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OBITUARY

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Figure 1. Lev Blinov, September 2012, Moscow.

Lev Blinov (Figure 1) passed away on 16 March 2023 in Moscow at the age of 83. Prof. Blinov was an outstanding scientist, unlike many others, he lived in science not one, but several lives. The spectrum of his scientific interests and achievements was extremely wide and covered not only the area of liquid crystals, being one of the principal researchers in the field, but also semiconductors, electronics and optics of organic hetero-structures, Langmuir-Blodgett films and photonic structures. Lev Blinov was much loved and respected by his scientific peers and disciples. He will be sorely missed by the scientific community, his colleagues and friends.

Lev Blinov was born on 27 June 1939 in Arkhangelsk, and shortly afterwards the family moved to Naryan-Mar (farther to the North-East of the former USSR), to which his vivid memories of childhood and youth were being related. After finishing Naryan-Mar high school in 1956, Lev continued his education at the Faculty of Radio Communications of the Leningrad Electrotechnical Institute of Communications and graduated from there in 1962. Then he went to work in a branch of the State Optical Institute (Kazan), where he was engaged in the research of new semiconductor and photovoltaic materials. Blinov's postgraduate studies (1964–1967) were carried out at the Physical Department of the Moscow State University and the Moscow Lebedev Institute of Physics. He investigated electronic processes in semiconductor crystals excited by high-power laser radiation. At the time, these works were at the cutting edge of research in optics and electronics. On their basis Lev Blinov received his PhD degree in 1967. The next stage of Blinov's life that greatly determined the area of his scientific interests and further career was his work at the Research Institute of Organic Intermediates and Dyes (NIOPIK, Dolgoprudny, Moscow Region). This was favoured by the fact that a new 'Photonics' department was established at NIOPIK in the second half of the 1960s, where investigations in chemistry and physics of new organic materials were initiated. Initially, Lev Blinov took part in NIOPIK studies of optical and polar properties of ordered organic films using both the traditional spectroscopic methods and Stark spectroscopy. However, the need to develop new high-speed electro-optical materials suitable for use in flat panel displays and sensors, quickly led to the idea of exploring liquid crystal (LC) materials, which were little-known at that time.

In Blinov's laboratory work was carried out on anchoring energy studies of nematic LCs with substrates, various electro-optical effects and the 'guest-host' effect in LCs with dichroic dyes. Considerable efforts were aimed at studying electrohydrodynamic (EHD) instabilities in nematic LCs [1] and the flexoelectric effect [2,3]. These works were performed in close collaboration with the theoretical group at the Institute of Crystallography, Moscow, headed by Sergey Pikin. Particular attention was paid to LC display applications. An example of the implementation of these ideas was the creation of electrically driven transparent devices for use in optical information processing systems. This work was conducted at Lebedev Institute of Physics, Moscow, in cooperation with Igor Kompanets. It was at NIOPIK where Lev Blinov revealed his talent as a prominent scientist and a leader who created a powerful team of researchers to perform internationally excellent work. Lev Blinov had a rapid administrative career at NIOPIK, going up from Head of the laboratory to Head of the department and then Chief Chemist of the Institute. In 1977, Blinov received his Doctor of Science degree and later became Professor in Solid State Physics. The results of the studies on LCs were summarised in Blinov's first monograph 'Electrooptical and magnetooptical properties of liquid crystals' issued by the Moscow Publisher 'Nauka' in 1978. Subsequently, the book was published in English by Wiley [4].

At the same time, the laboratory led by Blinov studied the physical properties of ordered organic films – mono- and multimolecular Langmuir-Blodgett (LB) layers. Optical properties and electron emission spectra of various organic heterostructures were investigated. Stark spectroscopy was used to study the properties of excited states of organic molecules and the character of molecular ordering in individual molecular layers.

