Two-dimensional colloids

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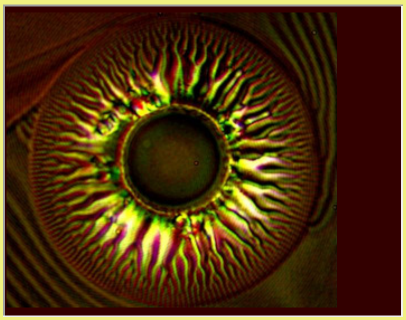
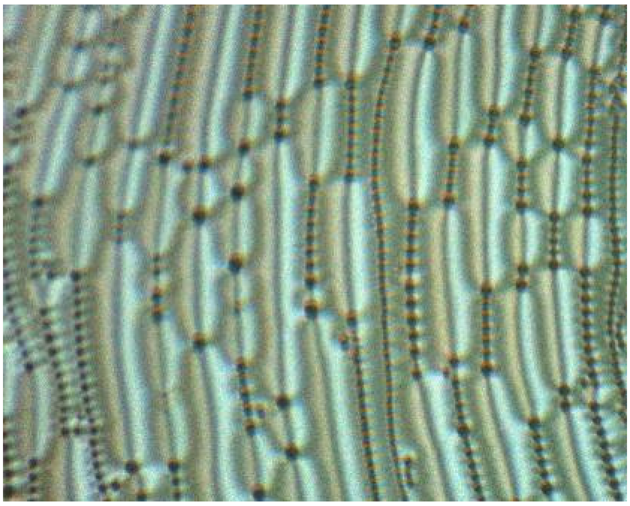


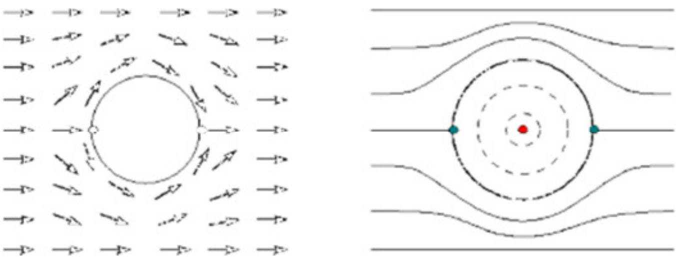
Self-organization of droplets in free-standing smectic films

Free standing smectic films are studied at the transition from the smectic phase to the isotropic phase. In the vicinity of the bulk transition temperatures, isotropic droplets of micrometer size appear in the film. Such systems represent convenient models for anisotropic, two-dimensional emulsions. A characteristic feature of the droplets is their mutual interaction by elastic distortions of the local orientation of the film, the c-director, which are related to the anchoring conditions of the c-director at the droplet border. The director deformations created by isotropic droplets of different sizes were analyzed, and their role in the spontaneous organization of regular droplet patterns was explored. Depending upon droplet size and anchoring strength, topological defects can be induced in the c-director field.

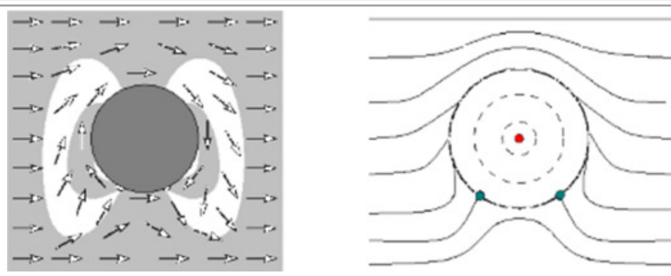
Droplets in freely suspended films can form regular structures like chains or lattices. The droplets in this image are formed by molten (isotropic) film material near the clearing point. The isotropic droplets coexist with the the smectic C film material. The local chain orientation follows the c-director texture, which is not uniform in this film. (white light in reflection, without polarizers). [Völtz2004]



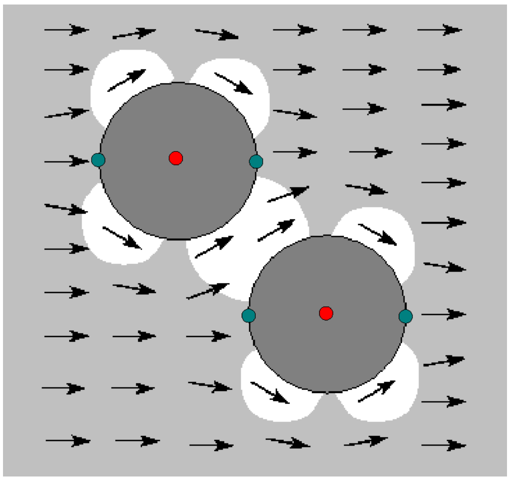
When the director field has a given structure, like inversion wall arrays in this image, the droplet chains follow the wall structure [Völtz2005,Stannarius2005].The image was taken in reflected white light with crossed polarizers. Dark regions represent director orientations in vertical or horizontal directions, bluish and grey regions reflect diagonal director orientations. The director field in absence of droplets is continuously twisted. [Völtz2005]



