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14th European Conference on Liquid Crystals in Moscow at the ninetieth anniversary of the Fréedericksz transition

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CONFERENCE REPORT

14th European Conference on Liquid Crystals in Moscow at the ninetieth anniversary of the Fréedericksz transition

When work is a pleasure, life is a joy. When work is a duty, life is slavery.

Maxim Gorky, 1868–1936

Resembling Orwell's Ministry of Truth from his dystopian novel Nineteen Eighty-four, the main building of Lomonosov Moscow State University towers 182 m above the Moskva river, the tallest educational building in Europe (Figure 1). One of Stalin's Vysotniye Zdaniye (*High buildings*), although more commonly known as the *Seven Sisters*, the institute has been *Alma Mater* to not only many Science Nobel Laureates: Alexey Abrikosov, Ilya Frank, Vitaly Ginzberg, Pytor Kapitza, Lev Landau, Alexander Prokhorov, Nikolay Semyonov and Igor Tamm; but also winners of the Peace Prize Andrei Sakharov and Mikhail Gorbachev. Approaching the formidable façade from the Vorobyovy Gory gardens to the North East, passing busts of other luminary students including Ivan Pavlov, Dimitry Mendeleev and Pafnuty Chebyschev, one cannot help but be awed by the exceptional intellectual heritage of this establishment. Here, in June 2017, it was host to the Fourteenth European Conference on Liquid Crystals.

It was fitting that the conference should be held in Russia, being the ninetieth anniversary of the paper by Fréedericksz and Repiewa on the field effects in liquid crystals. Tsvetkov's Plenary speech that opened the conference gave an excellent history of Fréedericksz, not just his science that was to revolutionise the world of consumer goods at the end of the century, but of the man too: his marriage to Dmitri Shostakovich's sister Mariya, his internment by the NKVD (the People's Commissariat for Internal Affairs; the Soviet secret police) in 1937 and his untimely death from pneumonia after his release early in 1944. His work on liquid crystals and the eponymous transition led to the modern liquid crystal display industry. It was clear from the conference that followed that both the fundamental science and non-display applications continue to be as exciting and relevant as they have been in the past. This was emphasised by the Fréedericksz Prize Lectures from Nelson Tabiryan on Diffractive wave-plates formed from photo-aligned liquid crystals and by John Goodby on the influence of shape entropy and steric packing effects for molecular design of liquid crystals. A highlight of the conference was the moment when many previous winners of the prize joined Tabiryan and Goodby on the stage to be welcomed to the conference, Figure 2.

The conference was opened by vice-rector of the university and conference chair Professor Alexei Khokhlov. The organisers, Profs Victor Belyaev and Alexander Emelyanenko allowed the conference to run with a relaxed and informal atmosphere that is conducive to academic stimulation, whilst Sofia Torgova and Tatyana Shabatina helped ensure that the conference did not become too relaxed. The organisers had put together a packed programme running in three parallel sessions, and with separate poster sessions on the Tuesday and Thursday afternoons. Tuesday evening included a bus tour of Moscow by night. Wednesday afternoon was free time, for which several excursions were on offer, including visits to the Kremlin and the Novodevichy Convent. The conference banquet was held on Thursday evening aboard a river boat that provided a different viewpoint of the glorious Moscow city attractions, as well as Russian dancing with a Gypsy troupe, ample Vodka and warm hospitality from all of the participants from our host nation.

The sessions were held in the spacious Shuvalovsky Building (Figure 3) overlooking the main building. This building provided ideal facilities for the conference, from the large lecture theatre dedicated to the plenaries, to the medium sized lecture theatres for the individual sessions, named after Fréedericksz, Lebedev and Landau.

