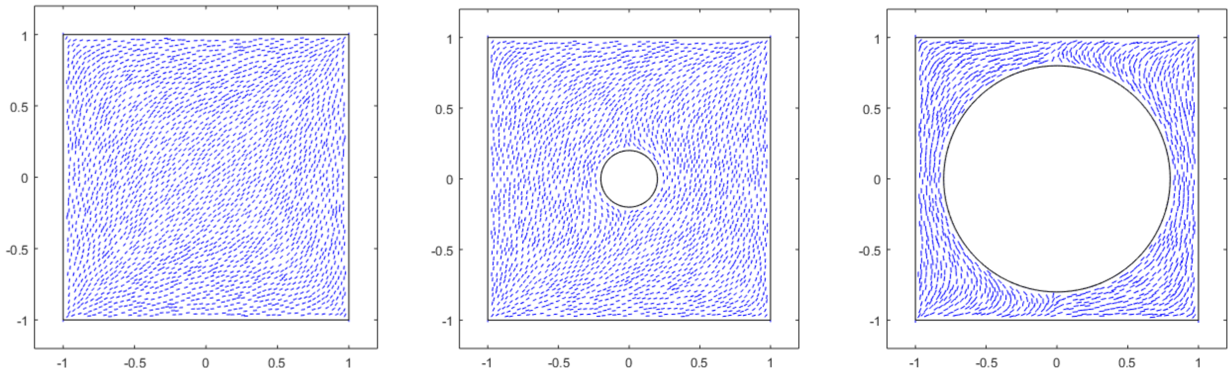


Figure 1. Demonstration of a multistable device: polarised optical microscope images showing the set of stable cardinal states that may be switched into using a small transverse, directional field (indicated by the yellow arrows).

Session 5:	DEVICE THEORY	Oral 18
Title:	**Asymptotics of nematic liquid crystals vector structure in rectangular wells with circular exclusions.**	
Presented by:	**Aaron Pim**, University of Bath	
Other authors:	Kirill Cherednichenko, Apala Majumdar and Jey Sivaloganathan, University of Bath	

Consider a nematic liquid crystal confined in a shallow square well subject to strong anchoring on the edges, such a system has been modelled experimentally and analytically in [1]. We introduce a circular exclusion of radius δ whose circumference is also subject to strong anchoring boundary conditions to disrupt the vector field. We utilise the standard one-constant approximation for the Oseen-Frank elastic constants and minimise the free energy subject to Dirichlet boundary data to derive a problem for the vector angle. Using the techniques derived in [2] we obtain an explicit analytical expression for the expansion of the vector field as a function of δ. We shall demonstrate this expansion up to 2nd order for the sake of tractability. We explore how the energy of the system varies as the size and position of the exclusion varies.



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Session 5:	**DEVICE THEORY**	**Oral 19**
Title:	**Well Order Reconstruction for Nematics on 3D geometries in the Landau-de Gennes Theory**	
Presented by:	**Joseph Harris,** University of Bath	
Other authors:	Apala Majumdar (University of Bath), Giacomo Canevari (Basque Centre for Applied Mathematics), Yiwei Wang (Illinois Institute of Technology)	

We perform a three-dimensional study on liquid crystal texture insider square wells, within the Landau-de Gennes theory for nematic liquid crystals. We analyse and stimulate the Well Order Reconstruction Solution (WORS) in a three-dimensional setting, first reported by Kralj, S. and Majumdar, A. Order reconstruction patterns in nematic liquid crystal wells. *Proceedings of the Royal Society of London Series A - Mathematical Physical and Engineering Sciences,* 2014, **470**(2169), 1-18 and analysed by Canevari, G., Majumdar, A. and Spicer, A. Order reconstruction for nematics on squares and hexagons: a Landau- de Gennes study. *SIAM Journal on Applied Mathematics*, 2017, **77**(1), 267-293. The WORS is a 2D pattern which is globally stable for nano-scale square domains, with an optical defect line along both square diagonals. We discuss the relevance of the WORS in a 3D context with realistic boundary conditions, including surface anchoring energies. We prove existence of locally stable critical points with three degrees of freedom and bounds under different temperature regimes in the Landau-de Gennes continuum theory. Using these results, we analyse the stability of a WORS with a constant eigenframe. We then conduct a numerical study of nematic equilibria with finite anchoring on the lateral surfaces of the square well. Numerical studies show that the WORS will no longer exist when the anchoring on the lateral surface is weak enough. We report novel 3D mixed solutions that interpolate between two different 2D solutions across the height of the 3D domain.

Session 6: **COLLOIDS II** **Oral 20**

Title:

Carbon Nanoparticles of Varying Dimensionality as Stabilizing Additives for Blue Phases

Presented by: **Ingo Dierking,** School of Physics & Astronomy, University of Manchester

Other authors: Tejas Y. Kalavalpalli and Adam Draude, University of Manchester

Blue Phases (BP) are liquid crystalline frustrated phases located between the isotropic liquid and the cholesteric (chiral nematic) phase. They have been shown to exhibit promising electro-optic behaviour for future displays and fast switching optical devices[1]. Advantages in the use of BPs for applications lie in the lack of a necessity for alignment layers, which reduces costs and rejects, and the fast response of the Kerr effect for optical switching times beyond video rate. One of the major problems for the exploitation of Blue Phases is their low thermodynamic stability of generally only about 1K, which is due to the frustrated nature of the phase.

A number of different ways to increase the BP temperature range have been proposed, for instance addition of chiral dopants or bent-core molecules, polymer stabilization, or the addition of nanopheres[2]. Here, the effects of adding carbon nanoparticles of varying dimensionality on the stability of Blue Phases were investigated. Employed particles were zero-dimensional fullerenes (F), one-dimensional single wall nanotubes (SWNT) and two-dimensional graphene oxide (GO), as a function of concentration. It was found that generally, all three particle types stabilized the BP at the expense of the cholesteric phase, while having no appreciable effect on the clearing point or the transition temperature to the smectic phase. The stabilization is due to the reduction of the elastic deformation energy contribution to the free energy of the phase, when nanoparticles accumulate at the cores of the defects. In case of the fullerenes, as well as graphene oxide (0D and 2D), the cholesteric phase vanished completely for nanoparticle concentrations above a critical concentration and a BP-N*-SmA* triple point could be observed. As estimated for fullerenes, this occurs at a defect fill fraction of approximately DFF=1. Also for single wall carbon nanotubes the Blue Phase was stabilized until saturation, but the cholesteric phase was never completely lost for the concentration regime accessible. The stabilizing efficiency of the carbon nanoparticles was found to be: graphene oxide>>fullerenes>>nanotubes.

Mixtures (1:1) of different types of nanoparticles, GO+F, GO+SWNT, F+SWNT evidence the above relation of the stabilizing efficiency and the cholesteric phase can now be observed to vanish for all three mixtures, including those with single wall nanotubes. Similarly, a 1:1:1 mixture of all three nanoparticles exhibits this behaviour, albeit at somewhat larger concentrations.

The observed stabilizing behaviour, as well as the stabilizing efficiency will be discussed in relation to particle dimensionality, size and shape.

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Session 6:	**COLLOIDS II**	**Oral 21**
Title:	**Multiscale Modelling of Liquid Crystals with Disordered Dopant Microstructure**	
Presented by:	**Giampaolo D'Alessandro**, Mathematical Sciences, University of Southampton	
Other authors:	Jordan R.E. Gill and K.R. Daly, Mathematical Sciences, University of Southampton	

The method of homogenisation[1] is a powerful mathematical framework that provides a highly accurate macroscopic description of systems with locally periodic microstructure. It allows us to represent the macroscopic properties of a micro-structured material through effective parameters, e.g. an effective elastic constant for a liquid crystal doped with nanoparticles, and macroscopic dynamic equations for an equivalent homogeneous medium. The key to achieving this remarkable result is the assumption of local periodicity: on a microscopic scale the micro-structured material is locally periodic. Changes in the micro-structure are allowed over a macroscopic scale, but locally the material is ordered. This assumption ultimately removes the need to solve the governing equations of the problem on all of the microscopic geometry, and just focus on a unit cell, thus vastly decreasing computation times as a result. Homogenisation has been used in a wide variety of situations where this microscopic periodicity is present (including flow in porous media, metamaterials, and elasticity) and has previously been used by our group to model the alignment and electric field in liquid crystals containing a periodic array of dopant particles[2].

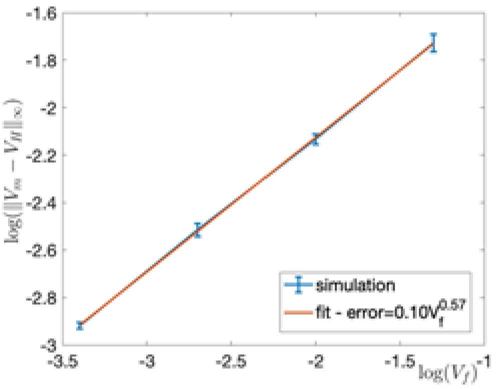

Figure 1 – Maximum difference in the potential estimated by integrating the microscopic (V_m) and the homogenised (V_H) equations as a function of the volume fraction V_f. The system studied is an anisotropic medium doped with randomly distributed particles.

A clear drawback is that often in real life systems this assumption of periodicity is not accurate. In this talk we study the effect of nanoparticles on the electric field in an anisotropic medium and demonstrate that for small volume fractions, as is the case with doped liquid crystals, we can drop the assumption of periodicity whilst still maintaining the accuracy of the macroscopic electric potential and permittivity of the system (see Figure 1).

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Session 6: **COLLOIDS II** **Oral 22**

Title:

The design and investigation of CdSe based nanoparticles linked to nematic mesogens

Presented by: **Haifa Ojaym,** Department of Chemistry, University of Hull

Other authors: G. H. Mehl, Department of Chemistry, University of Hull
W.D. Stevenson, X. B. Zeng Department of Materials and Science and Engineering, University of Sheffield

For nanoparticles (NPs), connected chemically to suitable mesogenic or dendritic groups it has been observed that liquid crystalline (LC) phase behaviour can be formed. Typically the structure of the LC phases detected depends on the size of the NPs, their coverage with organic groups and the size and shape of these organic groups. This allows to some extend for the control of the phase transition temperatures as well as the addressing of the two or three dimensional arrays of the NPs in the LC matrices. Though a range of NP systems have been epxlored, the focus has so far been mainly on gold or silver based LC NP systems. This is due to their excellent assessabilty and chemical stability. Surprisingly, to the best of our knowledge, there have so far been only one report on CdSe NPs which form LC phase behaviour, [1] as examples of quantum dots (QDs) linked to calamitic LC groups though there are a number of reports where QD have imported into LC mistrues [2,3]

Here we report the results of our investigations of CdSe NPs linked to laterally connected mesogens for which nematic phase behviour as well as 2D and 3D self-assembly behaviour has been reported before. [4] The QDs were prepared in a multistep step process using a kinetic growth method. [5] In a second step hexyl thiol groups were introduced in an exchange reaction. Finally, in a further exchange reaction mesogen LC groups were linked to the NPs. The chemcial structure of the QD_LC_NPs was characterised by NMR, transmission electron miscroscpy (TEM), UV/vis spectroscpy and thermogravimetric analysis (TGA) studies. The size of the NPs was determined to be ~3.3 nm based on TEM characterisation. We report the results of the investigations of the LC properties based on optical polarizing microscopy (OPM) and differential scanning calorimetry (DSC) as well as of the formation of the superstructure of the NPs using XRD. The experiemental results will be correlated to earlier work on conceptually related NP systems.

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Session 6: COLLOIDS II **Oral 23**

Title:

Swimmers in Smectics

Presented by: **C C Lakey,** University of Warwick

Co-author: M S Turner, University of Warwick

Continuum models describe the interactions between colloids embedded in smectic liquid crystals [1-3]. The presence of embedded particles, of diameter comparable to the smectic layer spacing, results in a distortion of the smectic ordering. We consider a system of self-propelling colloidal particles (“swimmers”) in a smectic liquid crystal. These swimmers are confined between the smectic layers, but interact with swimmers in other layers via the distortions that they induce in the smectic ordering. We find that the motion of these swimmers is then controlled by a combination of their own motility and the forces that they experience from the smectic mediated interaction potential, giving rise to rich dynamical behaviour.

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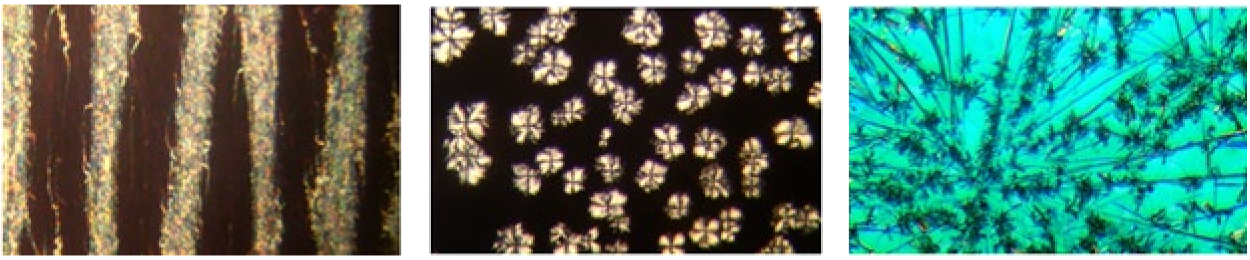
Session 7:	MATERIAL PHYSICS The 2019 Sturgeon Lecture	Plenary 4
Title:	**Unusual forms of liquid crystal-fibre self-assembly**	
Presented by:	**R. Pratibha,** Raman Research Institute, Bangalore, India	

The interaction between liquid crystals (LCs) and fibrous structures can result in novel forms of self-assembly leading to interesting nanostructured materials. One of the most well established examples of such a self-assembling process is found during the formation of liquid crystalline physical gels. However, most often the fibres are randomly dispersed in the LC matrix. On the other hand, controlled and well-ordered fibre assemblies have the potential to be used as templates for positioning nanomaterials, widening the scope and functionality of the gels. Two such systems composed of an organogelator and two types of structurally different nematic liquid crystals (NLCs) made of rod-like (R) molecules, which offer such a possibility will be described. The observation of grating-like tunable periodic patterns formed by an ordered arrangement of fibres composed of hydrogen-bonded gelator molecules interspersed with domains of the NLC in one case, and defects induced by gelator fibres in the other, will be explained in terms of the molecular interactions of the LC and gelator. It will be further demonstrated that the fibres emanating from the defect centres aid in anchoring quantum rods in the N matrix.

On a different note, it will be shown that the spontaneous expulsion of clusters of B_2 fibres in the chiral nematic (N*) phase occurring below blue phases (BPs) in a mixture of chiral R and achiral bent-core (BC) molecules, reveals that the BPs of this system may be stabilized by islands of BC molecules interspersed between the double twist cylinders formed by the R molecules. Another novel feature is the observation of a phase transition between two types of B_7 phases within the electro-responsive B_7 fibres.



