Undulation Instabilities in the Meniscus of liquid crystal membranes

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You need not be a scientist to notice that the surface of a liquid drop, such as a water drop, is perfectly smooth…Yet, in the case of "complex fluids" like liquid crystal, this is not always so: A weird finger-like structure composed of well aligned stripes may show up under certain conditions (see figure 1).

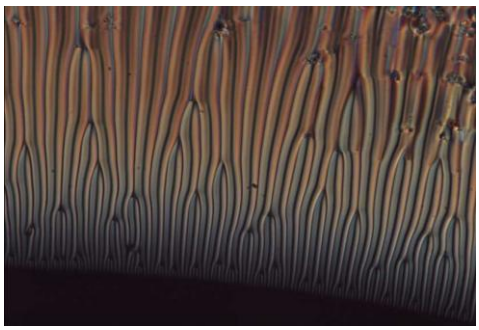

Figure 1 : Image of the meniscus in the smectic-C phase (White light illumination, transmission).

We discovered that those stripes actually correspond to an undulation of the liquid crystal air interface which is then no longer smooth but rather wrinkled and rugged. This phenomenon occurs in the meniscus of liquid crystal membranes obtained with lamellar phases of liquid crystal (e. g. SmC or SmC* phase).

Using optical microscopy, phase shifting interferometry [1], and atomic force microscopy, we characterize the undulated structures which appear in the meniscus of free standing smectic-C* films. We demonstrate that these periodic structures correspond to undulations of the smectic-air interface. The resulting striped pattern disappears in the untilted smectic-A phase. The modulation amplitude and wavelength of the instability both depend on meniscus thickness. We study the temperature evolution and propose a model that qualitatively accounts for the observations.

Last, it is interesting to note that the biological membranes of living cells share common features with our LC membranes: They are also elastic media made of thin layers of organized liquids. The reported results open up new perspectives for a better understanding of their highly complex machinery.

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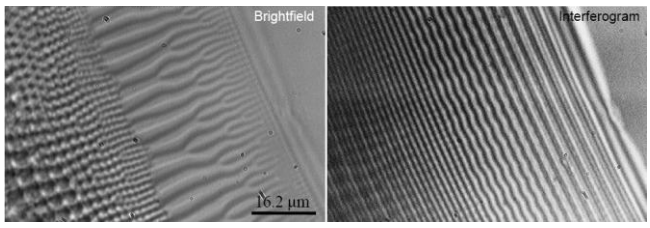

Figure 2 : Image of the meniscus in the smectic-C phase. (Left) White light illumination, transmission; (right). Interferogram recorded with red light illumination in reflection. The undulated interference fringes correspond to layer undulation.

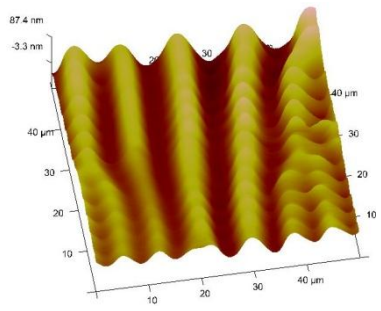

Figure 3: AFM picture of the Smectic-C meniscus.

References

[1] D. W. Robinson and G. T. Reed, *Interferogram analysis* (Institute of Physics Publishing, Bristol) 1993.
[2] J. C. Loudet, P.V. Dolganov, P. Patrıcio, H. Saadaoui, and P. Cluzeau, Phys. Rev. Lett. 106, 117802, 2011.