In addition to the plenary given by Prof Tsvetkov, and the prize winning talks of Profs Nelson Tabiryan and John Goodby, plenaries were given by Profs Sven Lagerwall, Noel Clark, Maria Godinho (Figure 4) and Sergei Palto. There was also a special session to celebrate the opening of a Russian Office of the conference sponsor, LCD company BOE, where CTO Dr Dong Xue invited participants to collaborate in areas of both LCD and non-display applications of liquid crystals.

I enjoyed the contrasting plenaries from two giants of the Liquid Crystal community, Clark and Lagerwall,

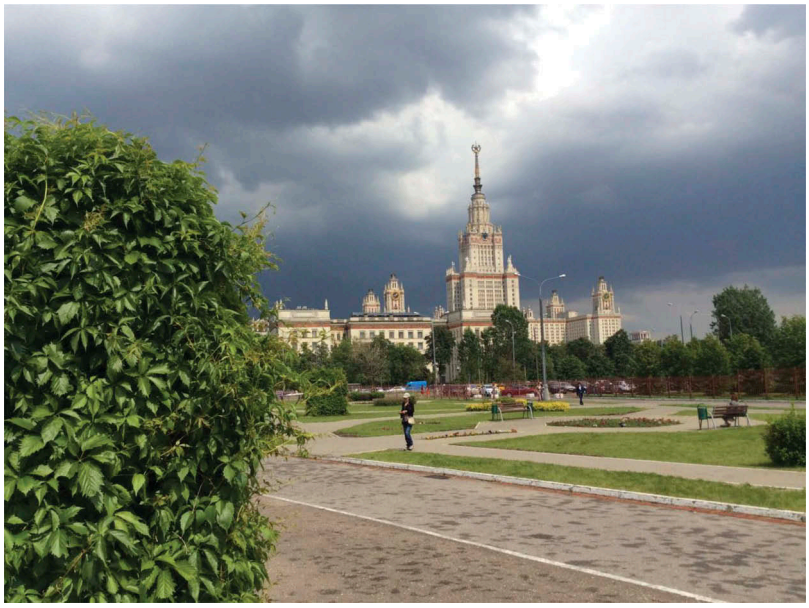

Figure 1. The Lomonsov Moscow State University, viewed from the conference building.

Figure 2. Past and current recipients of the Fréedericksz Medal from the Russian Liquid Crystal Society. Left to Right: Eugene Averyanov, (*Kirensky Institute of Physics of Siberian Branch of Russian Academy of Sciences* (*SB RAS*)), Nelson Tabiryan, (*BEAMCO, USA*), John Goodby, (*York University, UK*), Galina Zharkova, (*Khristianovich Institute of Theoretical and Applied Mechanics* (*SB RAS*)), Lev Blinov (*Shubnikov Institute of Crystallography of RAS*); Alexander Petrov, (*Institute of Solid State Physics of Bulgarian Academy of Sciences*); Nadezhda Usoltseva, (R&D Institute of Nanomaterials of Ivanovo State University); Sergey Pikin, seated (Shubnikov Institute of Crystallography of RAS); Sergey Palto, (*Shubnikov Institute of Crystallography of RAS*); Valeriy Shibaev, (*Lomonosov Moscow State University, Chemistry Faculty*); Vladimir Bezborodov, (*Belarusian State Technology University, Belarus*); Boris Ostrovskiy, (*Shubnikov Institute of Crystallography of RAS*); Noel Clark, (*Boulder University, USA*); Sven Lagerwall, (*Chalmers University, Sweden*). *Photograph by Ingo Dierking.*

both renowned for the invention of the surface stabilised ferroelectric liquid crystal (FLC) device in 1980. Lagerwall gave a statesman-like presentation of the history of FLCs, reminding us both of the enormous progress made through the worldwide effort on the phase through the 1980s and 1990s, and highlighting the potential for future applications, albeit unlikely for large area television applications. Lagerwall is always so

