Rheological Properties of Quasi-2D Fluids in Microgravity

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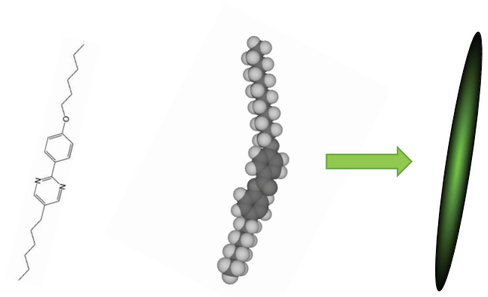
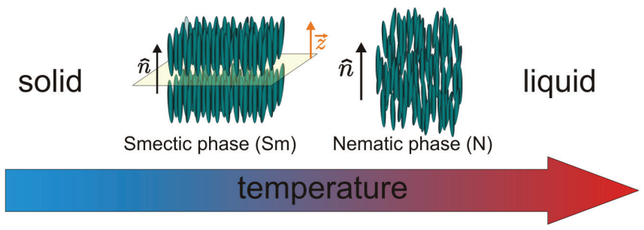
Liquid Crystals

- Liquid crystals (LCs) are anisotropic liquids,
- They possess the fluidity of a true liquid, as well as varying degrees of long range orientational and positional order that are normally associated with crystalline solids



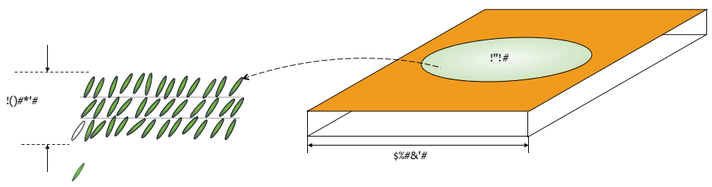
Structure and model of a liquid crystal molecule

Some thermotropic LC-phases



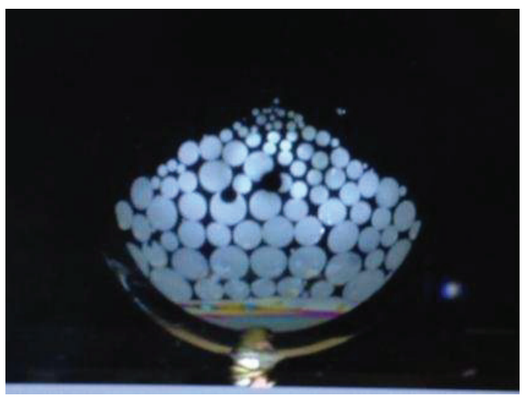
Science Background

The smectic layer structure facilitates the preparation of freely suspended films with thicknesses of few molecular layers and lateral extensions up to several cm, aspect ratios can exceed 106. Such films may serve as models for 2D liquids.



Schematic sketch of a setup for the preparation of freely suspended smectic films.

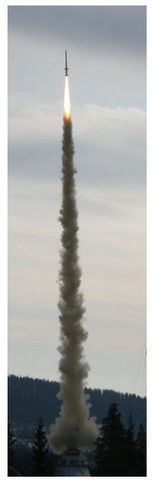
Smectic bubbles with diameters of several mm and submicrometer film thickness can be generated.



Ultrathin bubble (film contour is not seen in this image) with islands of excess molecular layers on the spherical film. These islands sediment immediately under normal gravity.

TEXUS Suborbital Flight

The OASIS-Tex project was scheduled as a parameter test for OASIS and it provided experimental data on the Marangoni instability in smectic films.

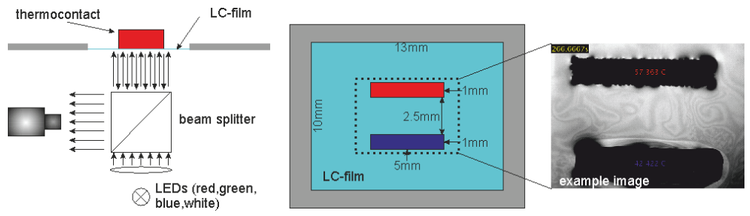


TEXUS-52 (left) with the OASIS-Tex experiment started successfully in Esrange (Sweden) on April 27, 2015, and reached a height of 250 km providing 6.5 minutes of microgravity (µg). The experiment (right) with was built in cooperation with German Space Agency (DLR) and Astrium.