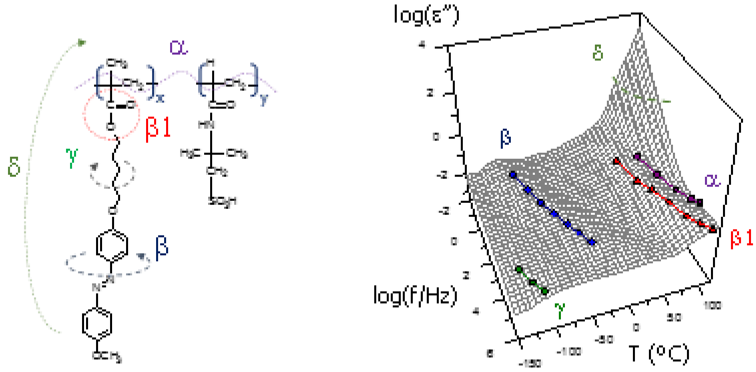
(a) (b) (c)

(a) Periodic orientation patterns formed by LC-rich and fibre-rich domains in E7 N-gel, (b) Defects induced by gelator fibres in CCN-mn N-gel, (c) Clusters of B_7 fibres in the N phase.*

Session 7:	**MATERIAL PHYSICS**	**Oral 24**
Title:	**Towards liquid crystalline polymeric electrolytes. Dielectric and conductivity analysis.**	
Presented by:	**Dr. Alfonso Martinez-Felipe**, Chemical and Materials Engineering Group, School of Engineering. University of Aberdeen	
Other authors:	Andrew Watmough Brown, Jason Main, and Kristian Campbell Smith, Chemical and Materials Engineering Group, School of Engineering. University of Aberdeen	

The development of new electrolytes with improved transport properties is paramount to increase the efficiency of electrochemical devices used for energy conversion and storage[1]. Liquid crystals hold promise as nanostructured electrolytes, due to their ability to simultaneously retain long-range order and local liquid-like mobility[2-4].

With the aim to optimise the conductivity of polymeric electrolytes in the absence of solvents, we investigate the molecular mechanisms responsible for ionic transport in a series of liquid crystalline side-chain copolymers[5]. More particularly, the *x/y*-10MeOAzB/AMPS copolymers, **Figure 1(a)**, exhibit the dielectric relaxations characteristic of the liquid crystalline P10MeOAzB homopolymer, **Figure 1(b)**. The motions of mesogenic groups in the lateral chains above the glass transition (δ relaxation) promote dc conductivity that can reach $\sigma_{dc} \sim 10^{-4}$ mS cm^{-1} at high temperatures (T>60°C). Additionally, the appearance of a so-called $\beta 2$ process at low temperatures (-40°C to 60°C), is also associated to long-range diffusion of ions, and both conductivity processes have signs of charge transfer decoupled from segmental motions. The present results, together with others obtained on similar copolymers, suggest the possibility to combine liquid crystallinity and low temperature conductivity in electrochemical devices.



(a) (b)

Figure 1 *(a) Dielectric relaxations of the x/y-10MeOAzB/AMPS side-chain copolymers; (b) Temperature/frequency dependence of the dielectric loss factor (ε'').*

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Session 7:	MATERIAL PHYSICS	Oral 25
Title:	Templating the twist-bend nematic phase	
Presented by:	**Nina Trbojevic,** School of Physics and Astronomy, University of Leeds	
Other authors:	Daniel J. Read (School of Mathematics) and Mamatha Nagaraj (School of Physics and Astronomy) University of Leeds.	

Over recent years, templating of various liquid crystal phases using polymers has sparked research interests as it offers great potential in understanding interfacial interactions between liquid crystals and polymers at the nanoscale. A representation of the stages in the templating procedure is given in Figure 1.

This work focuses on templating of one of the most fascinating liquid crystal phases – the twist-bend nematic (N_{TB}) phase. Twist-bend nematic liquid crystals provide promising applications in fast-switching photonic and electro-optic devices. However, understanding the mechanical and electrical properties of this phase is difficult in conventional N_{TB} materials due to its high viscosity.[1–3] In this presentation, a detailed study of the elastic, dielectric and electro-optic behaviour of the templated N_{TB} phase refilled with a nematic mesogen will be discussed.

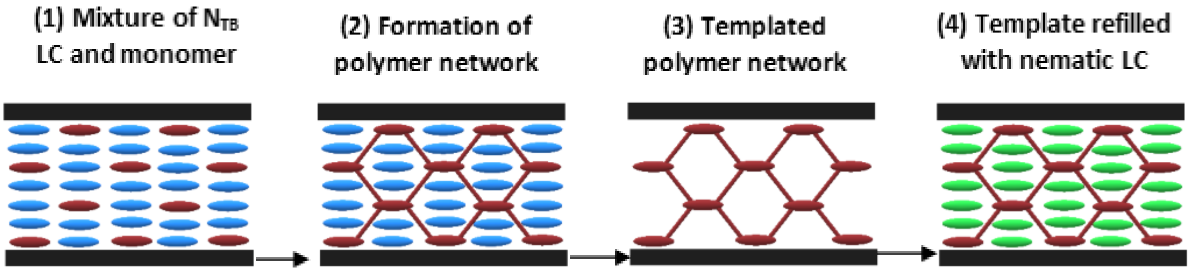

***Figure 1**: Schematic representation of the general templating procedure between two glass substrates.*

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Session 7:	**MATERIAL PHYSICS**	**Oral 26**
Title:	**Colossal barocaloric effects in liquid crystals**	
Presented by:	**G. F. Nataf**, Dept. of Materials Science & Metallurgy, University of Cambridge	
Other authors:	E. Stern-Taulats[1], J. Bermúdez-García[1], A. Avramenko[1], P. Lloveras[2], X. Moya[1] [1] Department of Materials Science & Metallurgy, University of Cambridge [2] Departament de Física, EEBE, Campus Diagonal-Besòs and Barcelona Research Center in Multiscale Science and Engineering, Universitat Politècnica de Catalunya, Barcelona	

Liquid crystals (LCs) have revolutionized visual display systems and play a key role in several technologies, but have been widely ignored by the research community working on caloric materials, despite LCs exhibiting the key ingredients required to achieve an outstanding barocaloric response.

Cooling is essential for perishable food, medicine, buildings and electronics. Current cooling technologies exploit large thermal changes that occur in fluids when driving liquid to gas phase transitions with pressure. However, these vapour-compression technologies are harmful to the environment and display low energy efficiencies[1]. By contrast, cooling based on pressure driven thermal changes in solids, i.e. barocaloric effects, promise novel environmentally friendly cooling technologies with high energy efficiencies close to the thermodynamic maximum limit[2]. While several major breakthroughs have been recently reported, solid barocaloric materials are still in their infancy, and their thermal response is still far from the performance of fluids, because they all operate at solid-solid phase transitions with limited pressure-induced changes in entropy.

Here I will describe barocaloric effects in LCs that show low values of hysteresis at their order-disorder phase transitions, and therefore large reversible values of barocaloric changes in entropy at low pressures. I will also report colossal barocaloric effects in LCs, reaching pressure-driven thermal changes close to those observed in fluids.

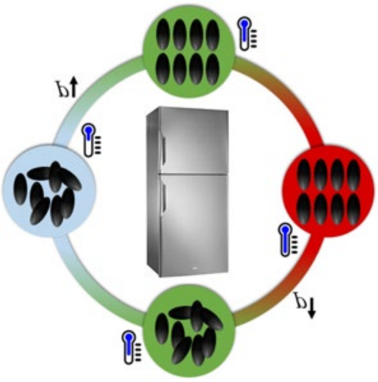

Figure 1. Schematic of pressure-driven thermal changes in a LC due to changes in the degree of ordering (changes in entropy). Black ellipsoids represent the molecules of the LC.

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Session 7: **MATERIAL PHYSICS** **Oral 27**

Title:

Triphenylene Discotic Liquid Crystalline Physical gels: predicting gelation and applications in optoelectronics

Presented by: **Ammar A. Khan,** Dept. of Physics, Lahore University of Management Sciences, Pakistan

Co-author: Sehrish Iqbal, Dept. of Physics, Lahore University of Management Sciences, Pakistan.

Discotic Liquid Crystals (DLCs) typically form columnar mesophases, stabilised by intermolecular pi-stacking and dispersive interactions. Physical properties such as high charge carrier mobility, controllable alignment and low working temperatures have made DLCs promising materials for optoelectronic applications and a considerable amount of research has been performed in this regard. Recently, another promising aspect and application of DLCs has emerged, their use as physical gelators in a solvent environment[1], [2]. It has been demonstrated that under favourable conditions, derivatives of triphenylene DLCs phase-separate from the solvent matrix to self-assemble into a three-dimensional network of interconnected supramolecular fibres. The fibre network constricts the bulk flow of the solvent, leading to the formation of a physical (non-covalently bonded) gel.

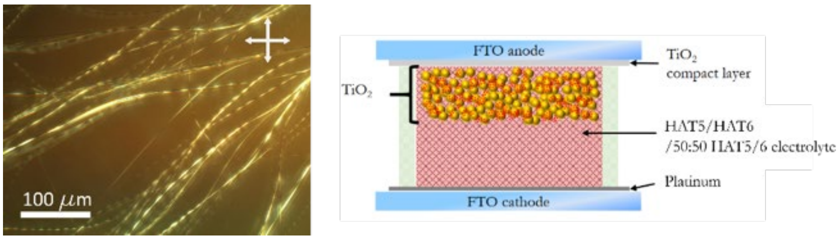

Figure 1. Optical Micrograph of a HAT6 physical gel electrolyte illustrating the fibre texture, and a schematic of a DSSC

In this work, we present recent progress on the application of 2,3,6,7,10,11-hexakis n-oxytriphenylene (HATn) DLCs in physical gels. It is demonstrated that HAT5 and HAT6 form stable gel phases in a wide range of solvents, whereas the longer chain HAT10 precipitates out. The Hansen Solubility parameter (HSP) approach is an empirical method of predicting solvation of a solute in a given solvent. Every molecule is given three parameters, based on the propensity of hydrogen bonding (δ_h), dispersive interactions (δ_d) and polarity (δ_p). Collectively the three parameters define a point in 'Hansen Space', and the distance between points can be used to predict solvation. We modify the HSP technique to predict gelation of DLCs in untested solvents. It is demonstrated that the technique is scalable and is also applicable to mixtures of solvents. Furthermore, the triphenylene DLC physical gels are applied as gel electrolytes in dye sensitized solar cells. One of the longstanding issues in DSSCs is the inherent instability of the liquid electrolyte used as a redox mediator due to solvent evaporation. Gel electrolytes are proposed as a possible solution to this challenge. We apply HAT5, HAT6 and a 50:50 HAT5/6 mixture as gelators in DSSCs. The gels extend device stability, and the mixture illustrates the highest power conversion efficiency. The latter is hypothesized to be a result of increased electron lifetime in the mesoporous titanium dioxide. The application of DLCs as physical gelators holds significant promise in optoelectronic devices, with a huge parameter space for understanding the microscopic driving mechanisms as well as optimizing physical properties for different device applications.

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2. A. A. Khan, M. A. Kamarudin, M. M. Qasim, and T. D. Wilkinson, "Formation of physical-gel redox electrolytes through self-assembly of discotic liquid crystals: Applications in dye sensitized solar cells," *Electrochim. Acta*, vol. 244, pp. 162–171, 2017.

Session 7:	MATERIAL PHYSICS	Oral 28
Title:	**Measurements of light induced order modification in liquid crystals**	
Presented by:	**Ethan I. L. Jull,** University of Leeds	
Co-author:	Helen F. Gleeson, University of Leeds	

The use of azo-benzene based materials (fig 1), which undergo a trans to cis isomerisation when irradiated with light of a specific wavelength, is firmly established in liquid crystal research. Their application in photo-patterning and bulk reorientation of director fields through the light induced molecular reorientation effect is widely utilised.

However, this light induced molecular reorientation effect is typically very slow. Another light induced phenomena that has scope in novel liquid crystal devices is the light induced order modification effect. This mechanism has been suggested as a photo-induced phenomena which can provide much faster response times[1] for photosensitive liquid crystal based devices[2].

The light induced order modification effect typically manifests itself in photo-induced phase transitions, however here we investigate the magnitude of the order modification quantitatively in real time.

This measurement is made possible through the combination of anthraquinone based dichroic dyes which give a direct measurements of the liquid crystal bulk order parameter. The light induced order modification effect is evaluated as a function of temperature and azo-dopant concentration. The quantitative description of the order modification will allow for further development of novel photosensitive mixtures and materials for new liquid crystal photoswitchable devices.

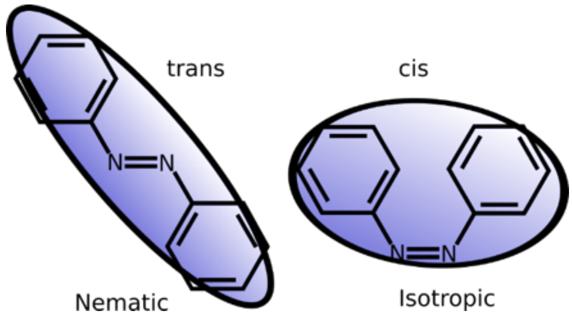

Fig 1: *The azo-benzene reversible photoisomerization process is shown. This conformal shape change disrupts the packing of the liquid crystal host, reducing the order of the system.*

The photo-switchable materials were provided through a collaboration with S. V. Serak and V. A. Grozhik, funded through INTAS-BELARUS N97-0635 (2001). The dichroic dues were provided by Richard Mandle and Stephen Cowling from the University of York. We are grateful for the continued use of these interesting optical materials.

1. Andrey Iljin, Light-induced order modification – The way to speed up, Journal of Molecular Liquids, **267**, pp.38-44, 2018.
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Session 8:	**CHEMISTRY**	**Oral 29**
Title:	**Sterically Hindered Lipids for Controlled Anchoring of Liquid Crystal Droplets**	
Presented by:	**Daniel A Paterson,** University of Leeds	
Other author(s):	Peng Bao, Sally A. Peyman, J. Cliff Jones, Jonathan Sandoe, Richard J. Bushby, Stephen D. Evans, and Helen F. Gleeson, University of Leeds	

Only recently have researchers begun to look into the effects of biological stimuli on Liquid Crystals (LC's) and in particular, the effects on alignment that give rise to interesting and informative optical changes. A series of studies have demonstrated LC materials with possible biological applications [1]. For example we have shown recently that lipid coated droplets are sensitive to the presence of Anti-microbial peptides [2]. A key challenge in designing LC materials for such applications is tailoring the interfacial interaction between biological amphiphiles and LCs so that small changes in the surface interactions are able to promote a distinguishable optical response. Lipid coated LC films typically give homeotropic alignment [3], but recent studies have demonstrated the possibility of achieving planar alignment from tailor-made bolamphiphile units [4]. Although, research is still ongoing on LC anchoring at aqueous interfaces [5]. We here demonstrate the synthesis of novel Phosphatidylcholine (PC) lipids containing "bulky" end units and their ability to form lipid monolayers on LC droplets, figures 1,2. We demonstrate through coating of these lipids onto a variety of different LC droplets that we can achieve a degree of control over director orientation within the droplets.

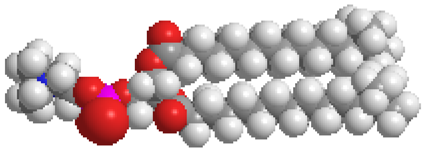

Figure 1. Example of the type of modified lipid used in this study.