In 1982, Academician Boris Vainstein invited Lev Blinov to head the laboratory of Liquid Crystals at the Institute of Crystallography of the USSR Academy of Sciences. Here, Blinov significantly expanded the directions of research on LCs and related organic materials. The development of microelectronics and computer technology required the search for new LC materials and the study of fundamentally new electro-optical effects to improve the optical characteristics, response time and operating control of LC devices. Cholesteric LCs and chiral smectics C (C* phase) possessing ferroelectric properties were considered and allowed the use of these materials for the development of high-speed optical modulators and information display devices.

In the 1980s, Lev Blinov and his co-workers Leonid Beresnev and Evgeny Pozhidaev continued their studies of the optical and polar properties of chiral ferroelectric C* phases, which had been started at NIOPIK. The relationship between the LC molecular structure and the magnitude of the spontaneous polarisation in the C* phase was investigated, new regimes of optical switching (fast modes, partial helix unwinding) were discovered. The experiments revealed a contribution to the dielectric permittivity of the helicoidal smectic C*, both of the Goldstone mode associated with the partial helix unwinding and of the 'soft' mode corresponding to a synchronous change of polarisation and tilt angle of molecules in the layers. These results were supported by the theoretical calculations of Sergey Pikin and Mikhail Osipov.

Noteworthy is the pioneering work by Lev Blinov and his co-workers on the creation of non-helicoidal ferroelectric C* LC [5]. Within the experiment mixtures of different chiral C* smectics differing in the sign of the helix twist were used. At a certain concentration of enantiomers, the helicoidal structure of the chiral LC appeared to be compensated, and the wave vector of the helix approached zero. In [6], fundamentally new results were obtained clarifying the microscopic mechanisms of polarisation appearance in the C* phase which took the partial ordering of the short axes of the molecules into account. Further, the authors succeeded in detecting a ferroelectric response in a lyotropic tilted LC in which a chiral additive was introduced [7]. Such a LC was a structural analogue of a biological membrane.

Since the mid-1980s, Lev Blinov became deeply involved in the physics of LC surfaces and studies of the anchoring energy *W* of nematic LCs within confining substrates. The value of *W* was experimentally measured by using traditional methods based on the Fredericks transition, the flexoelectric effect and birefringence measurements in LC cells with the hybrid (homeoplanar) alignment of the nematic director [8]. Blinov proposed an original method for estimating *W* from the measurements of the flexoelectric effect stabilised by a magnetic field.

Special interest in the electro optics of cholesteric LCs accompanied Blinov's entire scientific life. One of his first works referred to the observation of higher order Bragg reflection of cholesteric LCs [9]. Much later, a fast electro-optic mode was discovered in these materials, associated with a strong helix deformation by a pulsed electric field transverse with respect to its axis. Due to the deformation of the helix being localised in a short spatial range, equal to a quarter of the pitch, the electro-optical effect was shown to be hundreds of times faster than in nematic LC layers of the same thickness [10]. The problem of continuous unwinding of a cholesteric helix in confined layers long remained relevant since no defect-free continuous unwinding was observed in experiments. Many important features of the problem related to the topology of the twisted states were later considered by Blinov in the paper written in collaboration with Serguei Palto [11]. The results of the electro-optical studies of various LC materials performed in 1980s were summarised in a book by Lev Blinov and Vladimir Chigrinov [12].

Along with research into liquid crystals, Lev Blinov paid great attention to studies of the physical properties of Langmuir-Blodgett films as representatives of self-organised molecular systems. After Blinov had moved to the Institute of Crystallography, active collaboration with the liquid crystal laboratory at NIOPIK, headed by Mikhail Barnik, continued. This collaboration, in particular with Sergey Yudin and Serguei Palto, resulted in many achievements which acquired a new scope. As an example, it is worth mentioning polar LB films with pyroelectric properties, which were obtained and investigated for the first time. From different types of molecules, molecular superstructures consisting of two types of polar molecular sub-lattices were prepared and studied by Stark spectroscopy [13]. This made it possible to investigate unique physical properties and effects, such as charge transfer states [14], the orientational ordering of molecules in LB films [15], and local electric fields [16]. The work on charge transfer states was carried out in collaboration with the group of Carlo Taliani at the Institute of Molecular Spectroscopy (Bologna, Italy). The photoelectric effect due to the intermolecular charge transfer was also observed in donor-acceptor multilayer

