

BRITISH LIQUID CRYSTAL SOCIETY

LIQUID CRYSTAL NEWS

August 2006

GW Gray Medal for 2006 Professor Heino Finkelmann



Heino Finkelmann was born in Gronau in Lower Saxony in 1945. After school, his studies at the Scientific Technical Academy at Isny were in the field of chemical engineering and on the way to qualifying in 1969, he spent time with Unilever Research and with British Petroleum in Hamburg. He then studied Chemistry at the Technical University of Berlin, and it was here that he first began work on liquid crystals under Professor Horst Stegemeyer. He then went to the University of Paderborn in 1974 and there received his doctorate in 1975. He then moved into the field of macromolecular chemistry, working with the eminent Professor Helmut Ringsdorf in the University of Mainz from 1976 to 1978, before going to the University of Clausthal where he remained until 1984. In this year he received his habilitation degree and was appointed as Full Professor and Director of the Institut für Makromolekulare Chemie in the University of Freiburg.

Heino Finkelmann and I first met quite by accident in 1980 on a train going from Munich to Garmisch-Partenkirchen. We were on our way as invited lecturers to attend the third in a series of European Meetings devoted mainly to smectic liquid crystals. Two years later we strengthened our friendship in Bangalore, India where the Ninth International Liquid Crystal Conference was staged by Professor S Chandrasekhar at extremely short notice, because in early 1982 the international political situation in Poland became such that it was no longer possible for Professor J A Janik and his colleagues to hold the meeting

as originally intended in Krakow. Since these days, we have met very frequently, for example, when I was privileged to lecture in Professor Finkelmann's Institute and at many other scientific meetings not least of which was the Twelfth International Liquid Crystal Conference held in 1988 in Freiburg itself and chaired and organised by Professor Finkelmann. My wife and I well remember enjoying a glass of wine with Heino and his wife and two boys at their home after the closing ceremonies were complete and people like conference chairmen are at last allowed to relax.

I have put the material in the above paragraph early in this article about Heino Finkelmann, because I wanted to stress that his very great contributions to the subject of liquid crystals have been not only in the area of scientific research, but also, by his readiness to travel far and wide to give lectures, by spreading the word on the subject, by serving on the editorial boards of relevant journals, by organising meetings and conferences such as the 12th ILCC, by serving as he has twice done on the Board of Directors of the International Liquid Crystal Society and by acting as Chairman of the German Liquid Crystal Society as he did for many years.

Low molar mass liquid crystals are formed by molecules of a certain shape, notably rod-like or disc-like organic molecules (mesogenic molecules) and the mesophases that are formed in intermediate temperature ranges between the crystalline solid and the isotropic liquid phases may be either nematic, columnar or lamellar smectic in nature, or chiral analogues of these in appropriate cases involving chiral molecules. Lyotropic liquid crystal phases require amphiphilic molecules consisting of a polar head group and a hydrophobic chain and form the liquid crystal phases in association with for example water. In the late 1970's it was realised that using a flexible spacer to separate rod-like or disc-like mesogenic groups from the polymer main chain, side group liquid crystal polymers (SGLCP) could be made, and also that polymers with the mesogenic groups suitably separated by flexible spacer units in the polymer backbone, i.e., main chain liquid crystal polymers (MCLCP) were possible, as well as hybrid side group/main chain systems. A great deal of work quickly blossomed on a range of side group polyacrylates, polymethacrylates and polysiloxanes, and the existence of

lyotropic polymer analogues of these thermotropic liquid crystal polymer systems was also realised.

From these earliest studies, Finkelmann quickly realised the importance of cross linked systems, i.e., liquid crystal elastomers, and this soon became a field which Heino Finkelmann and his research associates have made their own. The importance of this area of course lies in the combination of rubber-like elasticity with the anisotropic properties of liquid crystal phases. Heino Finkelmann is now renowned for his work on liquid crystal elastomers, and this has been recognised in many ways; for example he won the Gay-Lussac Humboldt Prize in 2000, was awarded an Honorary Doctorate of the University of Toulouse in 2004, and jointly with Mark Warner of Cambridge, was awarded the 2003 Agilent Technologies Europhysics Prize for achievement in nanotechnology.

Just two examples may be quoted of how Heino Finkelmann has used the coupling of liquid crystal order with the elastic entropic properties of a rubber to produce materials with remarkable properties. Stretching a nematic elastomer generates a uniform orientation of the nematic director parallel to the mechanical field and nematic elastomers then have the optical properties of single crystals. Finkelmann has used such effects to demonstrate a film consisting of a chiral nematic liquid crystal elastomer, with the cholesteric helices aligned parallel, which strongly reflects light in a frequency range centred closely around the wavelength of the pitch of the cholesteric helices. By adding a green fluorescent dye with an emission peak corresponding to the wavelength reflected by the elastomer, this effect can be exploited to make a laser the wavelength of which can be changed, with only a small wavelength spread, from green to red by elongation of the elastomers. This tuning of a laser by simply stretching or squeezing a polymer is of very considerable interest practically and also theoretically.

Another example of Finkelmann's interests and originality of thought in the field of liquid crystal polymer networks has involved water soluble polymers with amphiphilic groups which are then cross linked in the

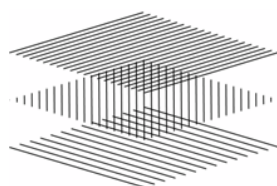
liquid crystal state. This results in hydrogels with unique properties. If the crosslinking is done when the liquid crystal phase is uniformly aligned, this results in hydrogels with the properties of single crystals. Obviously such aligned systems with perfectly uniform optical properties have commercial interest, one example being, as soft, organised material from which to fabricate a new type of bifocal contact lens.

Many other examples exist of Finkelmann's fine work on liquid crystal elastomers and the remarkable effects caused by their interaction with external fields (arising from temperature change, applied voltages or mechanical effects) and we can only speculate about the future possibilities of his work for creating artificial muscles that shrink or stretch under electronic control.

Professor Finkelmann has also been active in the quest for biaxial liquid crystal systems, in this case in liquid crystal polymers and elastomers. Overall, the results of his research have been published in over 200 scientific papers, covering both thermal and induced liquid crystallinity in polymeric systems and ranging from synthesis through to device engineering. Theoretical understanding of these systems has also been advanced by Professor Finkelmann's researches, and this was particularly noted in the citation for the award by the European Physical Society, which recognised the "brilliant interplay of theory and experiment" that was characteristic of his work.

Finally, I would like to say how disappointed I was that a temporary but very real problem with my back prevented my attending the annual British Liquid Crystal Society meeting in the University of York earlier this year and personally presenting Professor Finkelmann with the G W Gray Medal. He is a most worthy recipient of the medal and it has been a pleasure to write these words about him and to offer him my sincere congratulations and good wishes for his future and that of his distinguished research.

George Gray



**BRITISH
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The BLCS Annual Conference 2007

University of Sheffield

26-28th March, 2007

The 2007 BLCS annual meeting (AGM) and conference will be held on 24-28th of March at the University of Sheffield, under the chairmanship of Prof Goran Ungar. The main emphasis of the conference is for students and young researchers to present their latest work along with invited talks and the Sturgeon lecture. Papers are requested on any topic related to liquid crystal materials and their applications.

Inaugural Cyril Hilsum Medal awarded to

Helen Gleeson



At the 2006 Liquid Crystal Conference, Professor Helen Gleeson was awarded the inaugural C Hilsum Medal by the British Liquid Crystal Society. The medal was awarded for 'overall contributions to liquid crystal science and technology'. Professor Hilsum attended in person to present the inaugural medal. Helen graduated from the Victoria University of Manchester in 1983, where she continued her education and gained a PhD in 1986. During the same year she took up post as Senior Development Scientist in the Wolfson Liquid Crystal Unit at the Victoria University of Manchester, before becoming Lecturer in Physics and Astronomy. Later Helen became Reader and Professor of Physics and Astronomy. In 2002 she was appointed Research Dean in the Faculty of Science and Engineering.

Over the past twenty years Helen has made an outstanding contribution to the field of liquid crystals research developing several techniques that have allowed novel aspects of liquid crystal research to be investigated. She has illuminated the understanding of self-assembling and self-ordering materials, especially chiral liquid crystals. Much of her recent work has involved the use of laser diffraction techniques to study periodic structures with periodicities of the order of the wavelength of visible light, and new x-ray techniques which allow detailed insight into molecular ordering and structural deformations in liquid crystals and devices.

Her body of work has been published in many journals, books and patents plus numerous reports to industry and various funding bodies. Helen has also contributed strongly to the development of young scientists

including PhD and MSc graduates of whom 3 have won prestigious awards (two were winners of the British Liquid Crystal Society Young Scientist of the Year award (1998 and 2004), and one won the International Liquid Crystal Society Glenn Brown Award for best thesis). She was a Member of the EPSRC Panel to Review the Electronics Materials Programme in 2002, is a Member of the Functional Materials EPSRC College and acts as a Referee for the Australian Research Council Grants scheme. She has also taken a leading role in the running and organisation of the BLCS through her actions on the committee, then as Secretary and most recently as the newly elected Chairman of the BLCS. Her efforts on behalf of the BLCS have been tireless (ironically including the somewhat bizarre and fraught process of organising the fabrication of the Hilsum medal!) including a very strong initiative with the EPSRC to raise the awareness and funding levels of the liquid crystal research communities within the UK.