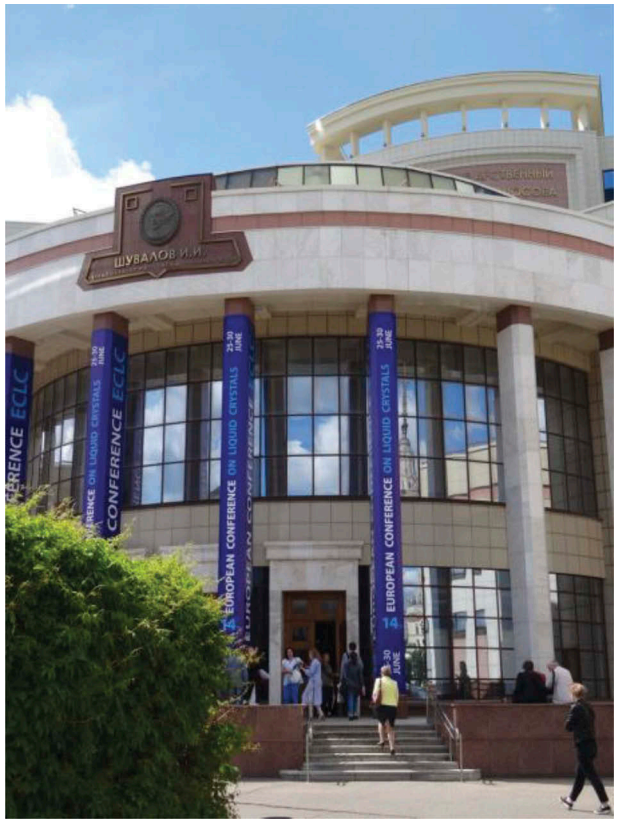

Figure 3. The conference venue. (Photo courtesy of I. Dierking.)

eloquent and erudite, and was able to give insights into the technology unique to him. Clark, on the other hand, gave an up-to-date summary of his ongoing work on the twist-bend nematic (N_{tb}) phase. He presented X-ray resonant scattering measurements for the N_{tb} phase of the odd dimer CB7CB, showing that the temperature dependent bend of the local director is linear in sin θ (the angle between the director and the N_{tb} helical axis). Clark's simple yet powerful model showed that extrapolating this plot to $\theta = \pi/2$ gives an intercept of the reciprocal molecular radius R_{mol}. Thus, the pitch of the phase $P = 2\pi\ R_{mol}.\cos\theta$ with the limit of $P = 2\pi\ R_{mol}$ at the $N - N_{tb}$ phase transition. As a physicist, Clark's talk rewarded the listener with its simplicity, and it will be interesting to see how universal this behaviour is for the multitude of N_{tb} systems that the chemists are now producing.

Tabiryan and Goodby exemplified worthy winners of the Fréedericksz Medal, reviewing, respectively, the rich diversity of optical devices that can be created using patterned oriented LC films, and the power of molecular packing considerations when designing novel liquid crystal components with the complexities of phases such as the twist-bend nematic. Godinho presented a plenary entitled 'Cellulose-based liquid crystals for advanced materials'. Particularly interesting was the effect of cellulose films and fibres that are sensitive to outside stimuli, evinced by the demonstration of a micro-motor of cholesteric cellulose spinning about an axle when exposed to humidity on one side. Palto described lasing in nematic liquid crystals using sub-micron metallic grating structures operating close to the plasmon resonance wavelength.

Each of the three parallel sessions began with an invited talk, with speakers from across Europe (UK, Russia, Germany, Italy, Spain, Belarussia, Ireland, Czech Republic, Luxembourg, France, Poland and Slovenia all being represented), together with guest speakers from China, Japan, USA and Taiwan. Picking out highlights from such a rich and varied conference is difficult. As naturally occurs for any conference with parallel sessions, I missed some presentations that were of interest due to the overlapping sessions. Hence, the reader must be excused if I give a parochial view of these sessions in this review.

