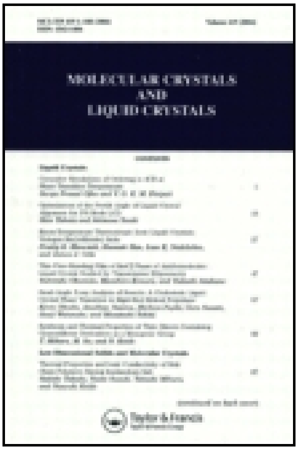

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Liquid Crystal Monopole?

Valentin A. Tsvetkov [a]

[a] Moscow State of Instrument Engineering and Informatics Academy, Stromynka 20, Moscow, 107846, Russia E-mail:

Version of record first published: 04 Oct 2006

Mol. Cryst. Liq. Cryst., 1999, Vol. 331, pp. 525-531
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Liquid Crystal Monopole ?

VALENTIN A. TSVETKOV

Moscow State of Instrument Engineering and Informatics Academy, Stromynka 20, Moscow, 107846, Russia, e-mail: tsvet@pop3.mipt.ru

Behavior of LC phase nuclei in the electric field is reported. The study was performed in a cell with a temperature wedge allowing simultaneous observation of three regions, i.e. with an LC phase, with an isotropic phase and a transient region. It was possible to apply voltage to all 3 regions at the same time. The most interesting effects were observed when electric current was transmitted along the electrodes of one of the substrates made of 5 micron strips with a 20 micron period. The electric current generates LC nuclei in the isotropic phase far from the transient region; generation arising from a number of active centers on nothing but plain electrodes and stopping when the current is off. The nuclei leave the active points at a high speed, their direction being the same for all of them and strictly perpendicular to the electrodes. With changing of the direction of the current, the newly generated nuclei moved in the strictly opposite direction. Such behavior of a nucleus in the magnetic field of the electrodes can be quite explicable if it were a classic Dirac monopole.

Keywords: temperature wedge; LC nuclei; magnetic field; monopole

INTRODUCTION

The phenomena described below were observed by the author back in 1972 as he was working over his PhD thesis. However, as they stood apart from the main subject of the thesis, they were not studied in detail. At the same time, the funny and odd character of the phenomena observed kept the author from publishing them. As «a ballon d'eesai», this material was presented at the 17th ILCC, where it generated a benevolent interest among a number of prominent scientists. In addition, numerous works devoted to LC round drops surrounded by the isotropic phase were presented at the conference. In this work LC round drops (LC phase nuclei surrounded by the isotropic phase) were observed too, though they were obtained in specific conditions. The phenomena presented here may constitute a good food for thought for theoretical physicists.

Experimental

A 40-50 μm nematic LC layer with a positive dielectric anisotropy (+10) was placed between two glass substrates. A system of transparent electrodes as strips, 5 μm each, with a 15 μm gap between them, were applied onto the lower substrate(Fig. 1)