Helen has held visiting professor positions at the Universities of Sydney, Case Western Reserve University and Griffith University in Brisbane. She was a member of the Interim Faculty Leadership Team and Interim Undergraduate Chair during Project Unity.

Helen's research interest and activities span many different areas of liquid crystal materials, properties and applications. This has included her work on time-resolved x-ray scattering from ferroelectric and antiferroelectric devices showing time resolution down to 10 microseconds which allows an understanding of the role of the layer structure in the switching mechanisms of these materials. In particular, we have recently demonstrated a change in layer spacing as part of antiferroelectric switching. This theme is continued in her work on resonant x-ray scattering, a collaborative programme with colleagues from across the world, including Ron Pindak (NSLS, Brookhaven), C C Huang (Minnesota) and Philippe Barois (Bordeaux). These experiments have been carried out at internationally leading synchrotron facilities across the globe. The measurements allow the determination of the structures of chiral liquid crystal phases that cannot be determined in other ways.

Many liquid crystals are iridescent, a beautiful property that has been made use of in lots of interesting devices! Helen has been interested in analysing the spectra of these materials to allow the determination of information about their structure. She has developed some excellent fitting techniques that determine exactly what the structure of a thin film of such material is, enabling the examination of effects of confinement, temperature and electric fields.



Helen's interest in novel applications and physical properties of liquid crystals has formed a study on laser tweezing of liquid crystal systems. This is a relatively new development carried out in collaboration with Mark Dickinson (Manchester). She has become interested in the transfer of optical angular momentum to liquid crystalline droplets, and in tweezing colloidal particles in suspension in liquid crystal fluids. This can

be analysed to find the effects which produce values for shear stress in the liquid crystal.

Finally Helen has started a new research interest into biological systems with liquid crystalline properties. Many biological systems form liquid crystal phases and this synergy has long been an interest. In particular, applying what is known about 'conventional' liquid crystals to provide a better understanding of some biological systems.

Helen's efforts across the spectrum of research, politics and educational development within the liquid crystal and wider scientific communities have made her a worthy recipient of the inaugural Hilsum medal.

**Maureen Neal
& Tim Wilkinson**

British Liquid Crystal Society Winter Workshop 2005

The British Liquid Crystal Society Winter Workshop was held in the Department of Chemistry at the University of Hull from lunchtime Monday 19th December to lunchtime Wednesday 21st December 2005.

As I am sure everyone is aware, the Workshop is designed for new entrants to the field of liquid crystals, particularly PhD students, but post-docs, technicians and industrialists also have much to gain from the event. Areas covered by the Workshop include a general introduction to liquid crystals, the synthesis of liquid crystals, identification of liquid crystal phases by optical microscopy, differential scanning calorimetry, and X-ray analysis, liquid crystal polymers, the physics of liquid crystals, liquid crystal devices, and modelling of liquid crystals. Theory and practical work is included, and there is ample opportunity for social activities. All participants are provided with notes from each of the topics covered.

The three-day format of the Workshop is now well established, and although well-attended and financially successful for many years, costs have increased, and numbers of delegates, particularly industrial delegates who bring in more money, have decreased, to the extent that the 2004 event was lowest attended Workshop ever. However, numbers picked up slightly for the

2005 Workshop, and more importantly, the number of industrial delegates has risen back to a reasonable level.

A total of 28 delegates attended the 2005 Workshop (20 last year), comprising of 7 industrial delegates (1 last year), 16 academic delegates (14 last year) and 5 non-residential delegates (5 last year). All delegates seemed to enjoy themselves, and I am sure that they all benefited from the academic and social programmes. Financial support from the EPSRC is being sought to assist with costs for the 2006 event, and if successful, at least the funding will be secure, if perhaps not the numbers attending. *<This has been successful so many thanks to Mike - ed>*

University accommodation was available once again, and so the price of the Workshop was maintained at the same as last year (£130- was charged for academic delegates, and £240- for industrial delegates). The larger number of industrial delegates enabled the 2005 Workshop to record a surplus for the first time since 2002.

**Mike Hird
University of Hull**

Don't forget the BLCS Winter Workshop 2006!

18-20th December in Hull, register early.

BLCS Young Scientist Lecture 2006

Complex Self-assembly in Thermotropic Liquid Crystals

XIANGBING ZENG

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Introduction

Self-assembly is ubiquitous in living organisms: from small units which are chemically and geometrically simple, larger entities are built with complex structures to serve all kinds of different functions. Similarly, a large number of synthetic compounds, including lyotropic systems, block copolymers and thermotropic liquid crystals, self-organize into bulk phases with periodicities on the $10^{-8} - 10^{-6}$ metre scale¹. In the simplest examples, molecules first self-assemble into layers, columns or spherical micelles, which then pack in space to form 1D (smectic), 2D (columnar) or 3D (micellar) periodic structures.

However, much more complex modes of self-assembly can be found in these systems. In below some of these structures, recently found in thermotropic liquid crystals, will be described. As the mode of self-assembly is ultimately decided at the molecular level, these complex structures provide unique subjects of study for the understanding of the principle of self-assembly. This also leads to the possibility of creating complex self-assembled structures by design at different length scales, with potential applications in the fabrication of functional nanostructures.

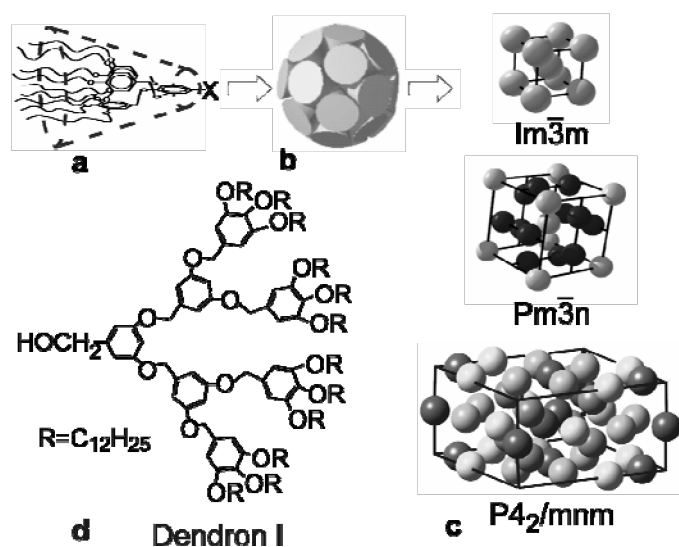


Figure 1. Tree-like molecules self-assembly to form various micellar phases.

Micellar Phases: from Cubic Phases to Liquid Quasicrystals

The first group of compounds we have studied, in collaboration with Prof. Percec's group at the University of Pennsylvania, are dendrons or dendrimers (tree-like molecules)². For monodendrons, micelles are formed by several or more molecules, each of which adopting a conical shape. Subsequently, micellar phases are formed by packing of the spherical micelles on a 3D periodic lattice (Figure 1a-c). The two most commonly found micellar phases are cubic in symmetry, with space group $Im\bar{3}m$ (body-centred cubic, BCC)³ and $Pm\bar{3}n$ ⁴ respectively. There are two micelles per unit cell in the $Im\bar{3}m$ phase, and eight micelles in the $Pm\bar{3}n$ phase. A more complex 3D tetragonal structure (space group $P4_2/mnm$), with 30 micelles in the unit cell, was reported three years ago⁵. It is interesting that all three phases are known structures in metals and alloys. For example, BCC is the structure of α -iron; the $Pm\bar{3}n$ structure is found in a series of binary transition metal alloys such as Cr₃Si or Nb₃Sn; the tetragonal $P4_2/mnm$ structure is known as σ -phase occurring in a number of alloys, such as Fe₄₆Cr₅₄.⁶

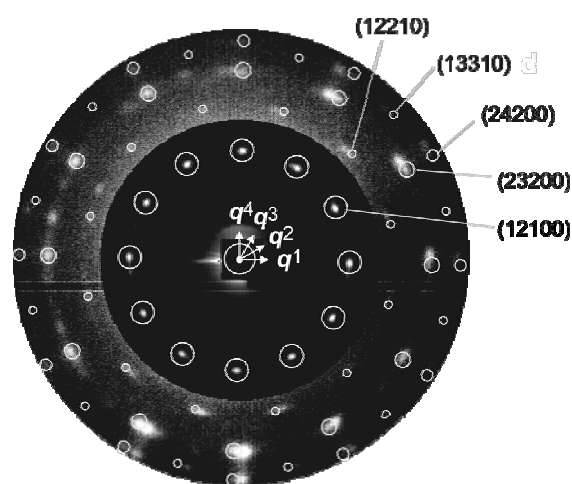


Figure 2. Experimental and calculated single domain x-ray diffraction pattern of LQC along the 12-fold rotational axis.