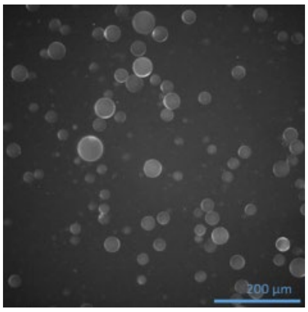

Figure 2. Fluorescence image showing the monolayer lipid coating of LC droplets.

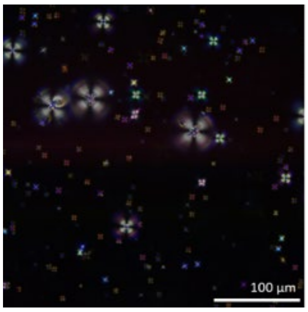

Figure 3. Radially aligned LC droplets between crossed polarisers.

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Session 8: **CHEMISTRY** **Oral 30**

Title:
The Colh-Colh Transition in LC Columns Self-Assembled from Wedge-Shaped Minidendrons; Insights from Theory and Simulation.

Presented by: **William S. Fall**[1,2]
[1] Science & Engineering, Xi'an Jiaotong University, China
[2]Department of Physics and Astronomy, University of Sheffield
Other authors: Ming-Huei Yen[3], Xiangbing Zeng[3], Liliana Cseh[4], Yongsong Liu[5], Gillian A. Gehring[2] and Goran Ungar[1,3]
[3]Department of Materials Science and Engineering, University of Sheffield
[4]Institute of Chemistry Timisoara of Romanian Academy, Romania
[5]Department of Physics, Zhejiang Sci-Tech University, China

Taper shaped mesogens, specifically dendrons, display an impressive array of LC phases formed from self-assembled sheets, columns or spheres. They usually comprise of an aromatic core with flexible pendant chains and are widespread as building blocks in supramolecular chemistry[1]. In this work we describe the discovery of an unusual transition between two mesophases of the same symmetry, i.e. hexagonal columnar (Col_h) phases, plane group *p6mm,* found in a series of 3,4,5-*tris*-benzoate salts of alkali metals, referred to as "minidendrons".

In the Col_h phase wedge-shaped molecules form supramolecular discs which stack into columns[2]; with increasing temperature these columns undergo continual lateral shrinkage while maintaining positive bulk expansion. This has been attributed to the continual shedding of molecules along the supramolecular column; where an optimal number of minidendrons per disc, <n>, exists at a given temperature[3]. We report a newly discovered phase transition in which the lateral shrinkage of the columns is first-order in nature[4], suggesting "molecular ejection", i.e. a quantised drop in the number of molecules in a supramolecular disc – see Figure 1.

This unique phenomenon can be modelled theoretically by breaking the inter/intra columnar interactions down into the intermolecular forces assumed responsible for column formation. The transfer matrix technique is employed with small additional mean field terms to account for long ranged interactions. The driving force behind the temperature-induced molecular ejection is the increased conformational disorder of the pendant chains, with a transition asymmetry arising from the local stability within the pure phase at low temperatures. Now new insights from theory and simulation suggest that a further transitional smoothing might occur with increasing length of the pendant chains from 12 to 18 carbons accompanied by a shift in transition temperature.

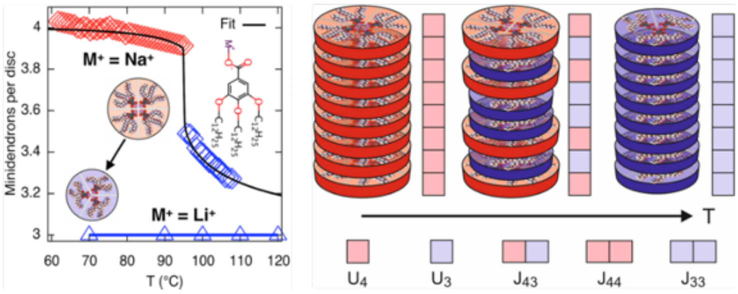

Figure 1: Left: Experimental number of minidendrons per supramolecular disc <n> for Na and Li salts 12Na and 12Li, along with the model fit curve for 12Na. Right: Model of interacting supramolecular discs of 3 or 4 minidendrons per disc showing the pure (4), mixed (43) and pure (3) phases with increasing temperature. The intra-disc interactions U_n, and inter-disc interactions J_{mn} are also indicated.

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Session 8:	CHEMISTRY	Oral 31
Title:	Top-down Estimation of Maier-Saupe Parameters in Nematic Conjugated Polymers	
Presented by:	**Kostas Ch. Daoulas,** Max Planck Institute for Polymer Research, Mainz, Germany	
Other authors:	Jaime Martin[1], Emily C. Davidson[2], Cristina Greco[3], Wenmin Xu[4], James H. Bannock[4], Amaia Aggire[1], John de Mello[4], Rachel A. Segalman[2], Natalie Stingelin[5] [1]POLYMAT, University of the Basque Country, Spain; [2]University of California, Santa Barbara, USA; [3]Max Planck Institute for Polymer Research, Mainz, Germany; [4]Imperial College London, UK; [5]Georgia Institute of Technology, USA	

Morphologies with macroscopically aligned conjugated polymers are interesting[1,2,3] because of their useful electronic and optical properties. Nematic alignment in polymers can be investigated with Maier-Saupe (MS) models[4], which combine a worm-like-chain description of molecular architecture with anisotropic MS potentials.

In this work[5] we apply MS models to conjugated polymers and address the problem of their material-specific parametrization. We present a method for estimating the strength of the aligning potentials, expressed through a material-specific MS parameter. For this purpose, we combine experiments (polarized optical microscopy and spectroscopy) with numerical mean-field theory. Our calculations take explicitly into account effects of temperature on persistence length, which are neglected in previous studies. By considering three different materials and several chain lengths, we address polymers in the rod-like, semi-flexible, and flexible regime. To reproduce situations considered in earlier studies, we also estimate MS parameters assuming that the persistent length is not affected by the temperature.

Our study demonstrates[5] that subtle assumptions made on chain flexibility can interfere with estimations of MS parameters and can lead to qualitatively different results. This finding is important for applications where MS parameters are used[6] as a guide for designing conjugated polymers with improved alignment properties.

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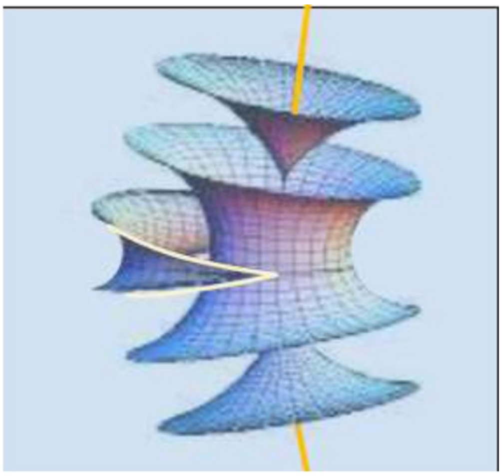
Session 8:	**CHEMISTRY**	**Invited 5**
Title:	**Focal Conics, Cyclides and controversy**	
Presented by:	**John Lydon**, Biological Sciences, University of Leeds.	



At the beginning of the 20th century, when Friedel and Grandjean [12] first used a polarising microscope to examine what we now know as smectic phases, they saw strange textures criss-crossed with patterns of dark lines, perfect ellipses and hyperbolae. With no X-ray diffraction evidence as a guide to the molecular arrangement, and with astounding insight, Friedel correctly predicted a phase composed of flexible molecular layers of constant thickness - and explained the lines in the optical textures in terms of the cyclide structures of Charles Dupin[3]-. Some years later a British mathematician offered a more analytical approach in a paper to Nature[4] which sparked off a long-forgotten international controversy.

This talk charts the richly-filled life of this mathematician, both beforehand - and in his subsequent career. And, although he met with some degree of success afterwards, this was his one foray into liquid crystals.

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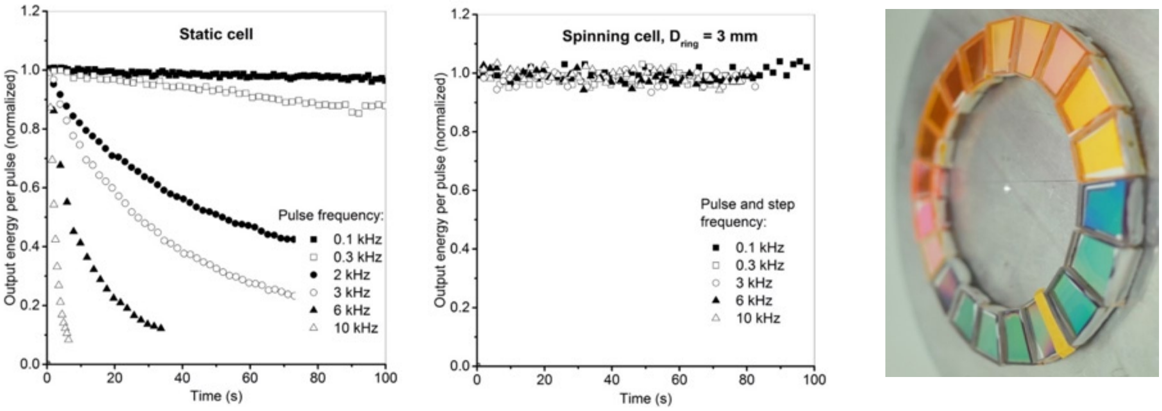
Poster Abstracts

Category:	**DEVICES**	**Poster 1**
Title:	**Improving repetition rates and tuning capabilities of liquid crystal lasers**	
Presented by:	**Calum M. Brown**, Institute for Integrated Micro and Nano Systems, University of Edinburgh	
Other authors:	Margaret C. Normand, Peigang Chen, and Philip J.W. Hands, Institute for Integrated Micro and Nano Systems, School of Engineering, University of Edinburgh	

Liquid crystal lasers (LCLs) are currently a prominent area of interest in photonics research. Their low-cost, ease of fabrication, self-assembling structure, high efficiencies (some up to 60%) and compact size make LCLs an appealing alternative to larger more expensive tunable systems [1]. There are, however, still several technological hurdles to overcome before viable commercialisation can be achieved.

One such issue is the current limitation of repetition rate. Above a certain pump repetition rate of ~100 Hz, the liquid crystal laser begins to lose efficiency due to optically and thermally induced instabilities [2]. Here we present the highest repetition rates yet achieved. A liquid crystal laser cell was mounted on a disk spinning at a step frequency of 10 kHz and enabled laser pumping at 10 kHz. This minimised energy degradation over time and yielded an average output power of ~3 mW [3].

Multi-wavelength tuning was achieved by mounting cells, each filled with dye-doped liquid crystals of different chiralities, around the circumference of the disk. Twenty different wavelengths were obtained with a rotation rate of 15 Hz and an effective pump frequency of 5 Hz.



(a) *(b)* *(c)*

Figure 1 a) Degradation of output energy with increasing pump pulse frequency, b) output energy for spinning cell at different pump frequencies [3] and c) reflective laser cells positioned on spinning disk [4].

References:

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3. Normand, M. C., Chen, P., Can, C. & Hands, P. J. W. Overcoming repetition rate limitations in liquid crystal laser systems. *Opt. Express* **26**, 26544–26555 (2018).
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Category:	**DEVICES`**	**Poster 2**
Title:	**Liquid crystal lasers for ophthalmics**	
Presented by:	**Daisy K. E. Dickinson**, University of Edinburgh	
Co-author:	Philip. J. W. Hands, University of Edinburgh	

Ophthalmic imaging currently utilises systems that probe the condition of the retina by visualising fluorescence or by injecting fluorescent dyes to generate angiograms. Autofluorescence is commonly used to detect biomarkers within the retinal pigment epithelium such as A2E, a fluorophore thought to be indicative of degenerative retinal diseases.[1] The assessment of ocular health requires lasers ranging the visible spectrum from lipofuscins (450 nm) to melanin (800 nm).[2] Current tuneable laser systems are extremely expensive, bulky and require extensive cooling systems and single laser portable devices would lack specificity. The necessity for a portable, continuously tuneable device is evident in this field.

The tuneable, self-assembling structure of LCs combined with organic dyes allows us to make lasers spanning the entire visible spectrum (450 – 800 nm).[3] The cost, size and relative ease of production of these cells makes them attractive for potential utilisation in fluorescence imaging in this context. The ability to switch between specific wavelengths designed to image clinically relevant biomarkers could shorten diagnosis time and reduce the need for large numbers of bulky equipment.

Lasing in cholesteric liquid crystal systems was achieved experimentally in 1980[4] however, as of yet, there have been no successful applications for these lasers. Here we discuss the potential integration of liquid crystal lasers (LCLs) into ophthalmic applications.

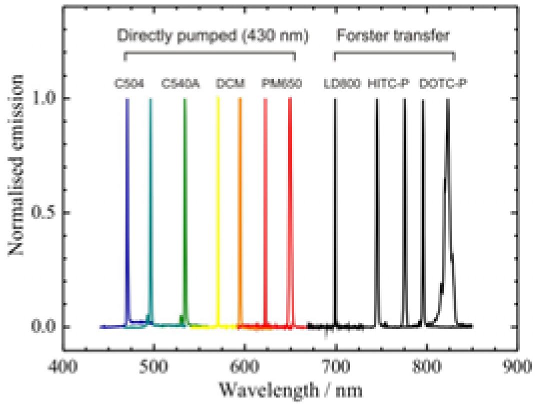

Figure 1. Spectral range from different lasers showing accessible wavelengths from visible to near-infrared.[3]

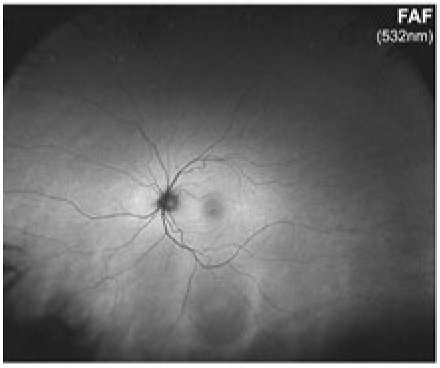

Figure 2. Fundus Autofluorescence ultra-wide field image. [2]

References:

1. Kennedy. C J, Rakoczy. E, Piroska, J and Constable. I, “Lipofuscin of the retinal pigment epithelium,” *R. Coll. Ophthalmol.*, 1995, **12**, 763–771.
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Category:	DEVICES	Poster 3
Title:	**Wide area measurements of photo-active liquid crystal cells**	
Presented by:	**G. D'Alessandro**, Mathematical Sciences, University of Southampton	
Other authors:	O. Buchnev, M. Kaczmarek, Physics and Astronomy; N. Podoliak, Mathematical Sciences – University of Southampton.	

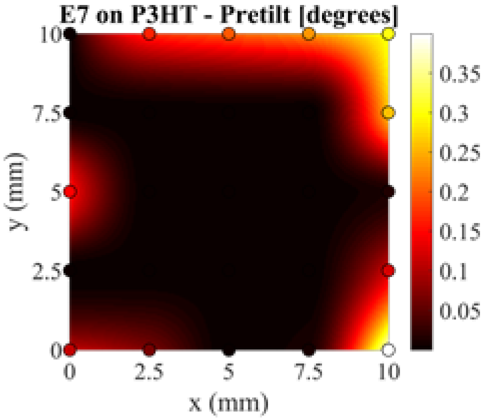

Figure 1 - Average pretilt (in degrees) in a cell filled with E7 and aligned with the photo-voltaic polymer P3HT.