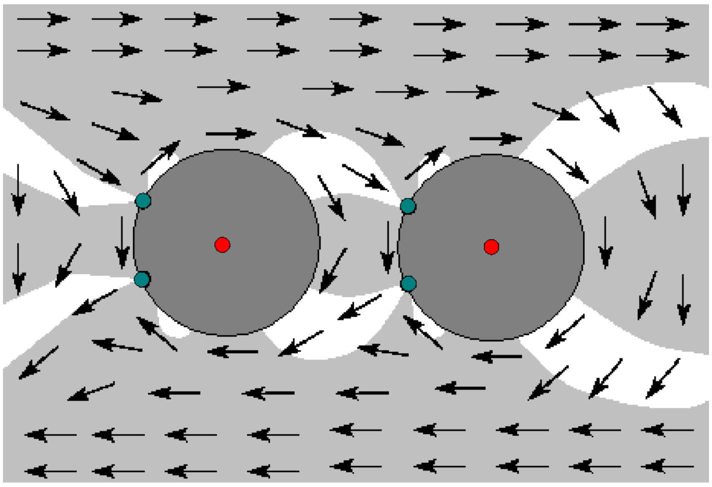
"quadrupolar" configuration of a central virtual topological defect of strength +1 and two oppositely placed defects of strengths -1/2 each [Bohley2006,Bohley2007]



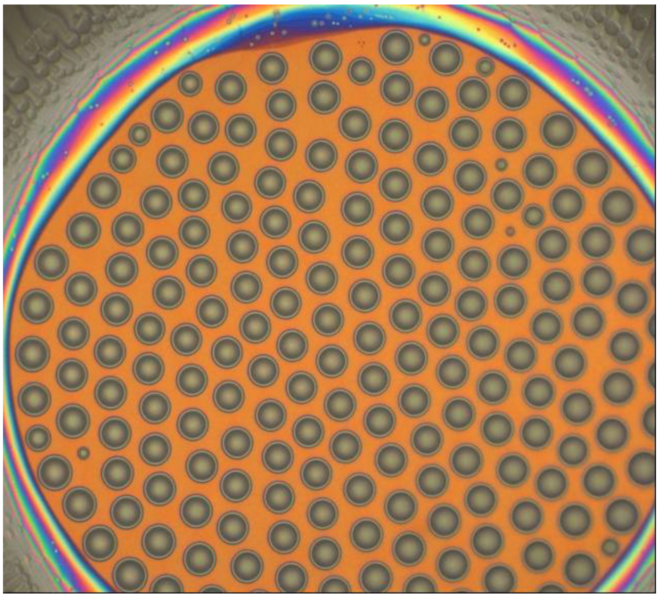
"dipolar" configuration of a central virtual topological defect of strength +1 and two defects of strengths -1/2 each at the periphery. The reason for this asymmetry is a spontaneous bend at the droplet boundary [Bohley2007]



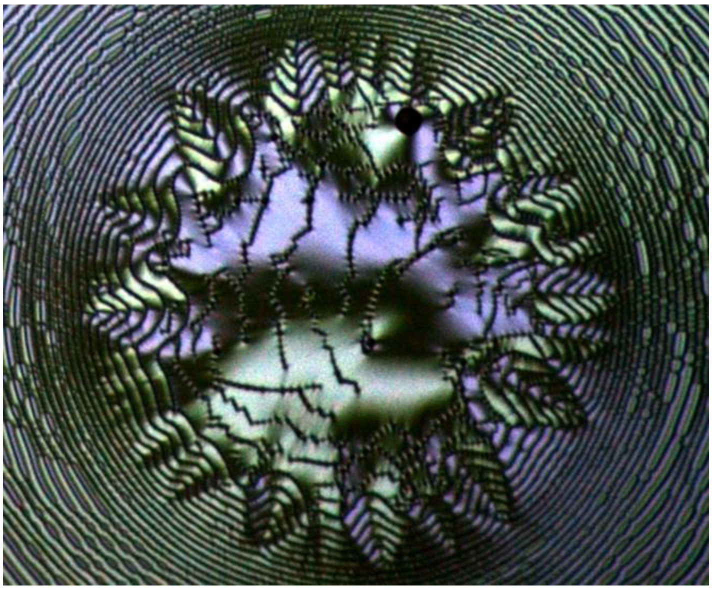
Two droplets with quadrupolar arrangement of defects (virtual +1 defect in the droplet center and two -1/2 defects at the periphery. Like electrical charges, these defects produce attractive or repulsive forces in the smectic film



Two droplets with dipolar arrangements of defects (virtual +1 defect in the droplet center and two -1/2 defects at the periphery) in an inversion wall of the external director field. This is the situation observed in the experimental image above.