More recently, another micellar phase was found in a number of compounds. Figure 1d shows the structural formula of one of such compounds (dendron I). Single-

domain x-ray diffraction pattern of the phase shows a distinctive 12-fold rotational symmetry (Figure 2). This is surprising because it is long proven that for periodic structures only 2-, 3-, 4- and 6-fold rotational symmetries are allowed. The observed “forbidden” rotational symmetry suggests that the liquid crystal structure is in fact a dodecagonal “quasicrystal” (liquid quasicrystal or LQC)⁷.

Quasicrystals which possess “forbidden” rotational symmetries were first observed in transition metal alloys about twenty years ago^{8,9}. The discovery overturned the long-held belief that crystals must be periodic. The famous Penrose tiling shows how a “forbidden” 5-fold symmetry can be achieved in a pattern with both long range translational and orientational orders, but without periodicity (Figure 3)¹⁰.

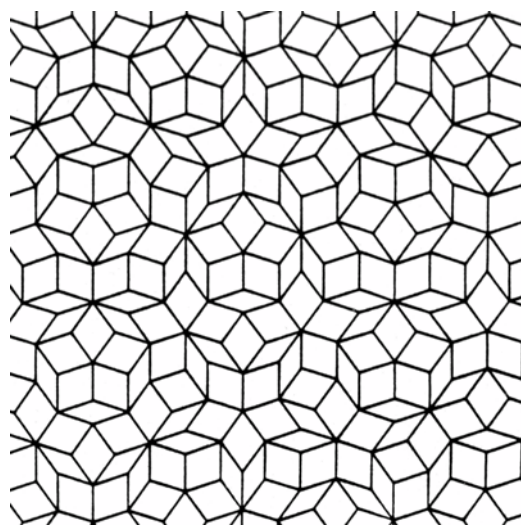


Figure 3. Penrose tiling in two dimensions showing pentagonal symmetry¹⁰.

LQC is the first quasicrystal ever found in systems other than metal alloys. Its structure is believed to be analogous to that of dodecagonal quasicrystals found in metal alloys. In LQC the supramolecular “micelles” stand in place of the metal atoms. The characteristic length of the quasicrystal is thus increased by nearly two orders of magnitude, from a few angstroms to nearly 10 nm. In liquid crystals as well as metal alloys, the dodecagonal phase is found in the vicinity of the $Pm\bar{3}n$ and $P4_2/mnm$ phases in the phase diagram, and it is thus expected that their structures are closely related. In fact, as shown in Figure 4, a model of the dodecagonal quasicrystal can be constructed by dodecagonal quasiperiodic tiling^{11,12} of the basic structural elements found in the $Pm\bar{3}n$ and $P4_2/mnm$ structures¹³. The simulated X-ray diffraction patterns (Figure 2) of the model give a reasonable fit to experimental ones in both the position and relative intensity of the diffraction spots.

According to the model in Figure 4, the alternation of densely and sparsely populated layers is carried through from Frank-Kasper structures to that of the dodecagonal

LQC. Each micelle on a sparse layer is at the centre of a hexagonal antiprism, as in Figure 4e. The ABCB stacking of layers of spheres can indeed be seen in the atomic force micrographs (ref. 7, supplementary information). Determination of the atomic positions in a quasicrystal by microscopy is extremely difficult for metal alloys due to limited resolution: current experimental methods can not reliably resolve structures at atomic scale. Since the size of the micelles in LQC is of the order of 4 nm, it is anticipated that a detailed AFM study will be able to determine the positions of micelles in the dodecagonal LQC unambiguously.

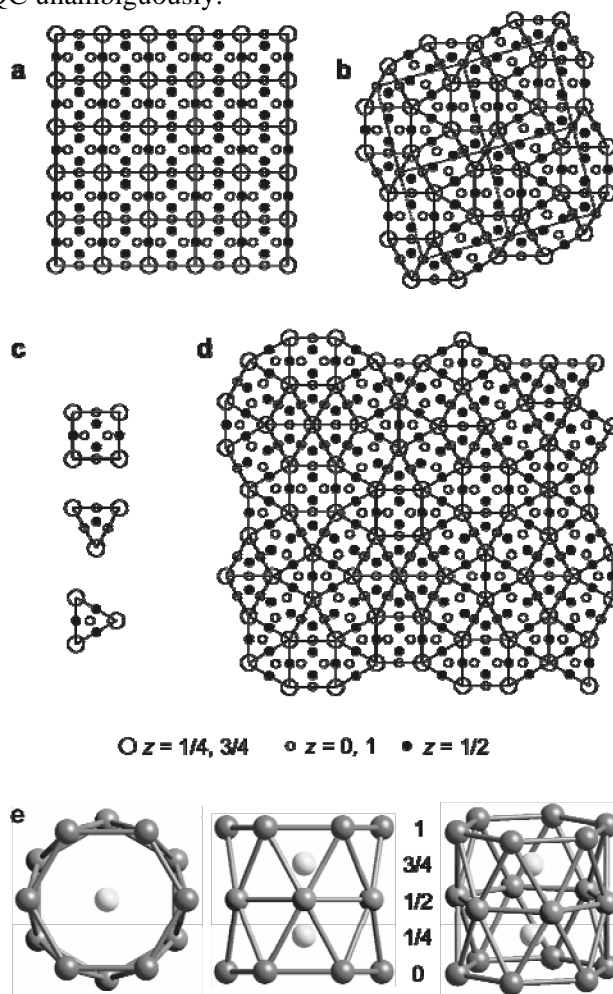


Figure 4. Packing of spheres in the LQC and other related t.c.p. structures. All can be generated from 2D tilings consisting of only squares and equilateral triangles (‘sparse’ nets, elevations $z = 1/4$ and $3/4$, large open circles). These tiles are ‘decorated’ with spheres at $z = 0$ (small open circles) and $1/2$ (filled circles), forming the ‘dense’ nets. a, Sphere packing in $Pm\bar{3}n$. b, Sphere packing in $P4_2/mnm$. c, Only three different decorated tiles, one square and two triangular, are used to generate both $Pm\bar{3}n$ and $P4_2/mnm$ structures. d, The same tiles, when arranged quasiperiodically, will generate the model of the LQC with 12-fold symmetry. e, Two ideal hexagonal antiprisms stacked along the 12 symmetry axis. There is a distorted hexagonal antiprism at each node of the square-triangular tiling in a, b and d.

The $Pm\bar{3}n$, $P4_2/mnm$ and quasicrystals are all members of the class of tetrahedrally close packed (TCP) structures, or Frank-Kasper phases.^{Error! Bookmark not defined.} These structures contain only tetrahedral interstices. For a system of a few equal-sized spheres, tetrahedral packing is the densest possible. However, packing based exclusively on regular tetrahedra cannot fill space. In fact, if the objective is to pack hard spheres on a regular lattice with a minimal unoccupied volume, the solutions are the two “close packings”, FCC and HCP. As FCC and HCP structures were never observed in dendrimer systems, the hard-sphere approximation of the micelles must be at least modified to better describe the system.

It is now well received that what makes dendrimers and metals adopt equivalent complex packing patterns is the similarity in the soft interaction potential between the spheres, albeit on different length scales. The “softness” of atomic d-orbitals plays a significant role in determining TCP structures in transition metals¹⁴. Supramolecular dendrimers have been approximated by hard spherical cores and soft aliphatic coronas with a tendency for surface minimisation¹⁵. The optimum solution of the packing problem for such a system coincides with the solution of the Kelvin problem of the minimum energy dry foam (minimum surface area per bubble)¹⁶. Kelvin’s original solution was the $Im\bar{3}n$ BCC structure, but in 1994 Weaire and Phelan¹⁷ proposed the cubic $Pm\bar{3}n$ structure as having a 0.4% smaller total surface area. Since froth is not a dynamic system, it was difficult to prove that the new solution was indeed ultimately the best. The appearance of $Pm\bar{3}n$ as the equilibrium structure in many supramolecular dendrimers and other LCs was taken as experimental vindication of the Weaire-Phelan solution¹⁵.

While at higher temperatures increased conformational disorder leads to lateral expansion of the dendrimer’s aliphatic corona, at low temperatures the driving force is its area minimisation. When the alkyl chains are offered too much lateral area by the spherical surface, and too little by the cylindrical surface, the system looks for a packing equivalent to the solution of the Kelvin problem. It is interesting to note that the micellar LQC has so far always been observed at temperatures above the columnar phase but below any other micellar phase. While it cannot be ascertained that LQC was always the stable phase, by all accounts it is thermodynamically stable in some cases, such as in dendron I, where annealing for up to a week close to the isotropisation temperature caused no phase change. The possibility is thus raised of dodecagonal quasicrystals replacing the $Pm\bar{3}n$ structure as the best solution of the Kelvin problem of minimum energy foam.