LB films. Photoelectric effects associated both with the intermolecular and intramolecular charge transfer in LB films were studied in [17]. This effect in organic semiconductors was of great interest for Blinov throughout his scientific life. The experimental work performed by him, and his co-authors, had large impact on that branch of science. The quantum efficiency in organic films approached the values characteristic of inorganic semiconductors [18].

In the 1980s, LB films which acquired anomalously high optical anisotropy after their irradiation with linearly polarised light within the absorption band, were for the first time obtained in Blinov's lab at NIOPIK. Some unique experiments were consequently performed at helium temperatures [19] and the physical mechanism of photo-orientation was proposed on their basis. The study of the photoinduced anisotropy effect was also initiated in collaboration with the laboratory of Helmuth Möhwald at the University of Mainz (Germany). The effect of inducing polar ordering in LB films under simultaneous action of the polarised light and electric field was discovered in these works [20].

Another important contribution of Lev Blinov and his co-authors was the work on the preparation and investigation of polar LB films based on vinylidene fluoride polymers, possessing ferroelectric properties up to the thicknesses commensurate with the size of the molecules – two-dimensional ferroelectricity [21]. These pioneering studies were the result of a collaboration of Blinov's Liquid Crystal laboratory, the group of Vladimir Fridkin at the Crystallography Institute (Moscow), and Stephan Ducharme's group (University of Nebraska, USA).

Lev Blinov successfully collaborated with many colleagues and research centres all over the world. One of the first examples of such cooperation was the Laboratory of Solid State Physics at the University of Orsay (France), where Lev Blinov, together with George Durand and his collaborators, studied surface properties and the flexoelectric effect in nematic LCs [22]. An informal international research group was organised by Lev Blinov and Wolfgang Haase at the Technical University of Darmstadt (Germany) to investigate the structure and several physical properties of LCs. The main focus was on dielectric, optical, and ferroelectric properties of chiral and achiral tilted smectics. In particular, Lev Blinov, Eduardo Soto Bustamante and other co-workers discovered a number of new polar states in the achiral bilayer smectic C phase with an alternating tilt of molecules in the neighbouring layers [23].

In the first half of the 1990s, Lev Blinov and Sergey Yablonsky at the Moscow LC lab productively collaborated with Jacques Simon and Francois Tournilhac at the ESPCI (Ecole Superieure de Physique et de Chimie Industrielles, Paris) on investigations of new types of tilted smectic phases detected among polyphilic LCs. Simultaneously, the structure and phase behaviour of these LC materials were studied by Tatiana Lobko and Boris Ostrovskii. Measured X-ray diffraction and IR absorption spectra indicated that the molecules in the smectic C phase are in a strongly bent conformation [24]. The optimal dense packing of such bent molecules in the smectic C phase is achieved only when the symmetry in the arrangement of the 'heads' and 'tails' of the molecules in the layers is broken, leading to a polar symmetry of the medium. This polar response was detected in some of the studied mixtures of polyphilic LCs using the original 'pulsating drop method' [25].

Lev Blinov had a long-term scientific collaboration with the Laboratory of LC Chemistry and Physics at the University of Halle (Germany). On the German side there were Dietrich Demus, Gerhard Pelzl, Siegmar Diele and Wolfgang Weissflog to take part in the collaborative work. The main efforts were devoted to study the structure and polar properties of various new smectic LCs, synthesised in Halle [26]. In 1999–2005 Lev Blinov repeatedly visited the LC laboratory at Osaka University (Osaka, Japan) headed by Katsumi Yoshino and Masanori Ozaki. They carried out a joint research programme on the surface polarisation and flexoelectric effect in nematic LC films [27].