The performance of liquid crystal devices is determined by a large number of parameters. Some are intrinsic properties of the liquid crystal, either in pure form or as a colloidal suspension, e.g. the elastic constants and the viscosity coefficients. Others characterize the interaction between the liquid crystals and the surfaces that contain them: examples are the anchoring energy and the pretilt angle. We have developed an experimental and modelling procedure to measure these properties over the whole cell area and have built a self-contained, portable prototype, the Optical Multi-Parameter Analyzer (OMPA), to perform such measurements quickly and reliably. Its performance was tested for planar, nematic liquid crystal cells. The idea at the heart of the device is to measure the cross-polarized intensity across the whole device area as a function of the frequency and amplitude of the voltage applied to the cell. The data are fitted using an Ericksen-Leslie model to determine the device and liquid crystal parameters. Point-wise measurements give us the elastic constants, the pretilt angle, the cell thickness and a set of Leslie viscosities[1]. The OMPA collects data from across the cell surface, allowing us to draw maps of the cell thickness and of the pretilt angle. Statistical bootstrapping applied to the whole cell data gives reliable confidence intervals for the liquid crystal parameters[2].

Here we present some results of our analysis of cells with photo-active layers, e.g. photo-aligning and photo-conductive materials. For example, we have measured the uniformity of the alignment on photo-voltaic materials (see Figure 1) and the relative impedances of photo-conductive and liquid crystal layers as a function of the incident light intensity[3].

References:

1. Bennett TP, Proctor M, Kaczmarek M and D'Alessandro, G, Lifting degeneracy in nematic liquid crystal viscosities with a single optical measurement, *J. Colloid Interface Sci.* 2017, **497** , 201-206.
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Category: DEVICES **Poster 4**

Title:

Polarisation-Independent Liquid Crystal Devices by Embossed Reactive Mesogens

Presented by: **Markus Wahle**, School of Physics and Astronomy, University of Leeds

Co-author: J Cliff Jones, School of Physics and Astronomy, University of Leeds

Reactive mesogens (RMs) have found their way into different branches of science and application. They can be processed as standard liquid crystals and can then be polymerised to stabilise their shape and anisotropic properties[1]. Their birefringence is used in optical compensation films while the complex director field is exploited for actuators. However, creating complex shapes while maintaining good alignment is a challenge in these applications. In the present work, the embossing of reactive mesogens is introduced. Embossing is a fast and large-scale method, which allows to form a large variety of structured reactive mesogen devices. To create a polarisation-independent lens, two birefringent Fresnel zone plates (FZPs) are embossed (Fig. 1a-d). A lens is formed by assembling the FZPs in a twisted nematic cell and filling the cell with a nematic crystal index matched to the RM (Fig. 1e,f). The device can be switched from a non-focusing to a focusing state by applying a small voltage. To reach efficiencies beyond 50%, multilevel Fresnel lenses are presented. While the described device is a switchable lens, the general principle can be applied to a multitude of polarisation-independent devices such as gratings, prisms and microlens arrays.

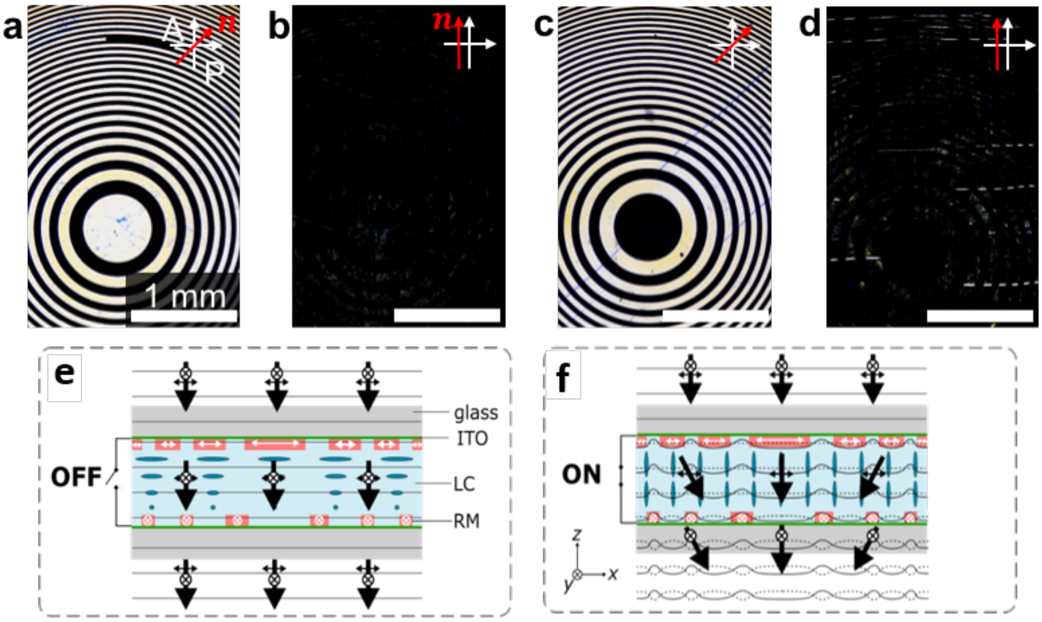

Figure 1. Polarising optical microscopy images of (a,b) a normal and (c,d) a complementary Fresnel zone lens embossed in reactive mesogen. (e,f) Principle of operation of a switchable polarisation-independent lens.

References

1. Wahle, M.; Snow, B. D.; Sargent, J.; Jones, J. C. Embossing Reactive Mesogens: A Facile Approach to Polarization-Independent Liquid Crystal Devices. Advanced Optical Materials. 2019, 7, 1801261.

Category: COLLOIDS **Poster 5**

Title:

Thermal treatment in chiral liquid crystal droplet generation towards sensing applications

Presented by: **Jason Norman**, School of Engineering, University of Edinburgh

Other authors: Margaret C Normand[1], Anne Pawsey[2], Davide Marenduzzo[2], Philip JW Hands[1]
[1]School of Engineering, University of Edinburgh
[2]School of Physics and Astronomy, University of Edinburgh

Due to their alignment sensitive optical properties, chiral liquid crystal droplets have been shown to form a useful platform in several applications including chemical sensing[1] and laser emission[2]. Currently the most reliable method for producing monodisperse droplets is via microfluidic devices[3], where liquid crystal is flowed in conjunction with an immiscible fluid to form a dispersed liquid crystal phase.

For droplet-based chemical sensing applications, there is a strong need for uniformity between droplets in terms of size and molecular alignment in order to ensure consistent response characteristics; however, due to the viscoelastic nature of liquid crystal phases, producing highly uniform droplets quickly and on-demand remains difficult as transient effects exist which often require in excess of an hour to stabilise. Therefore, improving the capacity of microfluidics to produce monodisperse, well aligned liquid crystal droplets is crucial to realising any chemical sensing application.

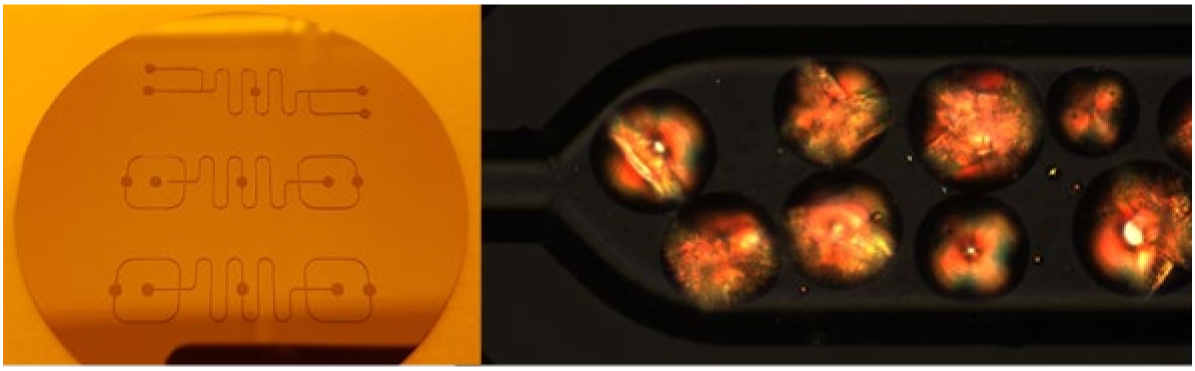

Figure 1 Microfluidics moulds prototyped using maskless lithography (left); Polydisperse chiral liquid crystal droplets in a microchannel (right).

Here, an investigation into thermal treatment of chiral liquid crystal droplets both during and after the generation stage is presented and discussed in the context of improving droplet consistency and reducing lead times with a view towards droplet-based chemical sensing.

References:

1. Lee H, Munir S, Park S. Cholesteric liquid crystal droplets for biosensors. *ACS Appl Mater Interfaces*. 2016, **8** (39), 26407-26417.
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Category:	**COLLOIDS**	**Poster 6**
Title:	**How does preparation of graphene oxide affect its liquid crystal properties?**	
Presented by:	**Adam Draude**, University of Manchester	
Other authors:	Robert M. Richardson, University of Bristol Aravind Vijayaraghavan, University of Manchester Ingo Dierking, University of Manchester	

Since their discovery at the start of this decade,[1] there has been increased interest in the colloidal lyotropic liquid crystals formed by two-dimensional materials in isotropic solvents. In particular, the study of graphene oxide in polar aprotic solvents has garnered the most interest.[2] However, many questions still remain, and some results seem contradictory to expected behaviours. In particular, the phase diagram of graphene oxide liquid crystals is often theoretically described using a system of ridged plate-like particles with little or no polydispersity.[3,4] Our results show that for the most common methods of producing these liquid crystals, this approximation is not an appropriate one. Furthermore, Kim et al.[5] have reported that graphene oxide liquid crystals can be aligned using magnetic fields, in contrast to our findings. Methods of material preparation and characterization are key to accounting for discrepancies in the literature, and these will be discussed in detail.

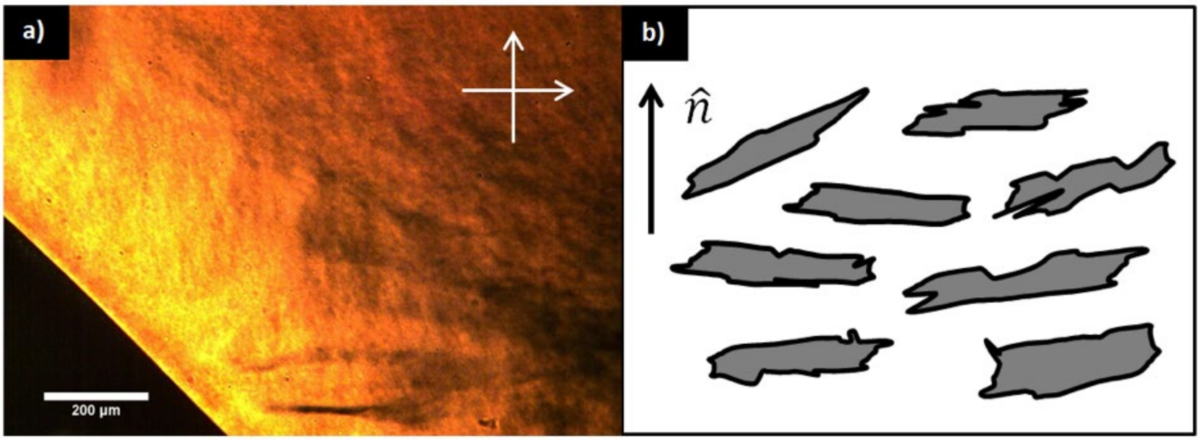

Figure 2. (a) Polarized optical microscopy image of a dispersion of graphene oxide (GO) in dimethylformamide. (b) Schematic showing the orientational alignment of GO sheets, along with the resultant director.

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5. Kim, J. E. *et al.* Graphene oxide liquid crystals. *Angew. Chemie - Int. Ed.* **50,** 3043–3047 (2011).

Category: COLLOIDS **Poster 7**

Title: Chaotic dynamics in a 2D active nematic

Presented by: **Linda S. Hirst**, Dept of Physics, University of California, USA

Other authors: Amanda Tan, Eric Roberts, Spencer Smith and Kevin Mitchell, Dept of Physics, University of California, USA

Recent years have seen a surge of interest in active materials, in which energy injected at the micro-scale gives rise to larger-scale coherent motion. One prominent example is an active 2D liquid crystal composed of microtubules in the nematic phase. We investigate a system composed of biopolymers (microtubules) and molecular motors (kinesin). The kinesin motors crosslink bundles of microtubules and as the motors hydrolyze ATP, they walk along the microtubule bundles, forcing the bundles to extend away from each other. When confined in 2D at an oil-water interface, the network forms an active nematic phase with topological defects that are continuously created and annihilated. The resulting 2D fluid flow exhibits self-generated mesoscale chaotic dynamics with a characteristic folding and stretching pattern.

We use fluid dynamics concepts to characterize this novel fluid by measuring the mixing efficiency, or topological entropy of the system on different length-scales. We analyze the system dynamics in the context of chaotic advection, in which the fluid can be viewed as "stirred" by the topological defects in the nematic order parameter.

To measure topological entropy on a local scale we couple beads directly to microtubules and track their separation curves. The separation between beads in the material is exponential. A similar analysis is carried out using defect tracking. We use these trajectories to measure the rate of separation in the material and thereby to calculate the topological entropy. In addition, we change the local stretching rate by varying the ATP concentration to study how changing the energy input on the microscale changes the global mixing efficiency.

As a global measure of mixing, we compute the topological entropy from defect braiding and show that all of the entropy arises from the positive one-half defects; the negative one-half defects, which are also present, contribute nothing to the entropy.

Our calculations show that the topological entropy generated by defect braiding (virtual stirring) can be understood as a direct consequence of the micro-scale stretching.

Category:	**LYOTROPICS**	**Poster 8**
Title:	**Lipid-based nanoparticles for controlled release of bioactives**	
Presented by:	**Zexi Xu**, School of Food Science and Nutrition, University of Leeds	
Other authors:	Michael Rappolt, School of Food Science and Nutrition, University of Leeds, Paul Beales, School of Chemistry, University of Leeds, Arwen Tyler, School of Food Science and Nutrition, University of Leeds	

Lipids form a variety of lyotropic liquid crystalline phases (LLCs) when mixed with solvents, including the fluid lamellar (L_α), hexagonal (H_{II}), and micellar cubic (Fd3m) phases, which have attracted enormous interest in applications such as drug delivery and biosensing[1-3]. When bioactives are incorporated into these lipid structures, release is known to occur via diffusion through the water channels of curved lipid phases, and the symmetry of the phase as well as the geometry and dimensions of the water channels can alter the release profiles. One of the major bottlenecks that has hindered exploitation of the applications of LLCs is an inability to create targeted systems that respond to external stimuli leading to a structural change followed by controlled release. We focus on lipid nanocarriers that consist of micellar “pockets” (based on spacegroup Fd3m) engineered to encapsulate bioactives which, when exposed to a low pH environment, rearrange to an H_{II} phase to release the contained cargo. We have developed novel stimuli-responsive nanocarriers that respond to changes in pH to create an “on” and “off” release system by reversibly changing between LLC phases.