More recent x-ray diffraction experiments also reveal interesting twinned structure of LQC domains. Two of such twinned domains can be identified in the x-ray diffractogram shown in Figure 5. In one of the domains

the 12-fold rotational axis is parallel to the incident beam, while in the other the 12-fold axis is perpendicular to it. Moreover, the 12-fold axis of the latter is always found to be parallel to one of the 12 equivalent axis of the first domain. Multiply twinned structures were also found, and in the extreme case it is believed that one domain is surrounded by 12 other domains, each oriented along one of the 12 axis in the quasiperiodic plane of the first one.

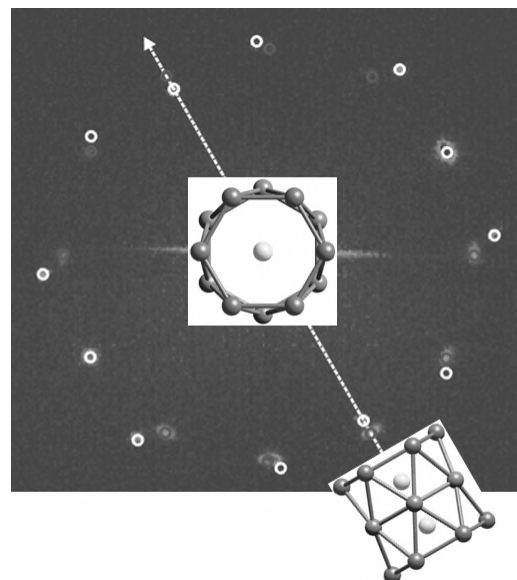


Figure 5. A LQC twin with two domains. The two 12-fold axis are perpendicular to each other. The reflections of the two domains are marked in red and white circles respectively.

T-shaped molecules

The next group of liquid crystal forming compounds are the T-shaped bolaamphiphiles¹⁸ and facial amphiphiles, synthesized by Prof. Tschierske’s group at University Halle¹⁹. Bolaamphiphiles have an aromatic rod-like core terminated by two polar chains, and a laterally attached apolar chain; in facial amphiphiles the positions of the polar and apolar chains are reversed - see Figure 6.

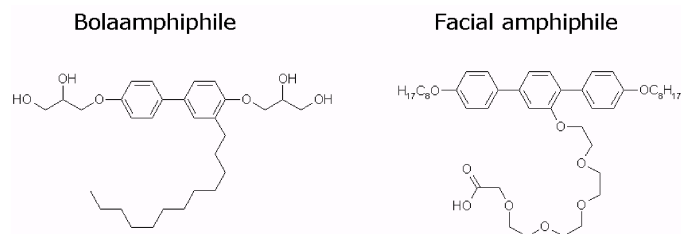


Figure 6. Typical liquid crystal forming T-shaped molecules.

Columnar liquid crystals with novel geometries have been discovered in these T-shaped molecules. These possess 2-d order, with rigid aromatic rod-like groups providing the walls of honeycomb structures containing polar channels of different polygonal cross-sections. In addition to hexagonal honeycombs, structures with triangular, square and pentagonal channels were

established, depending mainly on the relative size of the side group, and the presence of ions or water. Figure 7 shows electron density maps of three such phases found in facial amphiphiles, reconstructed from synchrotron X-ray data.¹⁹ Corresponding schematic molecular models are shown underneath. The pentagonal phase (Figure 7a) is particularly interesting. The liquid crystal nature of the material allows the necessary distortion, as regular pentagons are known not to be able to tile a plane.

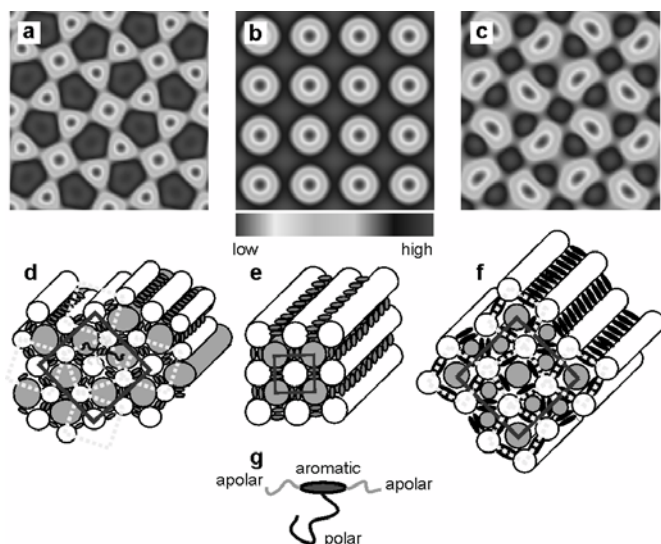


Figure 7. Reconstructed electron density maps (a-c) and corresponding models of molecular organization (d-f) of honeycomb columnar liquid crystal phases consisting of pentagonal (a,d), square (b,e) and mixed square and triangular (c,f) columns formed by T-shaped molecules (g).

Another recent discovery is that of a phase which, for the first time, combines the features of columnar liquid crystal (2-d packing of cylinders) and smectic liquid crystal (1-d stacking of layers). The 3-d electron density map of this “hexagonal channelled layer” phase is shown in Figure 8, together with superimposed schematic molecules²⁰. This organic structure with polar channels offers an opportunity to create chemically-responsive ionically conducting nanowire arrays for application in smart redox devices.

Triple-Network Tricontinuous Cubic Liquid Crystal

The third group of compounds of interest are polycatenar mesogens such as those shown in Figure 9a, which form an unusual cubic phase in the region between the lamellar and the columnar phase. The space group is confirmed by at single domain x-ray diffraction to be $Im\bar{3}m$ (Figure 9c). The complexity of the structure is indicated in the fact that the powder diffraction pattern is dominated by (321) and (400) reflections (Figure 9b).

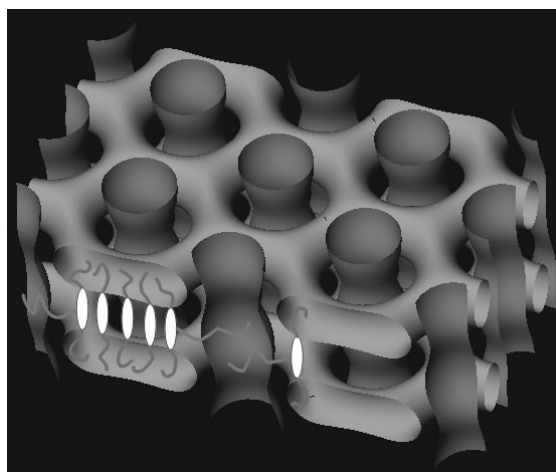


Figure 8. Reconstructed electron density map of the channelled layer liquid crystal phase: the blue isoelectron surfaces enclose the polar channel-like domains (high electron density) and the pink surface encloses the low-density aliphatic volume.

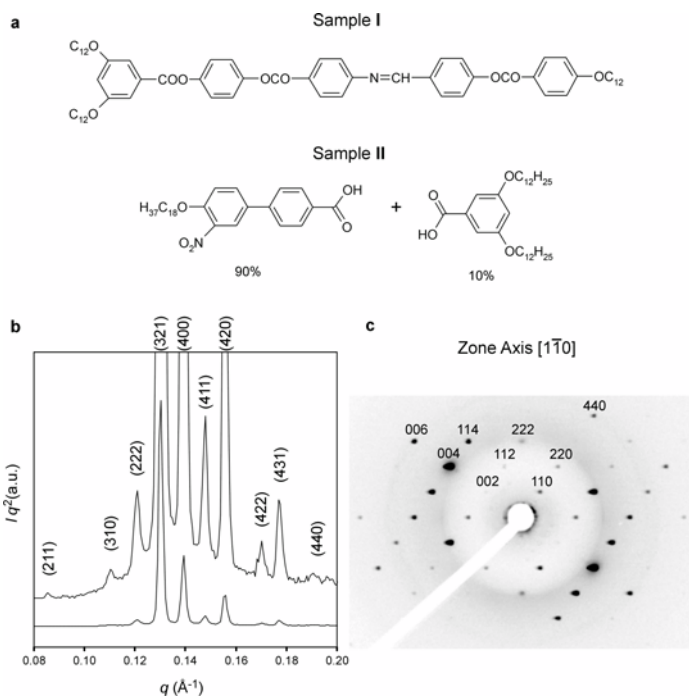


Figure 9. Chemical structures and X-ray diffraction patterns of the liquid-crystal phase which shows the unusual cubic phase. a, Structures of the compounds. b, Small-angle X-ray powder diffractogram of sample I. The curve on top is enhanced by a factor of 10. c, Single-domain diffraction pattern of sample II.

In between the lamellar and the columnar phase, there are three known bicontinuous cubic phases in lyotropic (i.e. solvent-containing) liquid crystals^{21,22} and block copolymers^{23,24}. They have space group symmetries $Ia\bar{3}d$, $Pn\bar{3}m$, and $Im\bar{3}m$ respectively²⁵. Each of them contains two interwoven networks made up of channel segments with junctions where 3 ($Ia\bar{3}d$), 4 ($Pn\bar{3}m$) or

6 ($Im\bar{3}m$) such segments join. If one connects all the midway points between the two networks, one obtains a so-called infinite periodic minimum surface (IPMS). These are of type G ($Ia\bar{3}d$), D ($Pn\bar{3}m$), and P ($Im\bar{3}m$)²⁶.