A special place in Blinov's life was occupied by his work at the University of Calabria (Cosenza, Italy) in 2002–2010. Within the framework of the Italian government special programme, Lev Blinov received a professorship and formed a scientific group to study the physics of LCs and related materials. New fields of LC research were initiated, including photonics and laser generation in LC media with spatial periodicity of the LC director field (Figure 2). The work was carried out in close collaboration with Italian colleagues, namely Roberto Bartolino, Riccardo Barbieri, Antonio Checco, Gabriella Cipparrone and a number of others. At the same time, Lev Blinov maintained a close interaction with the LC laboratory at the Institute of Crystallography in Moscow and actively participated in the work on lasing in LCs. Dozens of joint papers were published, related both to the enhancement of dye luminescence in LC layers and to the laser effect which was studied for different cell geometries.

Some original results were obtained for the classic cholesteric LCs, including the electric field-driven laser effect [28], as well as the observation of the leaky laser modes [29]. Both laser effects were related to the specific features of LC systems. A characteristic example was

Figure 2. Lev Blinov in Belgium. International conference "Liquid crystals for photonics", Gent, 2006.

a three-layer LC system in which two cholesteric layers were separated by a nematic layer [28]. The electric field in the nematic layer made it possible to control the phase-matching condition by means of a feedback loop spanning all the three LC layers. In LC systems, the generation condition can be simultaneously fulfilled for multiple directions in the plane of the LC cell, which leads to the possibility of observing the leaky laser modes [29].

Lasing was also obtained in a nematic LC in the planar geometry that does not require spatial modulation of refractive indices in the LC layer [30]. It was due to the specific geometry of the LC system, in which the aperture of the optical pumping of the LC layer and, accordingly, the size of the active (amplifying) region significantly exceeds the thickness of this layer. The progress in the field of LC micro-lasers was presented in a compendium, with Lev Blinov and Roberto Bartolino as editors [31]. It represented a significant number of outstanding papers by scientific groups all over the world. As a result, this book has become somewhat of a guidebook in this new field of research.

In 2011, Springer published the book 'Structure and Properties of Liquid Crystals' by Lev Blinov [32]. The book contains chapters related to a broad spectrum of LC science: structural analysis, phase transitions, elasticity theory and defects, electro-optics, chiral and polar phases. The monograph summarises much of the work performed by Lev Blinov and his co-authors. The book will undoubtedly be useful to a wide range of researchers in the field of soft matter.

Looking at the pathway Lev Blinov took in science, one cannot be but amazed by his fantastic efficiency, which led him to well-deserved worldwide recognition. Hundreds of scientific articles and many reviews, monographs and textbooks, lectures in Russia and Europe, cooperation with laboratories around the world – that made him the very Blinov who was appreciated and respected all over the world.

Lev Blinov, extremely sociable and contactable by nature, was involved in a wide network of scientific and organisational ties both in Russia and in the world. For many years he was an editorial board member of several scientific journals, headed the editorial board of the journal Molecular Materials, chaired or was a member of the organising committee of many scientific forums.

Professor Lev Blinov received much recognition. In 1985, he was awarded the USSR State Prize as the author's team member for the cycle of works devoted to studies of electro-optics in nematic LCs and their applications. In 1999, he was awarded the Freederiksz Medal for outstanding contributions in the field of physics of liquid crystals. In 2000, Professor Blinov was awarded the G.W. Gray Medal of the British Liquid Crystal Society for outstanding contributions to research in the field of liquid crystal science and technology.

Besides, Lev Blinov was a brilliant storyteller, a lover of poetry and history. He never complained about life or science problems, but instead he talked about physics and his many cultural interests with enthusiasm, strength, and inspiration. He loved football almost as much as liquid crystals (later it was ice hockey) and organised ball games whenever it was possible. Prof. Blinov's wife Galina, his daughter Anastasia and grandson Timothy should be rightly proud of his memory. We all can be sure that Lev Blinov will be remembered in the Russian and International scientific communities.

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