References:

1. Boyd, B. J., Dong, Y. D. and Rades, T. Nonlamellar liquid crystalline nanostructured particles: advances in materials and structure determination. *Journal of liposome research*, 2009, **19**(1), 12-28.
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Category: LYOTROPICS **Poster 9**

Systematic coarse graining of surfactant-polymer systems

Presented by: **Martin Walker**, Department of chemistry, University of Durham

Other authors: Erte Xi, Procter and Gamble, Cincinnati, Ohio
Mark Wilson, Department of chemistry, University of Durham

Lyotropic liquid crystals is an established field, which continues to be the largest commercialisation of liquid crystals, however, many challenges still exist in explaining their fundamental behaviour[1,2]. Manybody Dissipative Particle Dynamics (MDPD) is a mesoscale simulation technique that employs both pair wise interactions and a local density interaction to encompass three body terms[3]. Potentials that are dependent on a local density naturally lend themselves to exploring phenomena at the vapour-liquid surface, where the particle density will change dramatically across the interface. Coupling this with the soft potentials used by MDPD that provide access to the millisecond time scale, make MDPD ideal for probing some of the complex behaviour that can occur at phase boundaries.

The work presented in this poster focusses on systematically parametrising MDPD for simulating complex mixtures of surfactants, additives and polymers, the basic ingredients of a laundry liquitab.

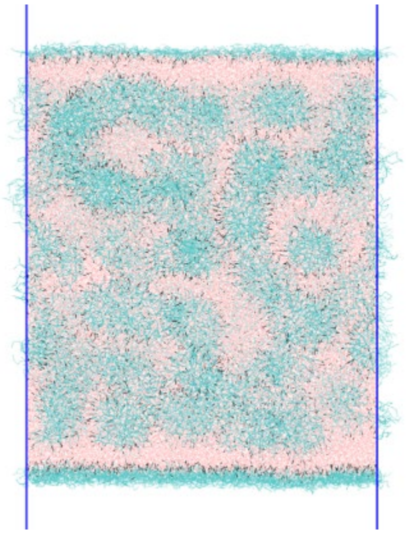

Figure 1. An MDPD simulation of a surfactant-water film

References:

1. Pershan, P. S. *Physics Today*, 1982, **35**, 5, 34.
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3. Warren P. B., *Phys. Rev. E,* 2003,**68**, 066702

Category:	**LYOTROPICS**	**Poster 10**
Title:	**Coarse-Grained Modelling of a Pseudoisocyanine Dye for the Simulation of Self-Assembled Aggregates in Solution**	
Presented by:	**Gary Yu**, Durham University	
Co-author:	Mark R. Wilson, Durham University	

Cyanine dyes are known to form large-scale aggregates in solution via spontaneous self-assembly. These aggregates often display interesting optical properties dependent on the structure of the aggregate. In particular, pseudoisocyanine (PIC) dyes exhibit a bathochromic shift (J-band) with a shift to a longer wavelength upon formation of a J-aggregate in aqueous solution.[1] Self-assembly of PIC dyes is akin to chromonic liquid crystals, which aggregate into stacks in solution. There are two dominant modes of alignment within these aggregates: direct stacking of molecular cores in H-aggregates and offset, staggered stacking in J-aggregates.[2] These motifs can form further complex structures such as double columns, hollow chimneys and brickwork structures as suggested in the literature.[3,4] Furthermore, cryo-TEM studies on the J-aggregate structure of PIC chloride show a rod-like morphology in its superstructure leading to a network of fibers.[5]

In order to explore the structure of J-aggregates, at the molecular level and beyond, molecular simulation methods have been employed to study PIC chloride. Atomistic level molecular dynamics simulations provide insight into the local structure and formation of stacks. In order to access larger time and length scales, a coarse-grained simulation approach may be used; where multiple atomistic sites can be combined to a single interaction site. The aim of this approach is to reduce the degrees of freedom whilst retaining the essential properties of the molecules. To this effect, bottom-up coarse-graining methods (parametrisation from atomistic reference simulations) have been applied in an attempt to simulate the hierarchy of self-assembled structures present in PIC dyes.

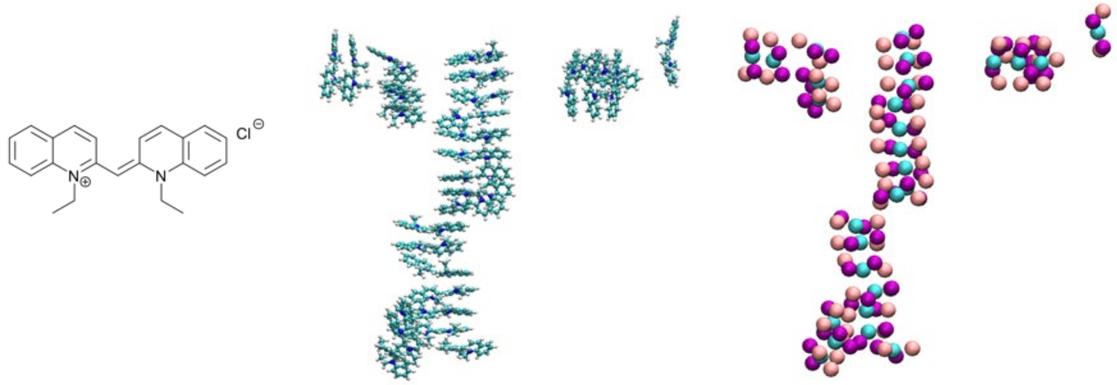

Figure 1: Molecular structure of PIC chloride (left), snapshot of an atomistic simulation (centre)

References:

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Category:	LYOTROPICS	Poster 11
Title:	**CTAB stabilized reduced graphene oxide (rGO) lyotropic systems**	
Presented by:	**Yizhen Shao**, School of Materials, University of Manchester	
Other authors:	Aravind Vijayaraghavan, School of Materials, University of Manchester; Ingo Dierking (School of Physics and Astronomy, University of Manchester	

Graphene oxide (GO) dispersed in water spontaneously forms lyotropic liquid crystal phases as a function of GO concentration. Liquid crystalline self-organization forms systems which macroscopically assembled GO sheets which exhibit long-range orientational ordering. However, the oxygen-containing functional groups of GO cause the graphene sheets to lose most of their electrically conducting properties. Reduction of GO has the advantage to recover functionalities, but the strong π–π stacking tendency of reduced graphene oxide (rGO) sheets in water, or most polar solvents, leads to the formation of irreversible agglomerates without liquid crystalline ordering. Significant advances in achieving stable graphene/rGO dispersions have been made by using capping reagents (polymers or surfactants)[1,2]. Here we present an approach for achieving lyotropic systems by surfactant-stabilization of rGO in an aqueous environment. The addition of surfactants at appropriate conditions is used to accelerate the chemical reduction of GO and then stabilizes the formed rGO sheets to remain suspended while exhibiting liquid crystallinity.

The cationic surfactant cetyl trimethyl ammonium bromide (CTAB) was used to stabilize rGO and form lyotropic systems, with a reducing agent sodium ascorbate (SA). In water, CTAB molecules can self-assembly into micelles and form different lyotropic phases. When the micelles co-exist with ascorbate anion (A^-), the A^- can be attracted and concentrated around the micelles due to electrostatic interaction, as well as the GO sheets[3]. Consequently, the reaction probability is enhanced and the reduction process is accelerated (Figure 1). When the reduction process is completed, CTAB acts as a stabilizer and a stable dispersion of rGO forming lyotropic liquid crystalline state is achieved.

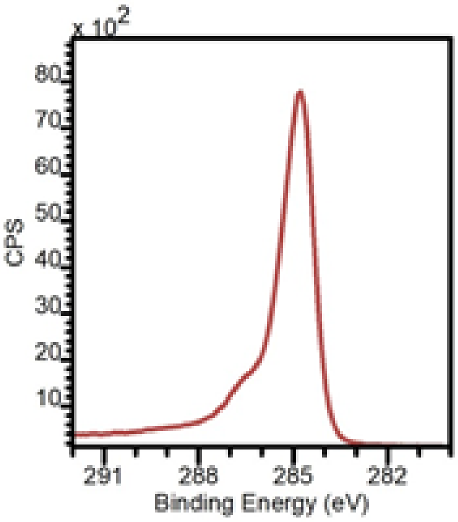

Figure 1. C1s XPS spectra of reduced graphene oxide

References:

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2. Zamora-Ledezma, Camilo, et al. "Liquid crystallinity and dimensions of surfactant-stabilized sheets of reduced graphene oxide." The journal of physical chemistry letters 3.17 (2012): 2425-2430.
3. Pal, Tarasankar, et al. "Organized media as redox catalysts." Langmuir 14.17 (1998): 4724-4730.

Category:	LYOTROPICS	**Poster 12**
Title:	**Coarse-grained simulations of chromonic liquid crystals**	
Presented by:	**Thomas Potter**, Department of Chemistry, Durham University	
Co-author:	Mark Wilson, Department of Chemistry, Durham University	

Coarse-grained modelling is a valuable tool for the study of liquid crystals. It is able to bridge the gap between atomistic and mesoscopic simulations, by allowing the study of relatively large systems over large timescales, while retaining chemical specificity. However, parametrising such models presents a number of challenges. This is particularly true for chromonic liquid crystals where a subtle balance between hydrophilic and hydrophobic interactions is required for the correct behaviour to be observed. We have previously published top-down coarse-grained models (parametrised from experimental data) using the MARTINI and SAFT approaches.[1] Both models exhibited chromonic stacking, but the stack structure and aggregation free energies did not match experimental and atomistic results.

Here, we present the results of simulations of the non-ionic chromonic liquid crystal, TP6EO2M, using the MARTINI 3 force field. This force field is a totally reparametrised version of the MARTINI model, which includes new bead types and sizes. First, we show that the new model significantly improves upon the representability of our original MARTINI and SAFT models of the system. Stacking distances and aggregation free energies now show good agreement with atomistic simulations. This improved accuracy in small-scale simulations encouraged us to scale up the model.

We present large-scale simulations carried out at a range of concentrations, using system sizes which would not currently be possible for atomistic simulations. At lower concentrations the nematic phase is seen, while at higher concentrations we see the hexagonal columnar phase; this shows good agreement with the concentration dependence of the experimental phase diagram. These are the first simulations of chromonic liquid crystal phases using systematic coarse-grained modelling. Ultimately, they paves the way for this methodology to be used for other systems, and for coarse-grained simulations to be used predictively for chromonic liquid crystals.

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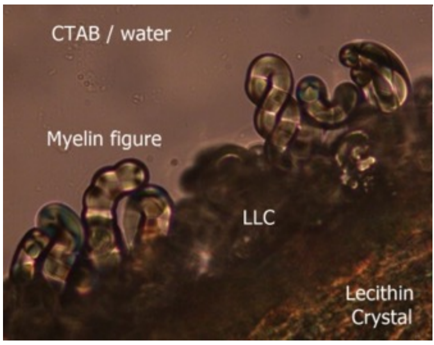
Category: LYOTROPICS **Poster 13**

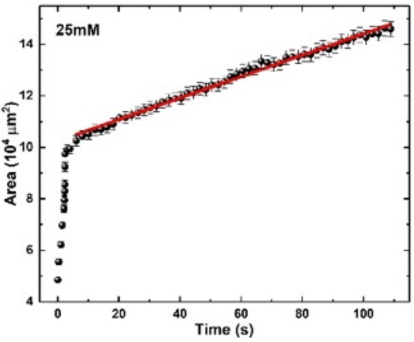
Title:
Growth of lecithin-CTAB Myelin figures

Presented by: **Bianca Marcucci**, School of Physics and Astronomy, University of Manchester

Co-author: Ingo Dierking, School of Physics and Astronomy, University of Manchester

Lyotropic liquid crystals (LLCs) are often found in living organisms, in the form of cell membranes, or the protective myelin membranes that cover nerve cells. They are thus a vital component of the brain and the central nervous system. When amphiphilic molecules come into contact with water, lyotropic lamellar structures form (L_α phase of LCs), depending on concentration. These often exhibit growth of writhing structures known as myelin figures. These are high viscosity, gel-like microtubes made up of an inner water layer surrounded by alternating amphiphile and water layers (Fig.1).





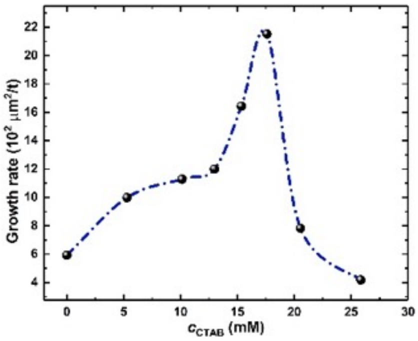


Fig1.(left): Microscopic image of the growth of Myelin figures (length: approximately 70 µm).

Fig.2(middle): Exemplary demonstration of linear Myelin area growth as a function of time (CTAB concentration of 25 mM).

Fig.3(right): Growth rate as a function of CTAB concentration in water as a solvent in contact with lecithin.

By relating the myelin growth rate to the spatial gradient of the local water fraction in the lamellar structure, Zou[1] predicted a $L(t) \propto t^{1/2}$ growth law suggesting a linear dependence of LLC area on time. This was confirmed for the thermotropic smectic A liquid crystal 8CB by Peddireddy et al.[2], using cetyltrimethylammonium bromide (CTAB) solutions. The authors discussed the LC area growth rate as the concentration of CTAB in water was increased, finding potential indications of a maximum growth rate, which was unfortunately only poorly resolved as a function of concentration. Because of the scarcity of the data reported, the behaviour of the growth rate is not known to a sufficient degree of precision. We investigated the growth rate of lyotropic myelin figures in the relevant concentration range, using lecithin as the LLC and CTAB/water as the solvent. Investigations were carried out by time resolved image acquisition and analysis of the growth process after the CTAB/water solvent was brought into contact with a small amount of lecithin. Growth was analyzed with a time resolution of 50 ms and the predicted linear area growth was confirmed (Fig.2). The growth rate as a function of CTAB in water concentration was found to increase until saturation, which was then followed by a steep rise before the final drop(Fig.3). The investigations provide clear evidence that the growth dynamics of the thermotropic smectic A phase and the lyotropic L_α phase follow a universal mechanism.

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1. L.-N. Zou, *Phys. Rev. E*, **79**, 061502, (2009).
2. K. Peddireddy, P. Kumar, S. Thutupalli, S. Herminghaus, and C. Bahr, *Langmuir*, **29**, 15682, (2013).

Category: LYOTROPICS **Poster 14**

Title:

Cholesteric liquid crystal droplets with lipid modification: towards novel biological sensors

Presented by: **Xiaoxue Du**, School of Physics & Astronomy, University of Leeds

Other authors: Richard Bushby, Daniel Paterson, Peng Bao, Sally Peyman, J. Cliff Jones, Jonathan Sandoe, Steve D. Evans and Helen F. Gleeson, School of Physics & Astronomy, University of Leeds

We describe the preparation of cholesteric liquid crystal (CLC) droplets with the aim of producing biological sensors. The director alignment in the droplets is sensitive to the surface orientation, and linking this sensitivity to responsivity of the surface to biological materials provides a mechanism of sensing biological materials. Such an approach has already been described for nematic droplets, where the droplet geometry changes from radial to bipolar when a lipid coating is disrupted by scorpion venom [1]. However, the surface interactions are known to be complex and there is much that remains to be understood about the specific relationship between surface treatment of the droplets and the droplet director orientation.