In thermotropic liquid crystals, cubic phases with space group symmetry $Ia\bar{3}d$ (commonly known as Smectic D phase²⁷) have also been identified. However, the structure of the thermotropic $Im\bar{3}m$ cubic phase remains unclear²⁸. Compared to molecular dimensions, the unit cell parameter is too large to be explained by the P-type “bicontinuous” structure. Another indication of the complexity of this structure is the fact that the dominant reflections observed in the powder x-ray pattern are (321) and (400), instead of the (110) as commonly observed in the lyotropic $Im\bar{3}m$ (P) phase.

Collaborating with Dr. Imperor-Clerc at the University of Paris at Orsay, we have determined the structure of the new cubic liquid crystal phase by reconstructing its electron density map from x-ray diffraction patterns²⁹. In the reconstructed map, the high-density regions can be best described by a model consisting of three sets of interwoven networks as drawn in Figure 10. Two of the three networks (yellow and blue) are identical but mutually displaced by $(x/2, y/2, z/2)$. Each of these networks contains an octahedron which sits either at a corner (yellow network) or at the centre (blue network) of the unit cell. The octahedra are connected by rods along the edges of the unit cell or from centre to centre of the cell. An octahedron is made up of 12 rod-like segments defining its edges. In between the two networks is the third “middle” network (magenta in Figure 10), every node of which joins three rod-like segments, as in the $Ia\bar{3}d$ “gyroid” (G) structure. Interestingly, the backbone of the “middle” network follows closely the P minimum surface, although it does not cover the whole surface. The three networks of high-density must be occupied by the aromatic mesogens lying across the rod-like network segments, with the surrounding low-density continuum made up of the tethered aliphatic chains.

This newly determined cubic liquid crystal structure shows how elaborate networked nanostructures can be generated by molecular packing alone. One important character of thermotropic liquid crystals is that molecules are required to fill the whole space without gap, while in lyotropic systems these gaps can easily be filled by the presence of solvent. As a consequence in thermotropic systems the mode of self-assembly is more sensitive to the geometrical shape of the molecules. Geometric calculations show that the shape requirements for molecules forming the triple-network structure are very similar to those for the formation of the $Ia\bar{3}d$ phase. These calculations also help rationalize the observed

phase sequence in a range of liquid crystal phases as a function of temperature and molecular architecture.

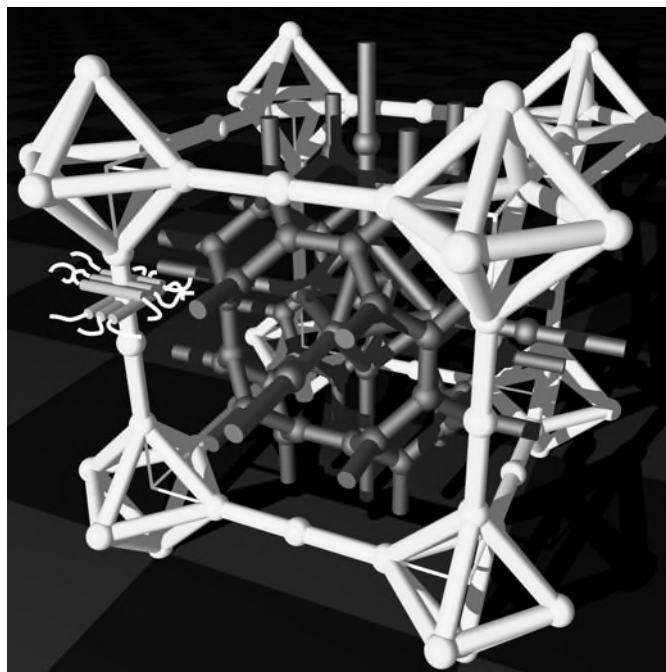


Figure 10. Network model of the new cubic liquid crystal structure. It consists of three infinite interpenetrating networks, coloured blue, magenta and yellow [gray-ed] respectively. White lines delineate the unit cell. Several molecules are also schematically shown as aromatic rods with white alkyl tails.

Conclusions

Complex modes of self-assembly can be achieved in compounds with relatively simple molecular structures, as demonstrated in tree-like, T-shaped and rod-like molecules. The understanding of these unusual structures sheds new light on the general principles governing self-assembly, and points the way to the rational design and fabrication of complex functional nanostructures.

Acknowledgements

The author would like to thank Prof. Goran Ungar, Dr. Yongsong Liu, and other members of our research group for their contribution to the work discussed above.

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The BLCS Committee 2006

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20th Annual BLCS Conference

11th-13th April, York, UK



The annual British Liquid Crystal Society meeting was held this year in the wonderful surroundings of the University of York between April 11th and 13th. The conference this year was organised by John Goodby, Avtar Matharu, Martin Bates and Stephen Cowling. The main emphasis of the conference, as always, was for students to present their latest research work alongside work from more established researchers.

The talks this year covered a wide spectrum of subjects within the field; from my own talk on the fundamental properties of ferroelectric liquid crystals to a talk by Dr. Cliff Jones on the trials and tribulations of getting a display device to market. Other talks of note were the talks of Dr. Per Rudquist on the stabilisation and design of orthoconic antiferroelectric liquid crystals (OAFLCs) and analogue switching ferroelectric liquid crystals (V-shaped switching), Prof. E.P. Raynes' talk on a novel technique for measuring the enantiomeric excess using the Cano wedge and a twisted nematic cell and finally a talk on the works of the York and Southampton chemistry groups in combining rod and disc shaped molecules into one dimer to aid the solubility of the individual disc and rod shaped molecules. The prize for best talk however was awarded to Tim Atherton who gave an excellent presentation on "Orientational Transition in a Nematic Liquid Crystal at a Patterned Surface".



Dr Xiangbing Zeng receiving the Young Scientist award

The poster session was as diversified as ever with over forty posters covering the full breadth of liquid crystal research. This year's best poster prize was awarded to L.A. Parry-Jones, P.D. Brimicombe, C. Kischka and S.J. Elston for their poster on the "Frequency Dependence of the Flexoelectric Coefficients in a Dual-Frequency Nematic Liquid Crystal".

The award of young scientist of the year was given to Dr. Xiangbing Zeng from the University of Sheffield for his work on Supramolecular Liquid Crystals. He gave an excellent talk on 'liquid quasicrystals and liquid crystalline networks composed of T-shaped molecules'.



Which brings us to the conference dinner (above), where two more prizes were awarded; The George Gray Medal; and a new medal in honour of Cyril Hilsum for outstanding scientists who are not yet eligible for more prestigious international or domestic awards. With the suspense mounting... The George Gray medal was awarded to Prof. Dr Heino Finkelmann <see p1> from the Institute for Makromolekular Chemistry in Freiburg for his works on Polymer Liquid Crystals. It was also a pleasure to see Cyril Hilsum award the first Cyril Hilsum medal to Prof. Helen Gleeson <see p3>.

This year there were also a number of surprise awards with the rather exotic title 'Lifetime contributions to Liquid Crystals and the BLCS' or 'Old-timers' for short. The recipients need little or no introduction, they were: Gordon Tiddy, John Lydon, Bill Crossland, Harry Coles, Peter Raynes, Roy Sambles and David Dunmur.



Gordon Tiddy receiving his 'Lifetime contribution' decanter.



Bill Crossland receiving his 'Lifetime contribution' decanter.

The dinner was a particular success, with excellent food and, what seems to be, the traditional activity of trying to commandeer as much wine for your table as possible – regardless the consequences.



John Lydon giving a small speech on behalf of all the recipients of the Lifetime contribution awards.

This year's conference, as always, was brought to a close by Dr John Lydon. I think it goes without saying that John's talks are always a particular highlight, especially this year, as he was awarded the honour of presenting the Ben Sturgeon Lecture. His review of the field of chromonic liquid crystalline phases was delivered in his usual enigmatic way and brought to a close a very successful conference.

A report by members of the Manchester Liquid Crystal Group

EPSRC Fellowship for Nick Roberts



Nick Roberts has been awarded a 3-year EPSRC Life Science Interface Overseas Fellowship. This Fellowship scheme is specifically for researchers at the interface between the physical sciences and engineering and the life sciences who are at an early stage of their career. The project is to be based at the University of Manchester, but as part of the work, Fellows are required to spend between 12-18 months in other overseas laboratories. For Nick, this time is planned to be spent in the laboratory of Prof. Craig Hawryshyn in biology department of Queens University, Ontario, Canada.

The project is entitled /Specialization in the Visual System: Designing Different Optics for Different Roles.

/The principal goal is to uncover how optical and physical design contributes to the different functional roles of the two types of light sensitive cells in the retina, called rod and cone photoreceptors. We already know that rods provide all vertebrates with low light level vision and cones mediate daytime and colour vision. However, we do not yet understand how the different lamellar morphologies of these two cell types determine these variations in function. The project will use optical and small angle x-ray scattering techniques to compare both the structure of the double membrane stacks that exist in the cells and the optical properties of the membrane environments in the two cell classes. Ultimately, the aim is discover how self-assembly within such cells actually controls both the biophotonic design and workings of the vertebrate retina, possibly the most beautiful and complex example of a functional, self-organizing organic optical system.