The discovery of the Nematic Twist Bend phase in recent years remains of major scientific interest, as displayed by the plenary by Clark and the prize winning lecture of Goodby. Mehl gave a presentation on odd spaced trimers and tetramers, including many examples with asymmetric spacers. Interestingly, the N_{tb} phase could be found in each of the examples where the both spacer units are odd, whereas and odd-even spacer combination destabilised the N_{tb} phase. Amongst the other chemistry presentations, I was particularly engaged by Prathiba's comprehensive talk on phase separation in binary mixtures of immiscible liquid crystals, and in particular the importance of viscoelastic phase separation in materials with large viscosity differences, such as bent-core and calamitic liquid crystals.

For me, the standout theoretical contribution was made by Selinger. His was a very clear presentation on some neat work about the trajectories of moving nematic defects, postulating an orientation vector **p** for each defect. For example, the +½ defect has a single vector **p** emanating radially from the disclination core in the direction parallel to the director. A −½ defect, on the other hand, is a triple valued vector, more readily described by a rank 3-tensor. This analysis allowed an analytical solution to describe the preferred trajectory of defects that depends on their sign and magnitude, which depends on the relative starting orientation of the defects.

Device physics was exceptionally well represented at the conference. Neyts presented work on the electric field of nematics with bigratings. Orlova demonstrated a personal UV dosimeter using the chirality induced in a

Figure 4. Plenary lectures presented by John Goodby, Sven Lagerwall, Noel Clark and Maria Gordinho. (Photographs courtesy of I. Dierking.)

calamitic liquid crystal when hydrogen bonded to vitamin D. De Santo presented an electrically tuneable multi-colour cholesteric laser, wherein droplets of each wavelength were initially formed in separate emulsions. D. Gorkunov showed how sub-micron pitch metal gratings can be used to produce fast switching effects for polarised light close to the plasmon wavelength for the grating. The SEM of an in-plane electrode structure with a 100nm gap and 300nm pitch was particularly impressive. Zyryanov reviewed the various anchoring transitions that are possible using ionic surfactants, with a particular focus on achieving the inverse mode (non-scattering in the off state) polymer dispersed liquid crystals for application in smart windows. LC droplets were also used by Dubttzov, who combined azo-dyes with nematic LC to create biological and chemical sensors, finding that the critical for the light induced transition from the bipolar to radial configuration of the droplet was strongly dependent on the concentration of a polar solute.

Liquid Crystal Elastomers continue to be a crowd pleaser at such conferences, with videos of light driven micro-machines usually evident. J. Lagerwall produced LC elastomer shells that could be swelled using osmotic pressure, wherein the elastomer forms a negative order parameter nematic with the director parallel to the droplet normal due to the isotropic stretching of the bubble in the shell plane. It was the random choice of talk-order that meant that Lagerwall could claim to be the first to report a negative S in an elastomer, thereby just beating Mistry who, in the following talk, also showed a negative order parameter LCE but within an elastomeric film and deformed using an ingenious 2D elastic stress-strain apparatus. This excitement made

me wonder what was actually the first example of negative S order in liquid crystals. I presumed that would be at the –½ defect core, but became enthralled by such other possibilities.