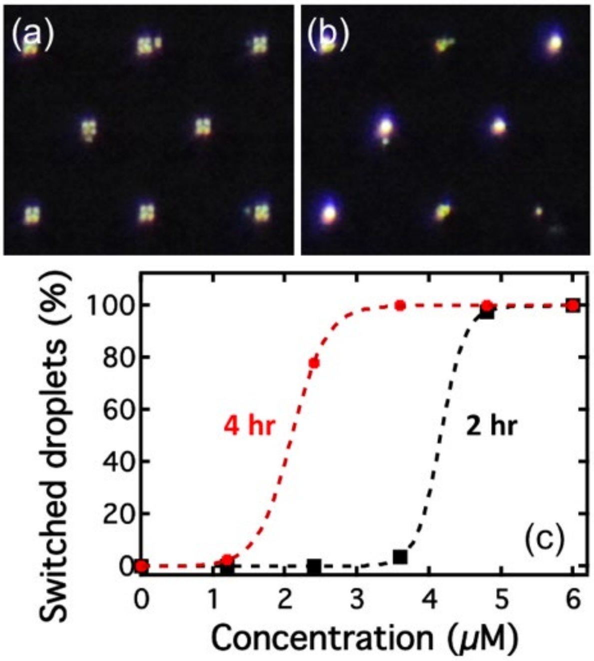
We consider the influence of four different lipids in modifying CLC droplets: 1-palmitoyl-2-dodecaneferrocenyl-sn-glycero-3-phosphocholine (MFPC), 1,2-didodecaneferrocenyl-sn-glycero-3-phosphocholine (DFPC), 1,2-dineopentadecane-sn-glycero-3-phosphocholine (DnPdPC) and 1,2-dioleoyl-sn-glycero-3-phosphocholine: 1,2-dioleoyl-sn-glycero-3-[phospho-rac-(1-glycerol)] (DOPC: DOPG). A complementary study has shown that the different lipids have distinct influences on nematic droplets, with the director configuration varying from radial to bipolar [2]. However, for sensors, CLC droplets are, in principle advantageous as the change in director orientation should be readily visible through selective reflection from the droplet. We compare the performances of lipids on CLC liquid crystal droplets in which we have taken into consideration the helical pitches, droplets sizes and types of lipid.

References:

1. P. Bao et al., Lab on a Chip. 2019 (DOI: 10.1039/C8LC01291A).
2. D. A. Paterson et al., Oral 29, BLCS 2019.

Category:	LYOTROPICS	**Poster 15**
Title:	**Lipid coated liquid crystal droplets for the on-chip detection of AMPs**	
Presented by:	**Peng Bao,** School of Physics and Astronomy, University of Leeds	
Other authors:	Daniel A Paterson[1], Patrick L Harrison[2], Keith Miller[3], Sally Peyman[1], J Cliff Jones[1], Jonathan Sandoe[4], Stephen D Evans[1], Richard J Bushby[1], Helen F Gleeson[1] [1]School of Physics and Astronomy, University of Leeds [2]Department of Chemistry and Biochemistry, University of Hull [3]Biomolecular Research Centre, Sheffield Hallam University [4]Leeds Institute of Biomedical & Clinical Science, University of Leeds	

We describe a novel biosensor based on phospholipid-coated nematic liquid crystal (LC) droplets and demonstrate the detection of Smp43, a model antimicrobial peptide (AMP) from the venom of North African scorpion *Scorpio maurus palmatus*. Mono-disperse lipid-coated LC droplets of diameter 16.7 ± 0.2 μm were generated using PDMS microfluidic devices with a flow-focusing configuration and were the target for AMPs. The droplets were trapped in a bespoke microfluidic trap structure and were simultaneously treated with Smp43 at gradient concentrations in six different chambers. The disruption of the lipid monolayer by the Smp43 was detected (< 6 μM) at concentrations well within its biologically active range, indicated by a dramatic change in the appearance of the droplets associated with the transition from a typical radial configuration to a bipolar configuration, which is readily observed by polarizing microscopy. This suggests the system has feasibility as a drug-discovery screening tool. Further, compared to previously reported LC droplet biosensors, this LC droplet biosensor with a lipid coating is more biologically relevant and its ease of use in detecting membrane-related biological processes and interactions has the potential for development as a reliable, low-cost and disposable point of care diagnostic tool.



(a) and (b) are typical images of arrays of droplets in traps under polarizing microscopy before and after Smp43 (4.8 μM) treatment, respectively. The images clearly show the switching from radial to bipolar states ((a) and (b) respectively). (c) The percentage of switched LC droplets, after two hours (black squares) and four hours (red dots) as a function of Smp43 treatment at different concentrations. The dashed lines are fits to these two sets of data using Sigmoid function. In this case, the concentrations that show full switching are 4.8 and 3.6 μM for the two-hour and four-hour treatment, respectively.

Category: LYOTROPICS **Poster 16**

Title:

Cross-polarised microscopy studies of diffusive hydration in phytantriol lyotropic mesophases.

Presented by: **Nisrin Alnaim,** Department of Physics, University of Bath

Other authors: Adam Squires and Kei Takashina, Department of Physics, University of Bath

Phytantriol is a well-known amphiphilic lipid which self-assembles into a range of mesophases, such as the bicontinuous cubic phase. These phases that are stable in excess water can be exploited as a template for generating hard nano-materials and have also found application in cosmetic products and drug delivery[1,2]. However, research into specific phases that are not stable in excess water, is relatively limited.

In this contribution, we address the dynamic hydration of phytantriol mesophases as a function of time. Cross-polarized optical microscopy is exploited to track the position of boundaries between optically active and inactive phases. Specifically, boundaries representing lyotropic transitions to and from the lamellar phase (L_α, (transitions $L_2 \rightarrow L_\alpha$ and $L_\alpha \rightarrow Q^{230}$)) are analysed and their displacements are found to evolve as $t^{1/2}$, reflecting a diffusive transport of water. This enables us to quantify the propagation of each boundary by a diffusivity constant *D* using a simple diffusive model[3].

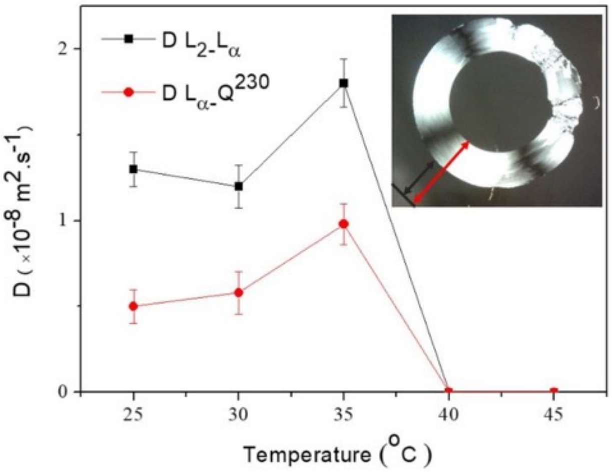


Figure 3. Diffusion constant D as a function of temperature, for mesophases transitions $L_2 \rightarrow L_\alpha$ and $L_\alpha \rightarrow Q^{230}$ *. The insert image shows a cross-polarised microscopy image of a droplet of phytantriol held between two glass slides that was hydrated for 20 hours at temperature 25°C. The black line marks the edge of droplet and black and red arrows represent the distance from the edge to the mesophase boundaries for transitions* $L_2 \rightarrow L_\alpha$ *and* $L_\alpha \rightarrow Q^{230}$ *respectively.*

This diffusivity *D* was measured at various temperatures, as shown in figure 1. Surprisingly, the diffusivity drops down at temperatures 40°C and 45°C and the droplet appears to cease hydrating from its boundary. This is well below the temperature where the hexagonal excess water phase would be expected around the droplet periphery and suggests the possibility of an unidentified water-blocking mesophase.

Acknowledgements

Nisrin Alnaim acknowledge financial support from the Ministry of Education in Saudi Arabia, and Saudi Arabian Cultural Bureau in London for making it possible to undertake this work.

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2. Barauskas, Justas. & Landh, Tomas. Phase behavior of the phytantriol/water system. *Langmuir*. 2003, **19** (23), 9562-9565.
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Category:	**NOVEL COMPOUNDS**	**Poster 17**
Title:	**Dendritic Liquid Crystal Amphiphiles**	
Presented by:	**James Brailey-Partridge**, University of York	
Other authors:	Tiantian Ma and Isabel M. Saez, University of York	

The process of self-organisation and self-assembly in amphiphilic liquid crystals is responsible for the specific mesophase structure.[1] Control of the self-assembling behaviour is thus realised through molecular engineering. Supermolecular and dendritic liquid crystals are materials displaying several liquid crystalline sub-units attached to a central scaffold through a flexible alkyl chain spacer, in which the modular design allows a variety of parameters (mesogenic group, dendritic branches, branching multiplicity, nature of the core, spacer length) to be investigated with regards to the self-organization and resulting mesophase structure.[2] Previously we have reported Janus dendritic liquid crystals, featuring opposing mesogens (A, B, Figure 1) (promoting either nematic, smectic or columnar liquid crystal phases) linked via a flexible scaffold.[1,3]

Here we report a family of Janus dendritic liquid crystals that have been designed to feature hydrocarbon, fluorocarbon and cyanobiphenyl mesogenic units with varying multiplicities and opposed across a rigid central scaffold (Figure 1). Fluorocarbon and hydrocarbon groups provide an alternative source of mutually incompatibility which can provide complex mesophase morphologies when segregated within the same molecule.[4] This allows an investigation into the competing effects of molecular curvature and nanophase segregation on the mesophase type and structure. The liquid crystal properties of these materials are shown to depend upon the nature and multiplicity of the substituents forming the dendritic lobes at each side of the rigid core and the opportunity for nanophase segregation between them.

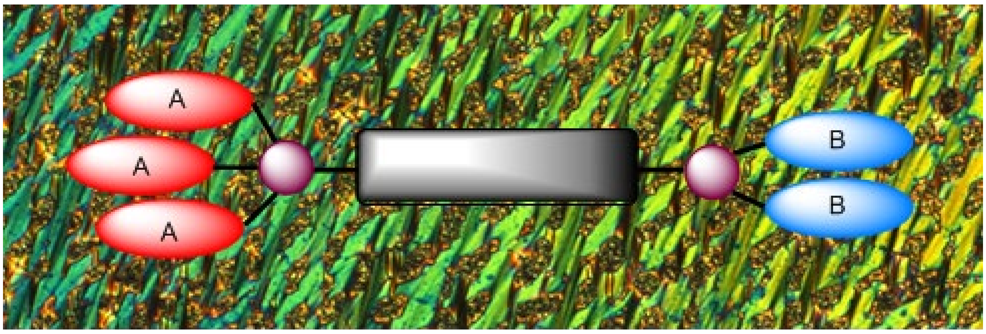

Figure 1. Schematic representation of an amphiphilic dendritic liquid crystal.

References:

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2. a) Q. Xiao, S. Zhang, Z. Wang, S. Sherman, R.O Moussodia, M. Peterca. A. Muncan, D. Williams, D. Hammer, S. Vértesy, S. André, H. Gabius, M. Klein and V. Percec V. *Proc. Natl. Acad. Sci. U. S. A.*, 2016, **113**, 5, 1162. b) H. Sun, S. Zhang and V. Percec, *Chem. Soc. Rev.*, 2015, **44**, 3900.
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Category:	**NOVEL COMPOUNDS**	**Poster 18**
Title:	**Investigating the twist-bend nematic phase in thioether linked liquid crystal dimers**	
Presented by:	**Ewan Cruickshank**, University of Aberdeen	
Other authors:	Professor CT Imrie and Professor JMD Storey, University of Aberdeen	

Dozov in 2001, predicted that banana-shaped molecules have a natural tendency to pack into bent structures. [1] Pure uniform bend is not allowed in nature and must be accompanied by a twist deformation of the director within a nematic phase giving rise to the twist-bend nematic phase. The twist-bend nematic phase was first observed in the mesogenic dimer CB7CB (1,7-bis(4-cyanobiphenyl-4'-yl)heptane) in 2011. [2] Since this discovery, a great deal of research has been conducted to understand the phase. While a number of mesogenic compounds have been synthesized utilizing a thioether linkage to the terminal group, [3] the number that utilize this linkage in the flexible spacer of dimers is limited. [4] In order to investigate the effect of altering the linker group on the twist-bend nematic phase, the series CBSnSCB (figure 1) has been synthesized. This series is compared to both the CBnCB series and CBOnOCB series which have been previously studied. [5]

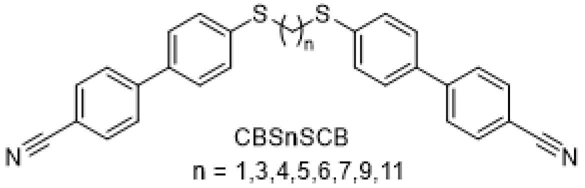

Figure 1: Molecular structure of CBSnSCB series.

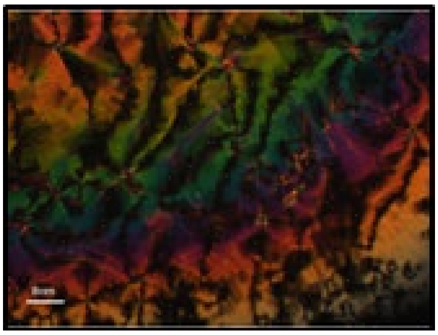

Figure 2: Blocky texture of CBS5SCB

The appearance of the twist-bend nematic phase (figure 2) in molecules with odd membered spacers followed the observations of the other series mentioned. However interestingly, the thioether linker provided less of a destabilizing effect on the twist-bend nematic phase when compared to the ether linkage, as well as also providing lower N-N_{TB} transition temperatures when compared to the methylene linked equivalents.

References:

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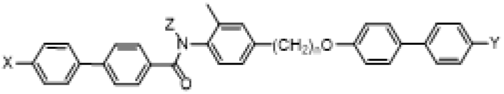
Category:	**NOVEL COMPOUNDS**	**Poster 19**
Title:	**A new series of liquid crystal mesogens based on aromatic anilide cores.**	
Presented by:	**Grant J. Strachan,** Department of Chemistry, School of Natural and Computing Sciences, University of Aberdeen	
Other authors:	Corrie T. Imrie, and John M. D. Storey, Department of Chemistry, School of Natural and Computing Sciences, University of Aberdeen	

The amide functional group is ubiquitous in organic chemistry, but relatively rare in the field of liquid crystals outside of polymer-based LCs. The most common examples of amides in low molar mass LCs are based on secondary amides, in which hydrogen bonding between amide groups can promote the formation of smectic phases.[1–5] As yet, there does not appear to be any reports of amide-based materials forming the twist bend nematic (N_{TB}) phase.

In addition to this, there are very few examples of tertiary amide groups in LCs. These use the amide group as part of the terminal group, rather than in the centre of dimers, or bent-core based structures[3,6,7].

Here we report the synthesis and characterization of a series of secondary and tertiary liquid crystal mesogens based on aromatic anilide cores incorporated into a dimer structure:



X, Y = Br, CN, Ar-CN
Z=H, CH_3
n = 6, 10

The structure was varied in an attempt to promote liquid crystalline behaviour. This led to the formation of the twist bend nematic phase for the secondary amide compounds with a longer central spacer. In addition, the dramatic difference between the behaviour of secondary and tertiary amides was investigated, and rationalised as an effect of changing molecular conformation.