“Recent Trends in Liquid Crystal Research”: A Report

India-United Kingdom (UK) Science Network

A three day seminar on the “Recent Trends in Liquid Crystal Research” was held from November 14-16, 2005 at Raman Research Institute (RRI), Bangalore, India. The seminar, first in the series of India-United Kingdom (UK) Science Networks was under the auspices of Department of Science & Technology (DST) New Delhi and The Royal Society, London.

In his introductory remarks Ravi Subramanyam, Director, RRI, extended hearty welcome to all the delegates both from United Kingdom and India to the seminar. He expressed the hope that such scientific interactions will bring more synergy between the scientists and professionals of both the countries for the benefit of science, society and humanity at large. John W Goodby, University of York, UK in his own classic style, was very optimistic about the fruitful results from such seminars and strengthening of the proposed scientific networks between the two countries. It will provide more opportunities and forum for young researchers to form international collaborations. In all 12 oral and 20 poster presentations were made in the seminar, attended by about 50 participants.

Five oral presentations were from UK scientists. The first lecture on Novel chiral effects in liquid crystals by John Goodby was mind blowing. He discussed about various issues in such systems and elaborated on the enantiomer formation and appearance of ferroelectric switching with non chiral moieties at length. Andy Cammidge, University of East Anglia, UK highlighted about the efforts made on the synthesis of discotic liquid crystals and the factors influencing their stability. His lecture mainly focused on the silicon thio-cyannines, polymers and copolymers of siloxanes to enhance the range of applications of such liquid crystalline materials in molecular devices. The lecture by C.T. Imrie, University of Aberdeen, focused on the novelty of liquid crystalline oligomers as the futuristic novel materials. He deliberated on the structure-property relationships in the context of dimers, trimers and tetramers. Helen F Gleeson, University of Manchester expressed her views about the theoretical modeling of various intermediates in chiral smectic c phase, still being debated. She talked about the use of resonant x-ray scattering techniques to determine the structures of such intermediate phases. Duncan Bruce, University of York talked about the Adventures with liquid crystals- from the non-covalent to the inorganic solid state.

The work carried out by Indian scientists was presented by N V Madhusudana, B K Sadashiva, Sandeep Kumar, Krishna Prasad among others. The



The official speakers’ photograph. Back left: Dr. A N Cammidge, Dr S Krishna Prasad, Prof D W Bruce, Dr Suresh Das, Prof. S Ramaswamy. Front left: Prof S Kumar, Prof H F Gleeson, Prof V G K M Pisipati, Prof J W Goodby, Prof B K Sadishiva, Prof C T Imrie, Prof N V Madhusudana.

focus was to explain some physical phenomena, review of some recent results on bent core molecules and photo induces effects in liquid crystals. The poster session indeed attracted the attention of the workers and research students depicting some new results on liquid crystalline material synthesis and characterization.



Poster sessions presenting the work from across India

In the concluding session, newer areas of liquid crystal research were identified and directions set for further collaborative programmes in this novel area of significance to both experimentalists, physicists, and materials chemists.

It would be wrong to not mention the wonderful social atmosphere that allowed the continuation of discussions beyond the official scientific sessions. The fantastic warm

and sunny weather allowed outdoor lunches and an evening dinner to be held. The food was excellent and the whole atmosphere was one that significantly contributed to the enjoyment and fruitfulness of the visit (this was especially noted by the U delegates).



Delegates enjoying lunch in the grounds of the Raman Research Institute



A lively debate over coffee

It was indeed a wonderful experience that allowed the sharing of thoughts amongst liquid crystal workers of both the countries. The sponsors of the meeting, the Royal Society, London and the Department of Science and Technology, New Delhi, are sincerely thanked for supporting this exciting and interesting meeting.

Professor K K Raina
Thapar Institute of Engg.
& Technology, Patiala, India.

Landmark year for two FRSs

On 21st December 2005 around 50 current and former colleagues and students of Profs Peter Raynes FRS and Roy Sambles FRS gathered in Bristol for a symposium held to celebrate their 60th birthdays. A series of informal presentations were given from associates covering past, present and future technologies associated with their long and distinguished careers. Particularly noteworthy was Steve Elston's whistle-stop tour of the optical waveguide characterisation techniques developed by Roy at Exeter over the past twenty years (complete with a "leaky-ometer" for the un-initiated!). Cliff Jones gave an entertaining account of his experiences as a PhD student of Peter's during his time at Malvern and then fittingly brought the day right up to date with the latest developments at ZBD. David Coates, also formerly of Malvern and now of Magink, presented his latest work on liquid crystal billboards. He also spoke about some of the more unusual requirements specific to this type of media, such as the need to accurately reproduce the red colour used by Coca-Cola and the necessity for billboards in Israel to be bullet-proof!

An industrial perspective on Roy's work was provided by his former PhD student Steve Kitson, now of HP laboratories, Bristol, on gratings and post-aligned bistable displays. Another former Exeter PhD student, Mike Linehan, provided the day's theory section presenting his current work on symmetry breaking and the foundations of liquid crystal continuum theory. Finally Paul Brimicombe, a current PhD student at

Oxford, spoke about his latest work on pi-cells and dual-frequency liquid crystals which fittingly united both current work on dual-mode displays and dual-frequency materials originally associated with RSRE Malvern during the early days of Peter's career.



The event was a great success thanks to the combined efforts of Nigel Mottram, Rob Richardson and Carl Brown. The large number of companies and academic institutions represented at the meeting illustrated the broad range of areas that the two honoured guests have been involved in during their careers to date. In particular, the large number of Roy's former PhD students still actively involved in photonics research also paid testament to his infectious enthusiasm for the subject, which still shows no signs of fading!

Sharon Jewell, Exeter

BLCS Bursary reports:

21st ILCC, Keystone, Colorado, July 2-7th, 2006

This year the 21st International Liquid Crystal Conference was held in Keystone, Colorado. The meetings are biennial events held at various places where liquid crystal research is strong. This year the meeting was organised by the Liquid Crystal Research Centre at the University of Colorado in Boulder held under the auspices of the International Liquid Crystal Society. The conference, attended by over 600 people, represents the main international forum for presentation and discussion of new results in the multifaceted subject of liquid crystals.

The programme consisted of plenary and invited lectures, oral contributions and poster presentations covering a wide range of topics including Synthesis, Modelling, Chirality and Devices.

I presented a poster titled 'Rod-disc Amphiphiles as Candidate Biaxial Mesogens' and received interest regarding this work. I enjoyed the discussions and found thoughts on the research that highlighted aspects of my work beneficial and I will consider those as the research progresses. There was also ample time to view other posters on areas of great interest to me namely biaxial nematics and bent-core liquid crystals. I also took time to view posters from other areas and I enjoyed learning about them.

I attended the oral presentations from both plenary and invited speakers, finding them to be stimulating. It

was good to see many aspects of work on the forefront liquid crystal science. The areas of greatest relevance to me were Biaxial Nematics and Bent-core Liquid Crystals. I also found areas that were new to me very interesting and felt that I have improved my understanding of topics outside my area of research.

Colorado is home to some beautiful mountains. The altitude at Keystone is over 2,700 m so the effects of altitude could be felt on arrival to the area. Afternoons in the conference schedule remained free which presented the opportunity to see Keystone and its surrounding areas. During one afternoon, organised excursions were available for the conference delegates. I went on an excursion to Mount Evans and Echo Lake which was a memorable experience followed in the evening by the conference dinner. Celebrations on the 4th of July, Americas Independence Day, was a firework display across the lake at Keystone.

Overall, I found the International Liquid Crystal Conference 2006 to be an enjoyable experience. I would recommend other PhD students to attend because it is informative and many fruitful discussions are possible. Finally I would like to express my thanks for opportunity to attend this conference.

Pamela Martin
University of York

The 21st International Liquid Crystal Conference (ILCC) was held from the 2nd - 7th July 2006 in the Rocky Mountain resort village of Keystone, Colorado, located about 90 miles from Denver and at a staggering altitude of over 9000ft. The facilities, accommodation and scenery were spectacular and were greatly enjoyed and appreciated by all the delegates.

During the conference I attended various talks and saw many posters covering a wide selection of specialist and general areas within the field. These helped me gain a wider perspective of the world of liquid crystals whilst being able to apply some of the ideas to my current theoretical work. During a poster session I was able to present some of my work involving the measurement of compression constants in smectics. This gave me the chance to interact with others and explain some of my ideas and work, helping me to gain different outlooks and answer questions. Many of the talks and posters, from the forefront of liquid crystals, were inspirational and fascinating and vastly encouraged my appreciation of other theoretical

and applied aspects in the many diverse range of interests arising in liquid crystals.