Array of isotropic droplets in a freely suspended smectic C film. The droplets contain material in the isotropic phase. The lattice spacing is a consequence of the interaction energy minima. These interactions are mediated by the c-director field.

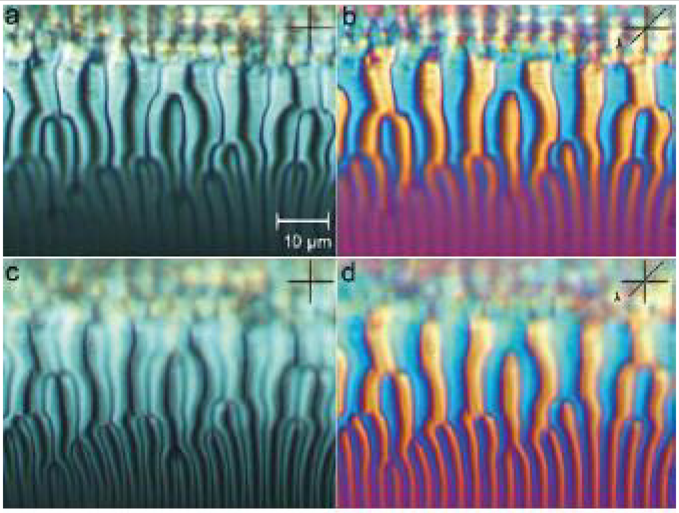


Chains of droplets in a freely suspended film of photosensitive smectic C material. The droplet concentration can be controlled by means of the illumination intensity, which induces local melting of the azoxy mesogens into the isotropic phase. The buckling instability is the response of an incorporation of more and more droplets into the closed chains surrounding the film center [Völtz2005,Stannarius2005].

Individual droplets or solid spheres can be used on an inclined film to perform two-dimensional rheological experiments. Thereby, a smectic film is tilted with respect to the horizontal, and the velocity of spheres or droplets sliding in the film is determined as a function of effective gravity (inclination angle) and inclusion sizes. [Eremin2011]

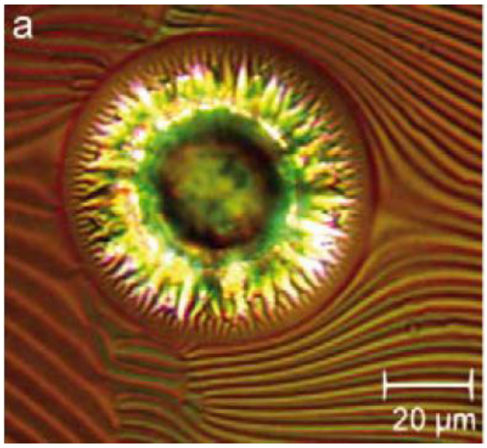
Corona patterns and splay domains

The meniscus of smectic C liquid crystal films is often decorated by regular stripe patterns. These structures were first described by R.B. Meyer, and they are commonly referred to as splay-domains. The explanation given by Meyer is based on the assumption that spontaneous splay of the surface layers leads to periodic director distortions which include defect lines and whose periodicity is related to the local thickness of the meniscus.



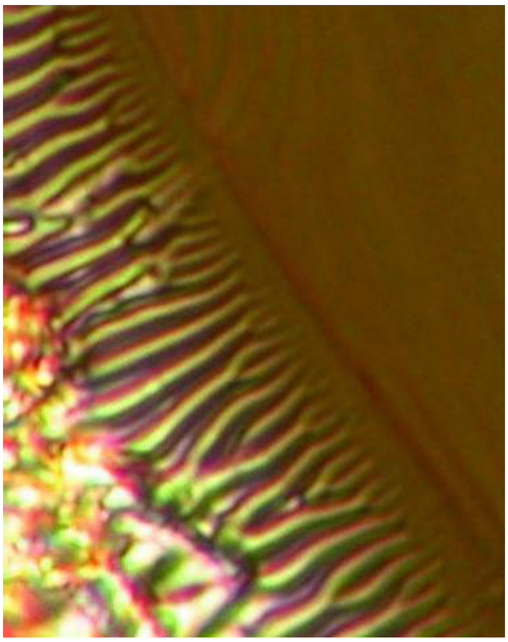
Striped patterns in the meniscus of freely suspended smectic films. The upper and lower rows have different focus planes, corresponding roughly to the upper and lower film surfaces in the center of the image. The images in the left column were taken with crossed polarizers, the images in the right column were taken with an additional wave plate in diagonal orientation to distinguish the two diagonal axes [Harth2009]. The stripes:

- are observed only in film regions with a thickness gradient,
- are directed along the local film thickness gradient,
- have widths that grow linearly with the film thickness,
- contain defect lines (or, planes) both at the upper and lower film surfaces,
- defects at opposite film surfaces are displaced by half the stripe period.