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2. Wang, H. *et al.* Direct evidence for the effect of lateral hydrogen bonding on the smectic phase *Liq. Cryst.* **38,** 767–774 (2011).
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Category: CHEMISTRY **Poster 20**

Title: **Photosensitive liquid crystals based on 7-hydoxynaphthalene-2-carboxylic acid**

Presented by: **Tereza Černá,** Department of Organic Chemistry, University of Chemistry and Technology Prague, Czech Republic.

Other authors: Lucie Mašková, Václav Kozmík, Jiří Svoboda, Michal Kohout, Vladimíra Novotná, Institute of Physics and Optics, Academy of Sciences of the Czech Republic, Czech Republic.

Liquid crystals (LCs), combining long range positional order of solids with the mobility of fluids, were discovered already in 1888 by Friedrich Reinitzer, a botanist working at the Charles University in Prague[1]. However, until the application of LCs in the construction of the first liquid crystal displays in 1968, these unique substances have been considered only a whim of nature. Since their application in electronics, the interest in their possible properties has steadily increased and extensive research activity has been devoted to describe their behaviour, such as response to applied electric and magnetic field, mechanical impulse or light. Currently, special attention is paid to the design and synthesis of light-responsive functional LC materials[2, 3], due to their potential applications in photonics.

In this study, we have designed and synthesized two series of new bent-shaped liquid crystals based on 7-hydroxynaphthalene-2-carboxylic acid central core[4], containing one elongating side arm with an ester linking unit and the other one with the photosensitive azobenzene building block (Figure 1). Mesomorphic behaviour of the materials has been studied by differential scanning calorimetryand polarising optical microscopy. We show that the position of the azo group in the molecule has a strong effect on mesomorphic properties of the materials. Moreover, the presence of the azo group in the molecular structure allows modifying the mesomorphic behaviour by irradiation with UV light.

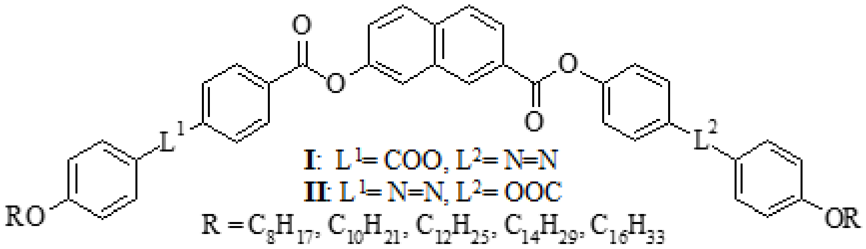

Figure 1. General structure of the target compounds.

This work was supported by Czech Science Foundation (reg. No. 19-03564S and 18-14497S*).*

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Category:	**CHEMISTRY**	**Poster 21**
Title:	**Preparation and characterization of new light-responsive liquid crystal materials**	
Presented by:	**Daniel Zaton,** Department of Chemistry, School of Natural and Computing Science, UK & Chemical and Materials Engineering Group, University of Aberdeen	
Other authors:	Dr. Martinez-Felipe, Alfonso[1]; Prof. Imrie, Corrie T.[2]; Prof. Storey, John M.D.[2] [1]Chemical and Materials Engineering Group, University of Aberdeen [2]Department of Chemistry, University of Aberdeen	

The twist-bend nematic phase (N_{TB}) is the most recently discovered nematic phase for which bend molecules are needed. These molecules tend to form bend structures, but pure bend is spatially impossible; thus, the spontaneous bend is accompanied by other deformations of the local director such as twisting. In the N_{TB} phase, the director exhibits periodic twist and bend deformations forming a conical helix with doubly degenerate domains having opposite handedness.[1,2]

Paterson et al,[3] have recently reported a reversible isothermal twist-bend nematic-nematic phase transition driven by the photoisomerization of an azobenzene-based nonsymmetric liquid crystal dimer, opening the possibility to control the N_{TB} phase via UV illumination, based on the fast and reversible azobenzene *trans*-to-*cis* isomerization, see Figure 1.

Herein we develop a series of liquid crystal dimers showing the N_{TB} phase containing azobenzene moieties in order to study the relationship between the terminal chains and the N_{TB}-N phase transition kinetics. Also, we have prepared mixtures, using azobenzene-containing molecules as dopants, in a N_{TB} mesogen, CB6OCB,[4] to study the azobenzene concentration dependence on the phase behaviour.

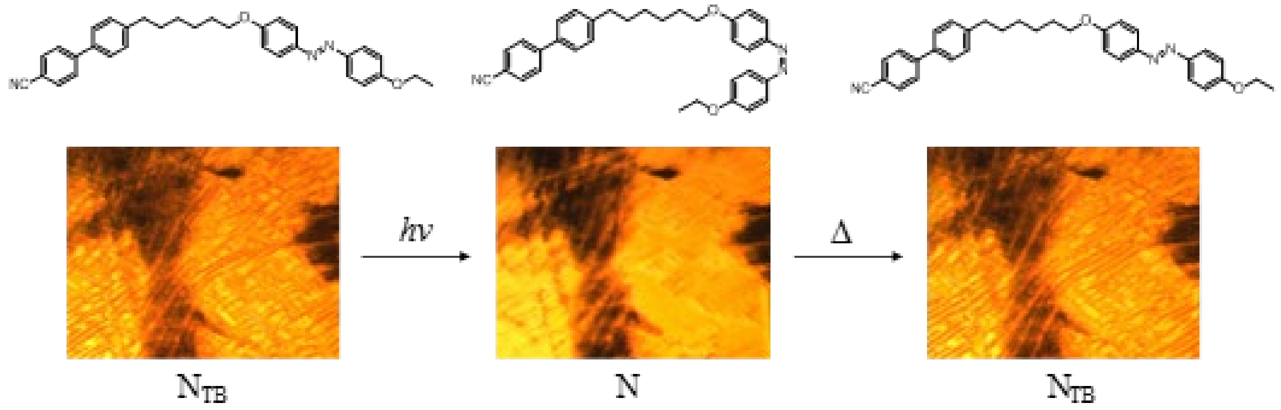

Figure 1 N_{TB}-N-N_{TB} phase transition of CB6OAzO2 upon UV light (350nm)

References:

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Category:	**CHEMISTRY**	**Poster 22**
Title:	**RAFT polymerisation for side-chain liquid crystalline polymers.**	
Presented by:	**Bartlomiej Czubak**, School of Physics and Astronomy, University of Leeds.	
Other authors:	Mamatha Nagaraj, School of Physics and Astronomy, University of Leeds; Nicholas Warren, School of Chemical and Process Engineering, University of Leeds.	

Reversible addition-fragmentation chain-transfer (RAFT) polymerisation is a type of controlled living polymerisation, capable of preparing polymers with low polydispersity and target molecular weights. It offers a gateway into polymerisation-induced self-assembly (PISA) of block co-polymers, affording nanoparticles of controlled morphology, size and surfaces. Side-chain liquid crystalline polymers (SCLCPs) are a group of macromolecules which posses a mesogenic group bound to a polymer backbone.

The combination of RAFT and PISA provides an efficient alternative path to preparing polymers, which not only exhibit liquid crystalline phases, but also possess desired physical properties such as responsiveness or surface preferences.[1,2] The current work is focused on better understanding the influence of the individual components and their impact on the system as well as characterising the liquid crystalline behaviour of the polymer. AFM studies are undertaken as they offer a powerful way of imaging and probing the polymer assemblies as seen in Figure 1.

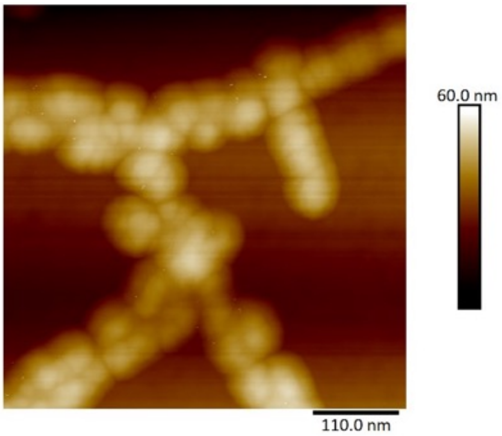

***Figure 1**. AFM height profile collected in intermittent contact mode of a diblock co-polymers prepared via RAFT.*

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Category: MATERIAL PHYSICS **Poster 23**

Title:

Odd nematic dimers: elastic constants and flexoelectric bistable latching

Presented by: **Nicholas J. Garner**, University of Leeds

Other authors: Mark Thompson, Sophie A. Jones and Prof J. Cliff Jones, University of Leeds;
Richard J. Mandle, Stephen J. Cowling, John W. Goodby, University of York

The flexoelectric properties of liquid crystal dimers were examined to determine their aptitude for use in bistable displays. Should there be an odd number of flexible carbon chains connecting the two rod like mesogens, the dimer has a molecular shape similar to that of a bent-core LC and so exhibits microscopic polarisation. It is preferable for these shapes to pack into a bent configuration, resulting in a flexoelectric polarisation[1].

This property can be exploited in a zenithal bistable device (ZBD)[2], wherein two director profiles are approximately energetically equivalent and can be latched between through the application of a bipolar voltage pulse. The polarity of the trailing pulse determines to which state the LC latches into, provided the voltage is above the threshold. This is a consequence of the pulse coupling to the flexoelectric polarisation[3], hence a material that exhibits high flexoelectric properties minimises the magnitude of the pulse required to switch between the two states.

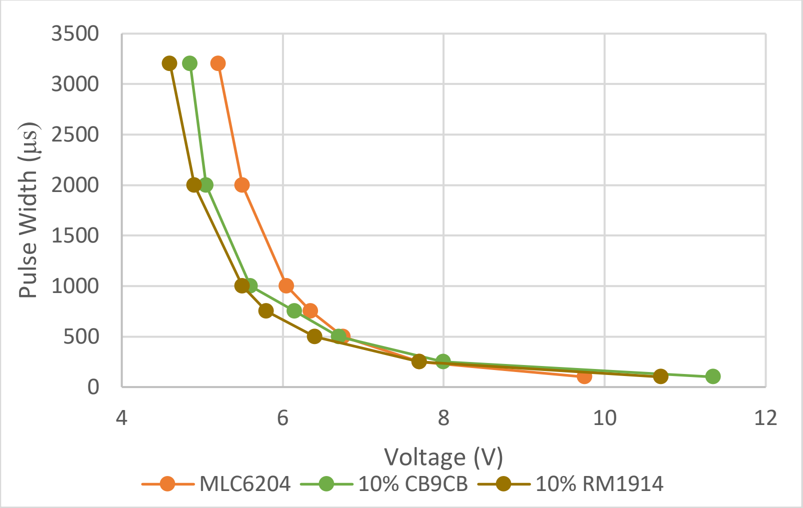

Figure 4: Latching curve for dimer mixtures, showing threshold pulse widths versus applied voltage for bipolar pulses.

Dimers CB7CB, CB9CB, RM1704 and RM1914 were used in varying concentrations in MLC6204-000, a commercial display mixture, and we found the respective elastic constants. The switching times and voltages were then determined through the application of a pulse to latch the mixtures into the desired state.

It is shown that the time frame for which this pulse is applied and the voltage needed can be reduced through doping the LC dimers into a nematic host due to the increase in flexoelectricity, making switching between the two states more efficient and latching easier.

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Category: MATERIAL PHYSICS **Poster 24**

Title:

Computer simulation of fluorinated liquid crystals

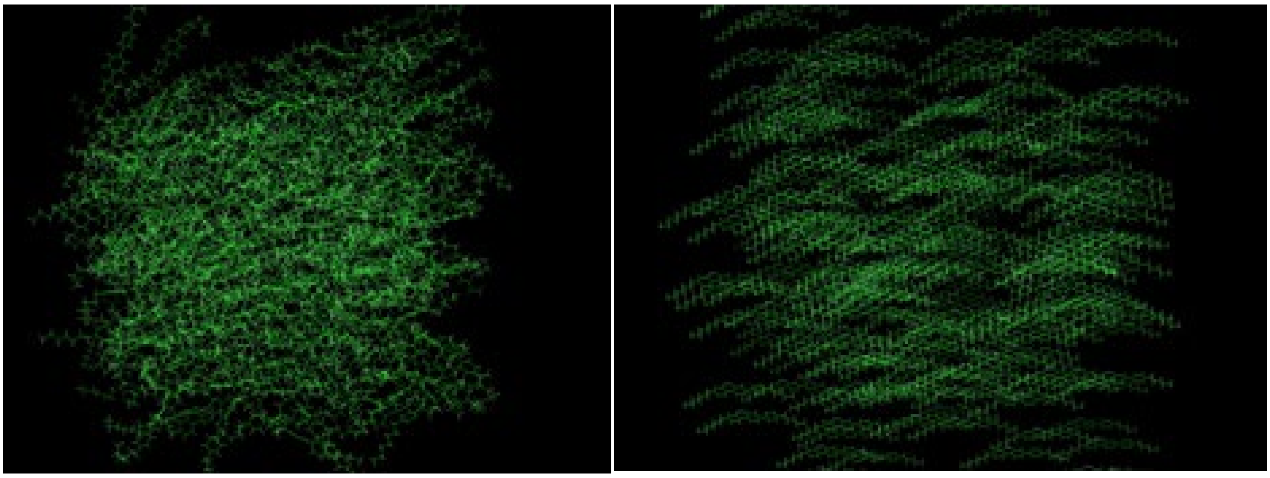
Presented by: **Lewis J. Hutton,** Durham University

Co-author: Mark R. Wilson, Durham University

LCDs have seen large improvements in the past 40 years, with fluorinated liquid crystals playing a large part in their success.[1,2] The highly electronegative nature of fluorine coupled with its small size makes it ideal for producing liquid crystals with high polarity.

Improvements in theoretical methods and computational power have meant that it is now possible to study many liquid crystalline molecules via computer simulation. Increases in computer power mean that (both) longer time scales and larger system sizes have become accessible. Despite this, there are few studies of fluorinated organic systems, and a lack of good atomistic force fields to model these molecules. Moreover, small inaccuracies in modelling molecular interactions for fluorinated liquid crystals can lead to large errors in the prediction of both transition temperatures and molecular ordering.

For this reason, we have set out to produce a quantum-chemical derived force-field, parametrised specifically for the atomistic modelling of fluorinated liquid crystals. For the initial phase of this force field development, we have used the Generalised Amber Force Field (GAFF)[3,4] to benchmark a current state-of-the-art small molecule force field against a series of fluorinated molecules, calculating both physical and thermodynamic properties of small fluorinated organic liquid crystal "fragment" molecules. We see inaccuracies as high as 120 % for certain quantities. Initial work has been carried out to improve GAFF, starting with the energy of torsional rotations for common fluorinated liquid crystal moieties.



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Category: **MATERIAL PHYSICS** **Poster 25**

Title: **Photo-induced director reorientation in chiral nematic liquid crystals**

Presented by: **Clare E. Verduyn**, University of Leeds

Other authors: Ethan I. L. Jull and Helen F. Gleeson, University of Leeds

Light-induced changes in textures and phase transitions in photochromic liquid crystals are of wide interest; they have potential to change optical properties of devices as well as changing shape in elastomers. The trans-cis photo-induced conformational change of azo-dyes can be used to control the molecular order and orientation of liquid crystal samples, hence inducing photo-sensitivity. The reorientation of azo-doped nematic liquid crystals illuminated by linearly polarised light has been widely studied since it was discovered by Gibbons et al.[1] in 1991. Optically induced phase changes of azo-doped cholesterics[2] have been comprehensively investigated[3], but cholesteric liquid crystal reorientation has not been reported. Here we investigate a new photochromic reorientation effect of cholesteric doped into an azobenzene derivative known as BAAB that is itself liquid crystalline and has been used in several other investigations[2,4,5].