Throughout the week we were fortunate enough to attend various social events: a welcome reception on the first evening, 4th of July picnic with fireworks at the lake and then the conference dinner midweek. All were thoroughly enjoyable (even though the trip to the conference dinner by a highly perched gondola did terrify me!).

The conference was a huge success due to the tremendous efforts of the organising committee from the Liquid Crystals Materials Research Center at the University of Colorado. The staff at the Keystone Conference Center were both extremely helpful and friendly. I would like to pay particular thanks to the BLCS for the bursary which aided my travel costs. I found my American trip invaluable, extremely worthwhile and an unforgettable experience and I thoroughly recommend future ILCC meetings to other research students.

Fiona Stewart
Strathclyde University

New directions in liquid crystal science

Report on the Royal Society discussion meeting organised by Duncan Bruce, Roy Sambles FRS, Harry Coles and John Goodby

For many people liquid crystals are known as the materials in displays. Over the past thirty years or so, LCDs have played an increasingly important role in life. Virtually everyone in the developed world owns at least one LCD and usually many more. They have dramatically changed over the past thirty years from the simple grainy black and white (or dark grey and light grey) displays measuring only a couple of square centimetres that first appeared in the 1970s. These of course still find use today as cheap digital displays in many household items such as washing machines and clocks. Their modern incarnation as colour displays in a variety of sizes is well known; from the small ($\sim 10 \text{ cm}^2$) displays common in mobile phones and cameras, through the medium sized ($\sim 100 \text{ cm}^2 - 1000 \text{ cm}^2$) screens used in personal DVD players and laptops to the large displays ($1000+ \text{ cm}^2$) now commonly available as LCD-TVs. High definition television screens with a 150cm diagonal are now being produced, showing how far the displays have come since the pioneering LCD consumers wore the small grainy displays on their wrists. None of this development would have been possible without the interaction between chemists, physicists and engineers whose combined research has led to the development of devices unimaginable three decades ago. Every generation of display technology has required new materials with different properties that need to be engineered from a molecular level. When we think of the advances made in LCD technology, in both the materials and the electronics, we may think that the liquid crystal field is a mature one. Displays are now so good that we may think that no further improvements are necessary, although it is almost guaranteed that the displays we will be using at home and at work will not be the same in twenty years time; these displays will require the same interaction between chemists, physicists and engineers that has been essential since the early days. However, the field of liquid crystals is about much more than just displays. A Royal Society discussion meeting was held in London in December 2005 to discuss future directions in the field of liquid crystals, from gene therapy in biology, to the manipulation of microwave radiation, to lasing and telecoms devices.

When we consider that cell membranes are constructed from liquid crystalline molecules, it is not surprising that liquid crystals play an important role in biology. However, we learnt at the meeting that the liquid crystalline phase plays a much larger biological role than just forming a bag which holds the cell

together. Cyrus Safinya discussed the structure – property relationship in DNA-liposome complexes, which are important for treating diseases using gene therapy. The liquid crystalline nature of these complexes, which can be probed by synchrotron x-ray diffraction, is responsible for the mechanism of gene release in the cell cytoplasm. Thus understanding the structure is an important part of understanding transfection efficiency and ultimately lead to better gene therapy treatments. Franois Livolant also discussed structure – property relationships, but in chromosome structures and dynamics. She showed how flat cylindrical nucleosome core particles, linked together in a chain, form self assembled ordered phases. Again, understanding the structure enhances our understanding of their biological properties in the body. Richard Templar proposed a universal mechanism of drug permeation into cells. He showed how drugs effectively eat their way through cell membranes. Understanding this mechanism is obviously a key step in designing new drugs, which can target specific sites or cells. John Seddon spoke about the technique of pressure jump synchrotron x-ray diffraction, and how it can be used to study the structures of, and transitions in, lipid systems. Pressure jumps have the advantage over conventional temperature changes in that the solvent properties are not significantly altered and pressure propagates rapidly through the system, thus the system equilibrates rapidly. Although so far only applied to lipid systems, future directions include aiming for microsecond timescales, and this could ultimately lead to the study of protein unfolding and DNA unwinding, as well as the phase transitions in conventional liquid crystals and block copolymers.

The structures of the liquid crystal phases have been long known to be responsible for their unique behaviour, and liquid crystals still have an important role in the materials field. Wolfgang Weissflog discussed new directions in bent core or banana molecules. He showed how molecular design could be used to construct molecules that form polar crystalline structures that can be switched. He also showed that non-chiral molecules could exhibit chiral phases, and that the handedness could be switched by inverting the field polarity. Ed Samulski also discussed banana shaped molecules, but ones that exhibit nematic phases. In particular, he discussed a series of bent core compounds with different bend angles, one of which has been found to exhibit the biaxial nematic phase. In this phase, the molecules align along three orthogonal directors, as opposed to the single director in a regular uniaxial nematic; this may lead to novel switching behaviour, since the molecules could be switched about a minor rather than a major axis. Andrew Cammidge took us

away from bent rods to discuss disc shaped molecules. He described synthetic routes to make molecules with disc-like cores in which the periphery of the discs are distorted away from the regular disc-like symmetry. Virgil Percec described his work on supramolecular systems as mimics for biological systems. He showed how, for example, small molecular building blocks shaped like slices of a pie could be used to build a columnar structure which acts as a biological mimic for a helical porous protein.

Tim Wilkinson discussed how the liquid crystal over silicon technology used in displays could be adapted to modulate the phase of an incident optical wavefront. This is predicted to be of use in telecommunications devices. Roy Sambles discussed how liquid crystals can be used to manipulate electromagnetic radiation outside the visible region. He discussed how devices can be constructed to manipulate wavelengths corresponding to the microwave region, by using a slit structure, and showed how these can be used to control the transmission and absorption of microwaves. Peter Palffy-Muhoray discussed how the soft structure of liquid crystals could be exploited to be used as tunable photonic band-gap materials. He discussed possible applications as switchable filters and mirrorless lasers, tunable large area light sources and sensors. Min-Hui Li described recent work in the field of artificial muscles. These are based on a network of side-on nematic liquid crystal homopolymers. When the temperature is changed and the liquid crystal undergoes a transition from the disordered isotropic phase to the ordered nematic, a contraction of the artificial muscle is observed. Photo-responsive muscles are also a possibility, in which UV light triggers a change in the conformation of the liquid crystalline molecule, which then causes the muscle to react. Iain McCulloch described the development of main chain liquid crystalline semiconducting polymers and reactive mesogen semiconductors and their use as organic electronics. In these materials, the semiconducting component uses an organic material as a replacement for silicon. These are expected to be useful in the manufacture of electronic products by low cost printing technologies, such as ink jet printing, with the semiconductor sprayed onto the surface. Helen Gleeson described her work on laser trapping of particles in a liquid crystal medium with an optical trap. By trapping and moving micron sized particles the shear viscosity coefficients can be determined. She also showed how droplets of liquid crystal could be manipulated in an

isotropic fluid, and how chiral liquid crystal droplets can be made to rotate when illuminated with linear polarised light. Henk Lekkerkerker discussed his groups advances in the field of colloidal liquid crystals. Colloidal particles are much bigger than conventional liquid crystal molecules, typically 100nm or larger. He described how these are essentially hard body liquid crystal systems, similar to theoretical models investigated by computer simulations. In contrast to small molecule liquid crystals, gravity is important for larger particles, and the transitions caused by prolonged standing in colloidal systems were discussed; for example, a biphasic system with an isotropic and a nematic phase becomes a triphasic one, with the addition of a columnar phase if left to stand. Although these systems are theoretically interesting, the columnar phases also have the possibility of being used to produce photonic crystals, with tunable particle spacings possible by using colloidal systems containing particles of different sizes. The technique of nanocasting was described by Markus Antonietti. He described how soft matter structures could be nanocast using silica to form inorganic materials. This technology can be used in two ways. The first is to prepare new types of porous materials in which the pore sizes and connectivity can be adjusted by using different liquid crystalline phases and compositions of materials to vary the soft matter structure that is being cast. The second is to cast unknown structures, much like plaster casts can be used to copy footprints made in soft ground, so that the rigid casts can then be analysed to reveal finer details of the structures that may not be accessible using other techniques.

Liquid crystals already play an important role in our lives, and will continue to do so in the future. Although liquid crystals are often thought of as the material in a display, this meeting taught us that many future technologies will rely on liquid crystals. It also taught us how understanding many nanoscopic biological functions relies on the understanding of the liquid crystalline environment the molecules find themselves in. Although liquid crystals may be perceived as a mature technology inasmuch as virtually everyone owns at least one LCD and we understand the structure and properties of conventional low molar mass liquid crystals, there is still much to learn, whether this is how to design new materials with specific properties for new applications or why biological systems self assemble in a certain way.

Martin Bates
University of York

10 Britons Who Shaped Our World:

The Independent, July 5th, 2006

George Gray



Eureka moment: Creating the first stable liquid crystals suitable for liquid crystal displays.