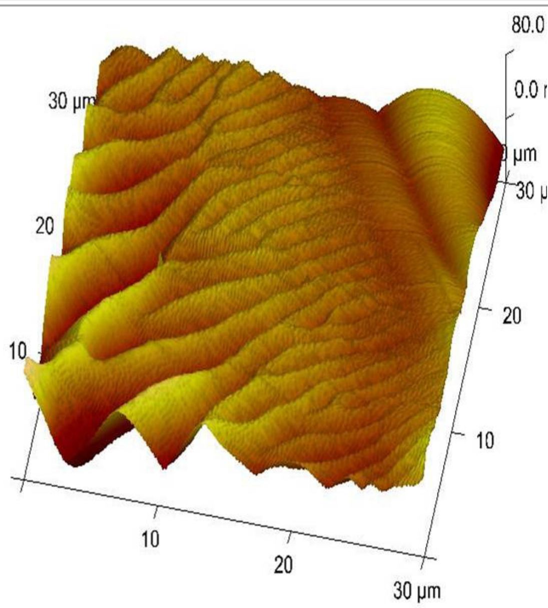


Liquid inclusion consisting of glycerol in a freely suspended smectic film. These inclusions are surrounded by a meniscus, which is decorated with the same type of periodic stripes as the outer meniscus of the film. Outside the meniscus, in the planar film, one can see a periodic stripe texture that is aligned at the meniscus boundary.

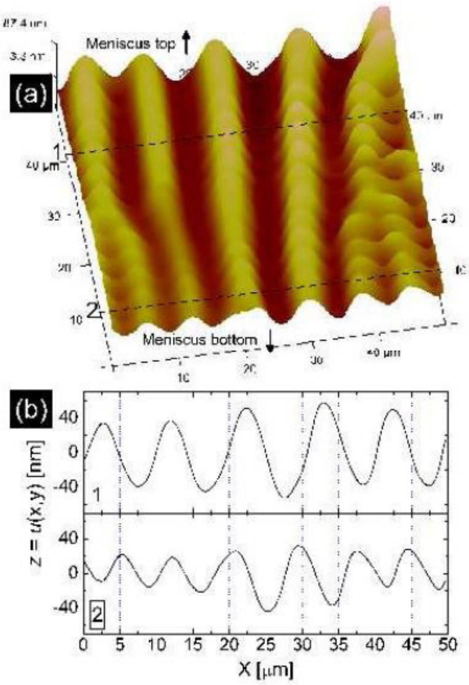
The striped pattern is not only a plain director texture. By means of AFM measurements, it could be demonstrated that the director texture is related to a surface undulation of the meniscus.[Harth2011,Harth2012]



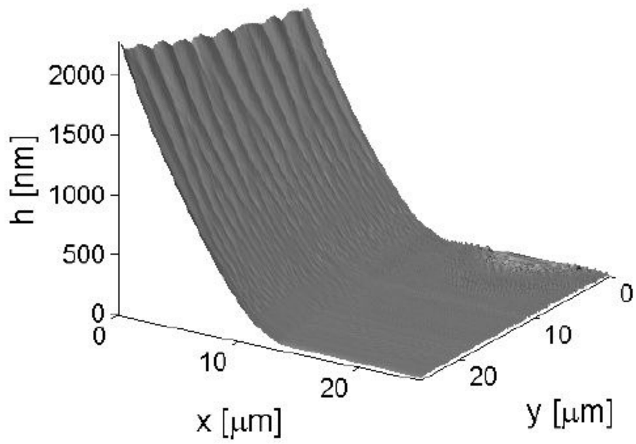
Optical texture of the stripe pattern in the meniscus of a smectic C freely suspended film



AFM image of the height profile of the meniscus. The surface is undulated with an amplitude of up to 50 nanometers. The positions of valleys are coupled to the defect lines seen in the optical images



[Harth2011,Harth2012]



complete meniscus profile of a smectic C film: it is clearly seen that the meniscus forms a non-zero angle with the flat film at its edge [Harth2011,Harth2012]

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