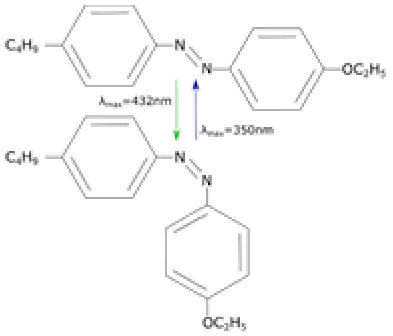

Figure 1: The reversible, light induced trans-cis isomerization of azobenzene

The transition dipole moment of the trans azo-dye configuration is aligned along its principal axis. The probability of absorbing a photon and isomerising is proportional to the cosine squared of the angle between the dipole moment and the polarisation direction of the exciting light. Thus, molecules aligned parallel to the polarisation direction are most likely to isomerise into their cis conformation. Relaxation into the trans conformation can occur with the transition dipole moment at any angle. Molecules with alignment perpendicular to the direction of polarisation have a reduced probability of exciting back into cis state. Therefore, over time there is an overall realignment of molecules at an arbitrary angle to the excitation light polarisation.

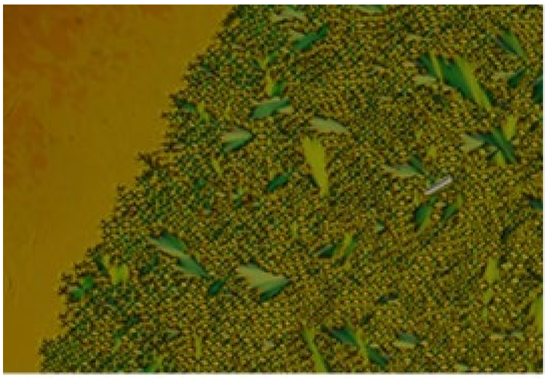

Figure 2: POM image of light induced reorientation of azo-liquid crystal BAAB2 doped with R1011 chiral dopant at 65°C.

Cholesteric liquid crystals have a helical structure, so for a planar structure there is no bias in 2D molecular reorientation. Instead, we observe a transition from a planar texture to a focal conic texture, figure 2, indicating a reorientation of the helical axis. We discuss the phenomenon and the regime over which this transformation occurs.

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Category: MATERIAL PHYSICS **Poster 26**

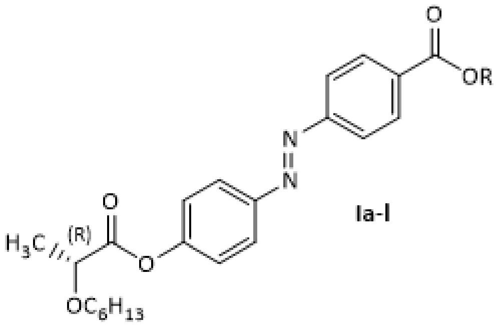
Title:

The effect of length of the terminal alkyl chains on mesomorphic and photosensitive properties of (R)-lactic acid-based materials

Presented by: **Michal Šmahel,** Department of Organic Chemistry, University of Chemistry and Technology Prague, Czech Republic

Other authors: Michal Kouhout; Department of Organic Chemistry, University of Chemistry and Technology Prague, Czech Republic
Alexey Bubnov; Institute of Physics, Czech Academy of Sciences, Czech Republic

Chiral photosensitive materials capable of structural changes upon irradiation with light, which leads to the change in their optical properties, are recently intensively studied due to the immense application potential in photonics[1]. In this study, a novel series (*Figure 1*) of chiral liquid crystals possessing a photosensitive azo group has been synthesized and studied. The prepared materials differ in the length of the terminal n-alkyl carboxylate chain in the achiral part of the molecule. The chiral lactic group on the other side of the structure has been elongated with a middle-length (C_6H_{13}, n-hexyl) chain. In the continuation of our previous study[2], we introduce a series of chiral liquid crystals based on (*R*)-lactic acid, the opposite enantiomer in comparison with other published materials[3]. Complete homologous series (C_1-C_{12}) has been prepared with emphasis on high optical purity of the materials. Subsequently, mesomorphic properties have been studied by means of differential scanning calorimetry and optical polarising microscopy to establish the effect of the length of the terminal n-alkyl chain on differences in mesomorphic behaviour.


Ia-l

a R = CH_3
b R = C_2H_5
c R = C_3H_7
d R = C_4H_9
e R = C_5H_{11}
f R = C_6H_{13}
g R = C_7H_{15}
h R = C_8H_{17}
i R = C_9H_{19}
j R = $C_{10}H_{21}$
k R = $C_{11}H_{23}$
l R = $C_{12}H_{25}$

Figure 1. General structure of the target materials.

Acknowledgement: This work was supported by Czech Science Foundation (reg. No. 19-03564S and 18-14497S).

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Category: MATERIAL PHYSICS **Poster 27**

Title:

Assessment of Highly Conductive Nematic Liquid Crystals Undergoing Electroconvection as Variable Pitch Diffraction Gratings

Presented by: **Rowan Morris**, University of Leeds

Other authors: Mamatha Nagaraj and J. Cliff Jones, University of Leeds

Electroconvection is a fascinating phenomenon found in many liquid crystalline systems. It derives from a discrepancy in minimum energy director profile, for the materials conductive and dielectric interactions. Where, the most efficient director orientation for ionic impurities to flow is inefficient at resisting the applied field dielectrically (typically permittivity anisotropy ($\Delta\varepsilon$) and conductivity anisotropy ($\Delta\sigma$) being of opposite signs)[1].

An example of such behaviour is displayed when a planar aligned nematic sample with a negative $\Delta\varepsilon$ and positive $\Delta\sigma$ has a certain critical voltage (V_C) applied across it. Here, the two competing energetic contributions lead to the formation of an instability causing a periodic director tilt with wave number, q_C[1]. This periodic director structure can then be used as a phase-shifting diffraction grating where q_C can be controlled by modulating the voltage and frequency simultaneously[2].

Due to the sample conductivity being a key driving factor in the assembly of these gratings, in this work we examine the effect of artificially increasing the conductivity of a negative $\Delta\varepsilon$ material (MLC 2081) by doping the liquid crystal with large quantities (<2%) of the ion Tetra-Butyl-Ammonium-Tetra-Phenyl-Borate (TBATPB). Confining the work to the systems at their critical onset state, we will present an assessment of these devices as variable pitch diffraction gratings incorporating the behaviour of: critical voltage, critical wave vector, diffraction angle, and diffraction efficiency as frequency is modulated.

It is found that V_C and q_C increase with approximately the 4th power of frequency (Figure 1), meaning higher V_C and q_C values as frequency is increased, which in turn leads to wider steering. From diffraction experiments we determine the $m=\pm2$ order are the most efficient (absolute efficiency ~15% at low frequencies), however efficiency will decrease as wider steerage is attained.

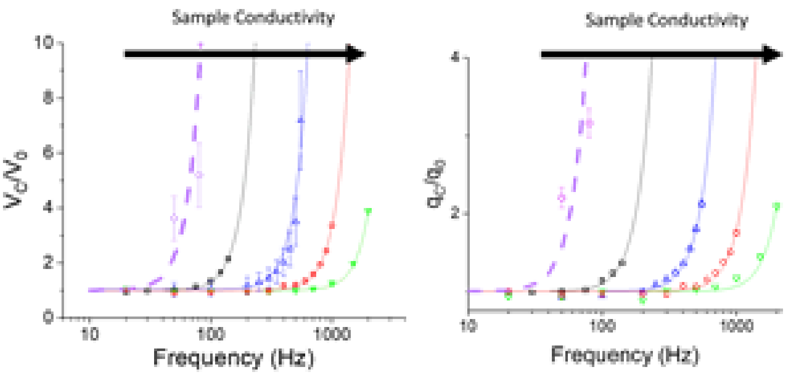

Figure 1. Plots of the behaviour of critical voltage and wavenumber as frequency is changed (normalised to low frequency values, V_0 and q_0 respectively). A fitting to a 4th power dependence of all samples is also included to show the trend of behaviour. The frequency at which samples show a rapid increase in both q_c and V_c appears to be determined by conductivity.

The authors wish to acknowledge funding from Merck and the EPSRC.

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Category:	**MATERIAL PHYSICS**	**Poster 28**
Title:	**Understanding liquid crystals that stretch**	
Presented by:	**Thomas Raistrick**, School of Physics and Astronomy, University of Leeds	
Other authors:	Helen Gleeson and Devesh Mistry , School of Physics and Astronomy, University of Leeds	

Liquid crystal elastomers (LCEs) combine the fields of polymer and liquid crystal physics with some amazing consequences. LCEs consist of a network of polymers with mesogens attached either within the polymer back bone (main chain) or laterally by spacers (sidechain). These materials exhibit interesting properties such as stripe domains[1], semi-soft elasticity[2], mechanical-Freedrickz transitions[3] and shape responsiveness to external stimuli such as temperature (see Figure 1). Because of their unique properties LCEs have far-reaching potential for applications such as soft actuators, artificial muscles and rubber lasers.

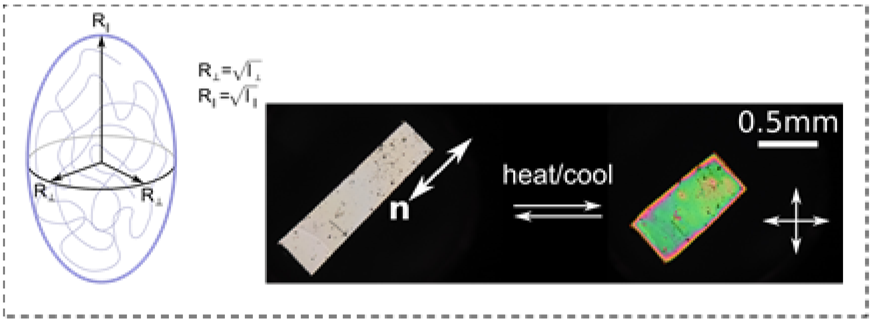

Diagram of the polymer conformation of an LCE in the nematic state (left). The shape change seen on heating a film of nematic LCE, the change in order causing a change in polymer conformation (right). Taken from 2.

Many of the properties of LCEs have been described by Warner & Terentjev theory[4]. One of the underlying assumptions to these models is that the order parameter of the LCE remains constant under mechanical deformation. Experimentally, some findings have shown this however many have shown a significant change in order.[3] Our material has shown a change from a positive value (+0.74±0.03) to a negative value (-0.41±0.01), deduced from the birefringence observed via polarising microscopy[2, 3]. This surprising result has been proposed to be related to the emergence of a negative Poisson ratio in our material[3]. However, Raman spectroscopy on the same material has shown an unchanged value in <P200> (from +0.67±0.05 to +0.61± 0.05) and <P400> (from +0.28±0.05 to +0.25±0.05) under mechanical strain. This discrepancy is not fully understood. Subsequent experiments have been attempted to fully understand and resolve the discrepancy between these imaging modalities. These are reported herein.

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92	Mr	Daniel	Zaton	University of Aberdeen	r01dz17@abdn.ac.uk
93	Mr	Amerigo	Zattarin	University of Aberdeen	a.zattarin.19@abdn.ac.uk

Quick View of Timetable

	Monday 15th			Tuesday 16th		Wednesday 17th		
08:15		Lyotropics Symposium (Jones and Hussain)	Registration and Continental Breakfast					08:15
08:30				Continental Breakfast		Continental Breakfast		08:30
08:40								08:40
08:50				Devices (Wilkinson)	P3 Dirk Broer 2018 Gray Medal	Material Physics (Gleeson)	P4 Pratibha Sturgeon Lecture	08:50
09:00			L3C Welcome					09:00
09:10			L1 Gordon Tiddy					09:10
09:20								09:20
09:30					I2 Markus Wahle 2019 Young Scientist		O24 Alf Martinez-Felipe	09:30
09:40								09:40
09:50			L2 Arwen Tyler		O8 Susanne Klein		O25 Nina Trbojevic	09:50
10:00								10:00
10:10					O9 Peter Wyatt		O26 Guillaume Nataf	10:10
10:20			Coffee Break					10:20
10:30					I3 Francesca Serra		O27 Ammar Khan	10:30
10:40			L3 John Seddon					10:40
10:50							O28 Ethan Jull	10:50
11:00				Coffee Break				11:00
11:10			L4 Mark Wilson			Coffee Break		11:10
11:20	BLCS Registration			Surfactants and Lyotropics (Tyler)	I4 Richard Bushby			11:20
11:30						Chemistry (Chakrabarti)	O29 Daniel Paterson	11:30
11:40			L5 John Lydon					11:40
11:50					O10 Zeynep Sumer		O30 William Fall	11:50
12:00		Lunch						12:00
12:10					O11 Charlie Wand		O31 Kostas Daoulas	12:10
12:20								12:20
12:30					O12 Mariam Hussain		I5 John Lydon	12:30
12:40								12:40
12:50					O13 Vanessa Woodhouse			12:50
13:00						Awards and Closure		13:00
13:10				Lunch		Lunch		13:10
13:20								13:20
13:30								13:30
13:40		BLCS Welcome						13:40
13:50		Colloids 1 (Jones)	P1 Ivan Smalyukh					13:50
14:00								14:00
14:10				Device Theory (Spencer)	O14 Timothy Atherton	BLCS Committee Meeting		14:10
14:20								14:20
14:30			O1 Dwaipayan Chakrabarti		O15 Joseph Cousins			14:30
14:40								14:40
14:50			O2 Nikita Solodkov		O16 Sophie Jones			14:50
15:00								15:00
15:10			O3 Huanan Yu		O17 Doug Cleaver			15:10
15:20								15:20
15:30		Coffee Break			O18 Aaron Pim			15:30
15:40								15:40
15:50		Novel Compounds (Mehl)	P2 Corrie Imrie 2019 Gray Medal		O19 Joseph Harris			15:50
16:00								16:00
16:10				Coffee Break				16:10
16:20								16:20
16:30			O4 Rebecca Walker	Colloids 2 (Nagaraj)	O20 Ingo Dierking			16:30
16:40								16:40
16:50			I1 Richard Mandle		O21 Giampaolo D'Alessandro			16:50
17:00								17:00
17:10					O22 Haifa Ojaym			17:10
17:20			O5 Ewan Forsyth					17:20
17:30					O23 Christopher Lakey			17:30
17:40			O6 Warren Stevenson					17:40
17:50				BLCS AGM (all to attend)				17:50
18:00			O7 Sam Gorman					18:00
18:10								18:10
18:20		Posters 1		Posters 2				18:20
18:30								18:30
18:40								18:40
18:50								18:50
19:00								19:00
19:10								19:10
19:20		Walk to University House		Walk to University House				19:20
19:30		Dinner		Drinks Reception Conference Dinner				19:30
19:40								19:40
19:50								19:50
20:00								20:00
20:10								20:10
20:20								20:20
20:30								20:30
20:40								20:40
20:50		Evening in Leeds						20:50
21:00								21:00
21:10								21:10
21:20								21:20
21:30				Evening in Leeds				21:30
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