How has it changed our lives? Liquid crystal displays (LCDs) are used in everything from pocket calculators and watches to mobile phones and laptop computers. Scientists had been aware of the potential for using liquid crystals in displays for many years, but the materials that were available were insufficiently stable at room temperature, and could be destroyed when exposed to moisture, air or light. Working with the Ministry of Defence in 1973, Gray and his colleagues at the University of Hull discovered a new class of liquid crystalline material which was stable at room temperature. This was seized upon by the electronics industry and consumer products that contained small LCDs, such as watches and calculators, rapidly became ubiquitous. Liquid-crystal technology now forms the basis of an industry estimated to be worth some £20bn worldwide.

What next? Gray is now retired from the University of Hull but continues to play an active role in liquid crystal matters around the world.

The section on the left (please excuse the poor quality reproduction) was taken from the article on the 10 Britons who have shaped our world. The list highlights 10 British academics who have shaped the modern world through their research. George Gray has been listed in this illustrious list which also includes: Alf Adams, Martin Sweeting, Ian Wilmut, Fred Sanger, Deborah Withington, Martin Evans, Peter Fleming, Helen Muir and Peter Mansfield.

Simon Hadlington
The Independent

Dr Steve is now Prof Steve!

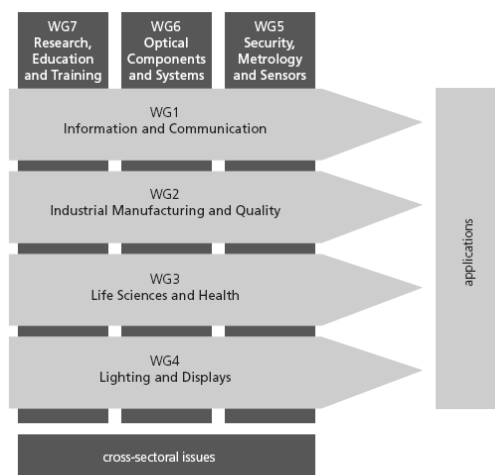


Congratulations to Steve Elston on being awarded a chair at Oxford University Department of Engineering. His research interests are mainly in the field of novel liquid crystal materials and applications, both theoretical and experimental. The theoretical work includes: (i) the applications of liquid crystal continuum theory to novel phases; (ii) the interactions between order and elasticity; (iii) advanced optics of LCDs. Experimental work includes the study of alignment and switching processes in novel liquid crystal phases, and applications in both display technology and surface sensing systems.

Strategic Research Agenda in Photonics

The European Technology Platform Photonics21 has been founded in December 2005, based on an industry-led initiative. Comprising more than 350 members from 27 countries, Photonics21 unites the majority of the leading Photonics industries and relevant R&D stakeholders along the whole economic value chain throughout Europe. Presently, Photonics21 comprises seven work groups (WG):

For more information see:
http://web13.vdi.net-build.de/download/sra_april.pdf



British Liquid Crystal Society ***Registered Charity (328163)***

Balance Sheet at 18th March 2006

Description of Income

	£	£
1. Cash at Bank (opening balance, 18.03.05)		
<i>General Fund</i>	12277.75	
<i>Sturgeon Fund</i>	5959.93	
Total Cash at Bank		18237.68
2. Subscriptions		325.00
3. Cambridge Conference (2003)		580.42
4. Manchester MU Conference (2004)		2411.65
5. Interest accrued (2004-2005)		
<i>General Fund</i>	422.81	
<i>Sturgeon Fund</i>	205.24	
Total Interest		628.05
TOTAL INCOME		22182.80

Description of Expenditure

1. BLCS Young Scientist Prize 2005		250.00
2. BLCS Winter Workshop 2004		852.22
3. RSC/BLCS Prize		30.00
4. Website administration costs		45.24
5. York Conference (2006) loan for expenses		1982.23
6. <i>Cash at Bank (closing balance, 18.03.06)</i>		
<i>General Fund</i>	12857.94	
<i>Sturgeon Fund</i>	6165.17	
Total Cash at Bank		19023.11
TOTAL EXPENDITURE		22182.80

Treasurer's Annual Report

The accounts continue to remain in a healthy state with modest annual growth culminating in £19023.11 cash at Bank on 18.03.06. Growth has been due to recouping funds from previous conferences (Cambridge 2003, Manchester 2004), strong resurgence in Membership and a good rate of interest. The majority of cash at Bank continues to be retained in a high interest account with the Yorkshire Building Society as a registered charity.

Expenditure has been minimal this year and the Society was aware of the loss of £852.22 from the Winter Workshop from the previous year. A loan of £1982.23 was made to the University of York to cover initial expenses for the 2006 BLCS Annual Conference. A one-off payment of £30 was made to a BLCS member in recognition of winning the Best Poster Prize at the RSC Materials Chemistry Conference in Edinburgh 2005.

The capital value of the Sturgeon Fund continues to increase due to the addition of interest. However, this figure may drop since expenses of £420.73 in respect of the 2004 annual conference have still not been received.

Although the balance sheet is in a healthy state the following expenditure is already envisaged for 2006/7: BLCS Young Scientist Prize (£250); BLCS Bursary to attend ILCS 2006 (£200); Design and manufacture of C Hilsum Medal (£3106.71). To this effect, it is important that the Committee acts to recoup funds from

the 2005 BLCS Annual Conference (Exeter) since income from other sources for 2006/7 will be limited.

Finally may I take this opportunity to thank Professor Helen Gleeson in presenting the accounts at BLCS2006 in my absence, Dr Mike Hird for aiding with the smooth hand over of accounts and to all members of the BLCS for their support during financial year 2005/6.

Dr AS Matharu
BLCS Treasurer

Editor: Tim Wilkinson
Contributions to tdw13@cam.ac.uk

I would still like to do an issue earlier in the year, but to do this I need contributions, think of it as a cheap publication!



Size is everything in displays!

Top – LG.Phillips 100” TFT display, Bottom left – Panasonic 103” plasma display, Bottom right - Panasonic 61" LCD Projection TV

Procedures for the Ben Sturgeon Award

Eligibility for the Award

1. Young Scientists or Engineers (under 40).
2. Must have made significant contributions to the displays field over the past 10 years.
3. Ideally the work they are nominated for should be in the liquid crystal display field (this includes all aspects of technology used in LCDs).
4. Under exceptional circumstances nominees from other display areas will be considered. In that case the international value of the work must be clearly demonstrated.

The Nominations

1. Letter of nomination clearly setting out the value of the nominees' work.
2. Additional letters of support are helpful but not essential.
3. CV for the nominee.
4. Publications (papers and patents) list.
5. Copies of key papers.
6. Nominations should be sent to the Chair of SID (UK).

The Role of SID (UK)

1. The SID (UK) Committee will appoint two of its members to the Ben Sturgeon Award sub-committee to review nominations for the Ben Sturgeon Award and make recommendations to the SID Committee.
2. The SID (UK) committee will publicise the award through the SID Newsletter, the SID (UK) Homepage, through EPSRC, DTI and through individual networking.
3. The Ben Sturgeon Award Sub-Committee is responsible for selecting the winner (s). The decision of the Sub-Committee will except in exceptional circumstances (e.g. where the Sub-Committee is unable to come to a majority decision) be approved by the SID (UK) Committee which is responsible for making the award. In any such exceptional case the SID (UK) Committee will make the final selection of the winner based on the information presented by the sub-committee, through a majority vote. In this case the vote will exclude the two SID (UK) nominees to the Ben Sturgeon Award sub-committee.
4. SID (UK) will present the award at their annual autumn conference (usually in association with EID) unless the recipient cannot attend that meeting. In that case SID will make the award at the next SID (UK) Technical meeting.

The Role of BLCS

1. The BLCS committee will appoint two members of the BLCS to the Ben Sturgeon Award sub-committee to review nominations and make recommendations to the SID (UK) Committee. This will allow the BLCS Committee to select the best-qualified people taking into account the candidates nominated. In practice the Sub-Committee members would be appointed from BLCS Committee members provided they have appropriate expertise.
2. BLCS will publicise the award through their Newsletter and the BLCS Homepage, through individual networking and other appropriate routes.

The Role and Constitution of the Ben Sturgeon Award Sub-committee

1. The sub-committee is constituted of two members from the SID (UK) committee and two members from the BLCS committee, selected by the BLCS.
2. One of the two SID (UK) Committee members will be appointed by the SID (UK) Committee as co-ordinator.
3. The SID sub-committee members are responsible for writing the call for nominations in consultation with BLCS.
4. The members of the sub-committee should individually review all nominations and then either meet or through other means come up with recommendations for the award. The recommendations should include a ranking of all the nominations and a justification.
5. In the exceptional case that the sub-committee cannot agree, individual recommendations (with justifications) should be made to the SID (UK) Committee. The Sub-Committee can also recommend two awards being made

Timetable

Nominate SID Sub-committee members	February
Write call for nominations	March
Issue call for nominations	March/April
Deadline for submission of nominations	June
Appoint BLCS Sub-Committee members	July
Review of nominations	July/August
Sub-committee recommendations	End August
Selection of award winner	Early September
Inform winner	Early/Mid Sept
Publicise Award ceremony (EID)	September
SID order plaque	Mid September
Award ceremony EID	November