Another area that continues to progress with enthusiasm is the effect of defects in liquid crystals. Particularly, interesting was the work of Jagodic, who studied fractal colloids in nematic liquid crystals, with up to four iterations of a simple Koch fractal (where each iteration adds three triangles at each apex, starting from a simple equilateral triangle). He compared theoretical modelling with particles of a variety of sizes fabricated using two-photon laser lithography. Two configurations occurred for each particle, with the 3 defect-pairs for the two configurations of the first iteration, but increasing asymmetrically as the number of integrations increase: 8 and 6 for the 2nd: iteration; 28 and 24 for the 3rd. Of course, in practice both the practical length scales achievable and the effect of finite anchoring meant that only theoretical results could be shown for the 4th iteration (corresponding to 420 and 384 defect pairs). As the particles reduce in size and the fractal dimension increases, the defect cores combine to form a symmetric delocalised defect around the particle. The similarities between this and the defect mediated bistable transition of the zenithal bistable display intrigued me, and so the potential for this topic to make further impact on future devices is something to watch out for. Other work on defects in 3-dimensional structures included a paper by Solodkov, who showed that multiple nematic droplets contained within larger droplets give combinations of linear and tetrahedral structures to conserve the total topological charge within the larger droplet. Defects also played an essential role in the study of inclusions within 2D SmC(*) films by P. Dolganov, who showed that both topological dipoles and quadrupoles are possible in the SmC structure due to the symmetry braking at the inclusion/smectic C interface. As with Solodkov, the inclusions formed linear chains, but because of the 2D nature of the film, square and hexagonal structures were also formed, with the obvious extension for photonic applications.

For those interested in what the next volume application in liquid crystals might be, Lavric may have described an answer: electrocalorics. This effect utilises hysteresis in the entropy when an electric field is applied during one half of a heating-cooling cycle, thereby showing potential for use in heat exchangers and refrigeration. This study concentrated on the elasto-caloric effect that occurs close to the ordering phase transition in a main-chain LC elastomer, whereby heat is removed from a system by mechanical work done by the elastomer. With 2K/MPa being 100 times that reported in other systems, this already seems promising. Materials with higher latent heats of transition (more first order) and lower crosslinking densities were requested.

Figure 5. One of the well-attended poster sessions, which were held on the Tuesday and Thursday afternoons. (Photograph by I. Dierking.)

Poster sessions were very well attended and busy (Figure 5), but those that managed to get attention from presenters were rewarded with a wealth of content and ideas. The last ECLC was organised by Helen Gleeson who was asked to judge the best three posters. She had a difficult job of sorting through the cornucopia of topics and new science. The winners were: Žigo Kos on the Cross-talk between topological defects in different fields revealed by nematic microfluidics, Yoko Ishii on defect control in nematic shells using magnetic fields, and Moritz Dechant on Phthalocyanine Hybrid Star Mesogens for photo voltaic application.

My overall impression of the state of liquid crystal research was that, although we have clearly a rich legacy of prestigious researchers in the field, both historically and attending the conference, the field remains vital, both in terms of its scientific progress but also for its youth. It was gratifying to see not only the mid-career researchers that continue to push the barriers of our understanding, but an ever increasing proportion of young scientists from across Europe already beginning to impact our diverse subject.

The conference ended in good spirits, with Prof Alexander Emelyanenko leading the awarding of the poster prizes, and the thanking of both the student helpers and Unifest representatives that had kept the conference moving. This was followed by a look forward to the next conference in 2019. The choice of where this is to be held is yet to be made, but the two possible venues were presented to the audience: Francescangeli presented on behalf of Barberi for Calabria University in Italy, and Boris Ostrovskii presented the case for the Military Academy of Wroclaw in Poland. Both locations were enticing, and when Prof Emelyanenko said that the choice was to be made democratically, I did not know which to cast my vote. Thankfully, Prof Emelyanenko's eye twinkled as he stated that the democratic vote will be organised by the President of the Russian Liquid Crystal Society: the conference delegates would be saved such a difficult choice, which was delegated to the International Advisory Board. We were in Russia after all.

For those fortunate enough to stay in the city beyond the conference, a wealth of culture awaited. The impressive fortress of the Kremlin; the unique interior of St. Basils Cathedral; shopping in Gum; avoiding storms in Gorky park; exploring the famously beautiful Metro; encircling the centre on foot through the parkway Boulevards from of Nikitsky to Yauzsky; all provided memories that will remain long with me. Most of all, it was the unimpeachable art displayed in the Tretyakov and Pushkin Galleries that captivated: Russian and French art at their height. It was easy to see how scientists from across the ages have been stimulated and inspired by the wonderful city that is Moscow.

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