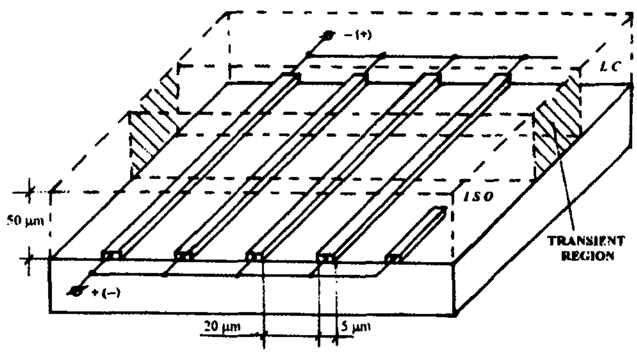
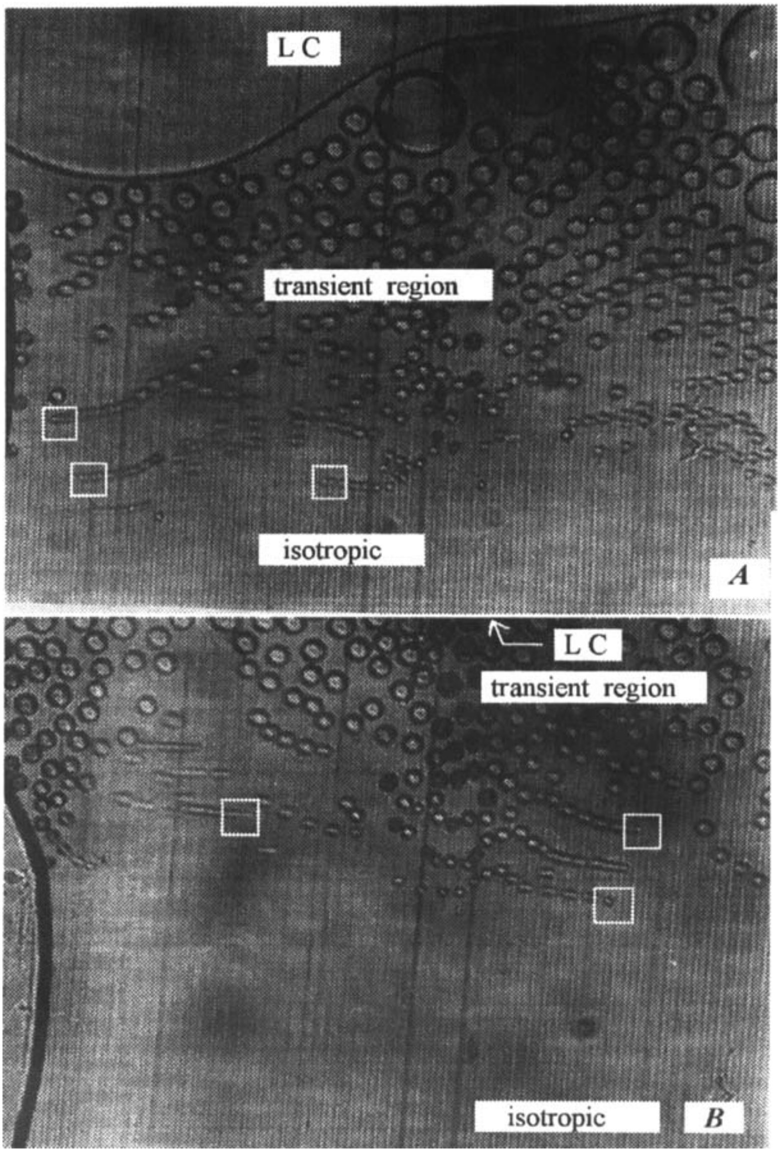


FIGURE 1 Layout of the experimental cell.

The substrates were rubbed along the strip direction to achieve a perfect planar orientation. A temperature wedge was achieved lengthwise along the strips such that in the microscope's field of vision one could simultaneously observe a nematic phase area, an isotropic phase area and a transient region in which round LC nuclei float in the isotropic phase. As the temperature changes, the transient region can move lengthwise along the strips either side.

In the original state, two solid transparent areas with LC and isotropic phases, and a transient region in which various size nuclei float in the isotropic phase are observed under the microscope. On some of the nuclei there can seen conoscopic crosses (the polarizers are parallel and their axes are oriented along the strips). For constant temperature the picture is stable for an unlimited period of time. If constant current is passed along the strip electrodes, the pictures observed are as follows:


L C
transient region
isotropic
A
L C
transient region
isotropic
B

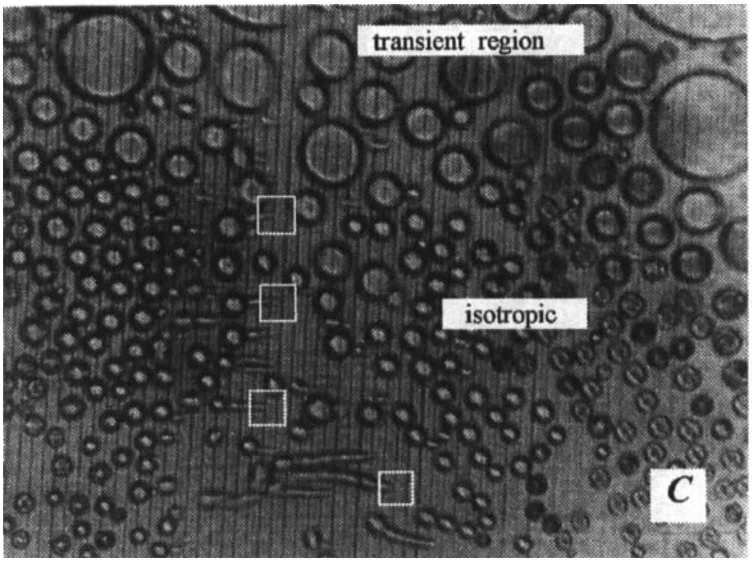


FIGURE 2 Photograph: generation of nuclei moving right (a), left (b) and generation from a great centers (c). □ -- some centers of generation

In some points, in no way remarkable, of different electrodes within the definitely isotropic phase, there start generating round nuclei of the LC phase (Fig.2).

This process lasts indefinitely long and stops on switching off the current.

With the current switched on, the nuclei move «chain-wise» in the direction perpendicular to the strip electrodes. Two different «fates» may expect the nuclei at the end of the motion, namely:

1. On reaching some in no way remarkable strip electrode, the nuclei set on it, i.e. are located along this electrode without merging with each other. When the electrode becomes «occupied» and there is no room for other arriving nuclei, the nuclei chain motion and generation of nuclei stop in spite of the fact that the current is not switched off.

   The impression is that the nuclei «column» remaining on the spot of generation prevents generation of more nuclei.

2. In the second case the moving nuclei chain reaches some also unremarkable electrode and disappears in it. The process of generation, motion and disappearance of nuclei lasts as along as the current is switched on.
   As soon as the current is switched off, the nuclei chain motion stops, the nuclei remaining at the places they were during switching off the current. The nuclei formed are either absorbed by the isotropic phase or while drifting join those LC nuclei which earlier existed in the transient region.
   If in the process of nuclei generating the direction of the current is quickly switched, the generation stops in those points where it took place and starts in other, quite unremarkable points but the direction of the newly generated nuclei movement is strictly opposite. All the above processes occur with this polarity as well.

The nuclei generation rate is about 2 nuclei per second, the speed of their movement is 100 μm/s. The maximum distance covered by a nucleus was noted to be 2-3 mm, the time of current-sensitive existence of nuclei was not more than 30 seconds.

All the above phenomena were observed and reproduced many times.

Discussion

Obviously, there can be different explanations of the phenomena observed. The author proposes one which does not contradict to the laws of physics nor to one of the facts described above.

1. The fact of formation of LC in the isotropic phase on application of magnetic or electric fields, or pressure, or flow, is known. Probably, in our case the surface magnet field facilitates formation of the LC phase nuclei in the isotropic phase. The fact that the LC phase nuclei are formed in quite unremarkable generation centers is also known.
   Consequently, the nuclei generation also in random points on application of our magnetic field configuration is not an extraordinary event. Unexpected is the way they move.

2. Let us assume that the nuclei generated have an inner arrangement such that for an external field, at least in its nearest zone, they are magnetic charges of the same sign (the Dirac magnetic monopole). The magnetic field of the strip-like electrodes at some distance from their plane is homogeneous and is directed perpendicular to the strip electrodes and parallel to the substrate plane (Fig. 3). If a magnetic charge of some sign is placed in such field, it will move to the opposite pole. When the magnet poles change places, the charges start moving in the opposite direction.

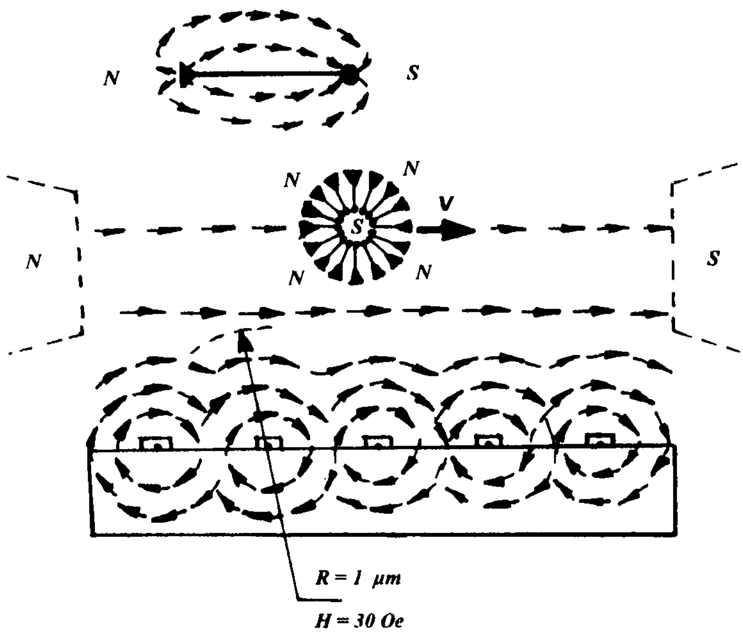


FIGURE 3 Configuration of the magnetic field and hypothesis model of nucleus.

On changing the current direction, the magnetic field poles exchange places and the nuclei generated behave like magnetic charges. The intensity of the magnetic field, in which the charges are capable of moving, in principle is not important, the only compulsory condition being that it should differ from zero. In our case, at a distance of 1 μm from the electrode, the field intensity is estimated as 30 Oersted and grows (tending to infinity) as it approaches the surface of the electrode.

Thus, there are no obstacles for the magnetic charges (if they really were) in their motion along the substrate surface on a peculiar kind of magnet «pillow».

3. The fact that the generated nuclei move without merging testifies that there is a one sign charge shell. It is difficult to say unambiguously whether the

charge is electric or magnetic but in view of the above, its magnetic character is quite possible.

4. The limited time of the current-sensitive existence of the nucleus does not contradict to admitting that it is a magnetic monopole. From the moment of its generation the magnetic charge has a particular sign. In the course of its motion, a rearrangement of the nucleus structure is probable such that by the moment of setting on either electrodes it becomes magnet-wise neutral and in no way different from the nuclei constantly existing in the transient region. In all probability, the notion of a «dynamic» (in terms of time) magnetic monopole is applicable.
5. From the experiments it can be seen that in our case only nuclei with a magnetic charge of the same sign are generated. The exact polarity (north or south) cannot be established at the moment since the track of these old experiments is partially lost. This phenomenon can be explained, for instance, by the fact that from the molecules we used (aminobenzonitrile, the mesophase region is 103-114°C), the structure formed can accept charges of only one particular sign, for example, «north». It is not excluded that molecules of another LC will form magnetic charges of the other sign.

Conclusion

1. The above description of the appearance of the LC phase nuclei does not exclude that the given experimental geometry they are dynamic magnetic monopoles.
2. The observations may be a good food for thought for theoretical physicists. It would be particularly interesting to modify the experiment by, for instance, reproducing it on LC of different structures and with various dielectric and magnetic anisotropy, with other directions of the temperature wedge and so on.

Acknowledgments

The author would like to express their gratitude for the support received from the Organizing Committee of 16th ILCC, Kent, USA in presentation of this paper to the 17th ILCC.