DLR Deutsches Zentrum für Luft- und Raumfahrt

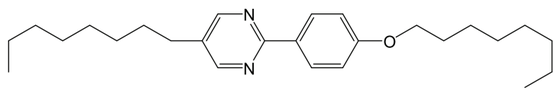
The OASIS-Tex Experiment

- Freely suspended smectic film with thermocontacts



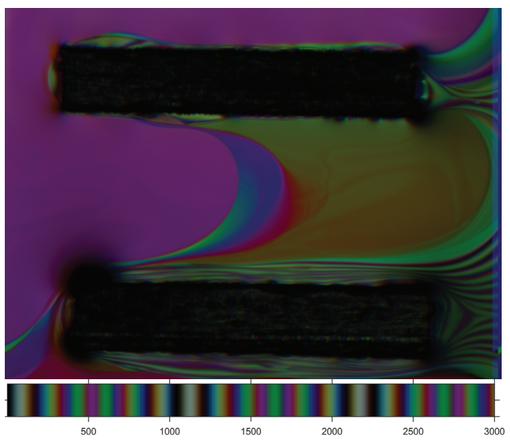
Schematic side view (left) and top view (middle) of the OASIS Marangoni setup. Two thermocontacts are placed on a free-standing smectic film. Convection is seen by the Schlieren texture of the smectic c director field. The camera shows an 7mm x 5mm section of the film plane (right).

- LC: 5-n-Octyl-2-(4-n-octyloxyphenyl)pyrimidine



Cr 28.5 SC 55.5 SA 62 N 68 I

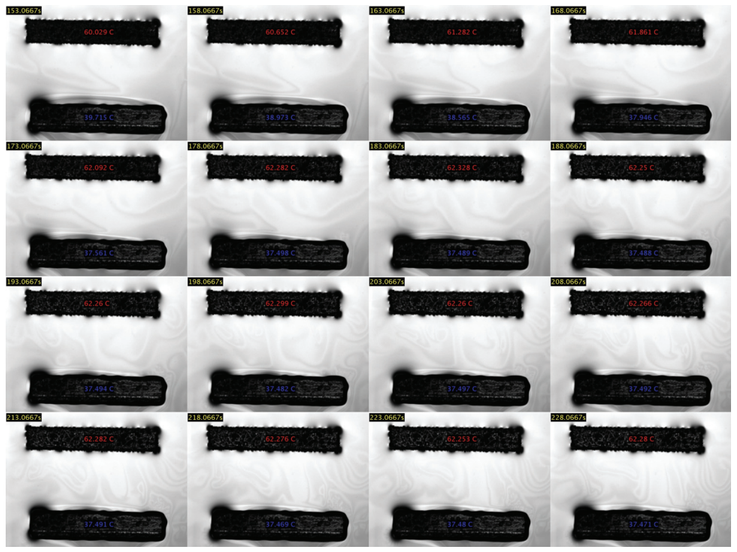
- Ambient temperature 50 °C
- Thermogradient up to 10 K/mm
- LC film thickness is approximately 500 nm



The film thickness was determined from reflectivity of the 3 different RGB-LEDs in the early stage of the experiment. During the experiment the marked 500 nm thick homogeneous part spreads over the whole film.

OASIS-Tex Early Results

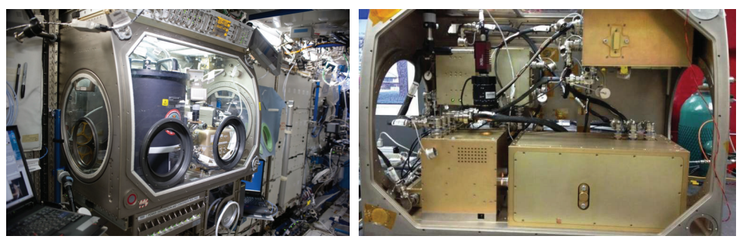
- Up to 8 K/mm almost no motion is visible
- At 10 K/mm (hot contact at smectic nematic phase transition temperature) onset of a slow convective motion (approx 100µm/s)



Snapshots of the OASIS-Tex Marangoni experiment. The formation of target patterns is an indicator for convective motion. Particle image velocimetry yields velocities around 100 µm/s.

The OASIS Experiment (ISS)

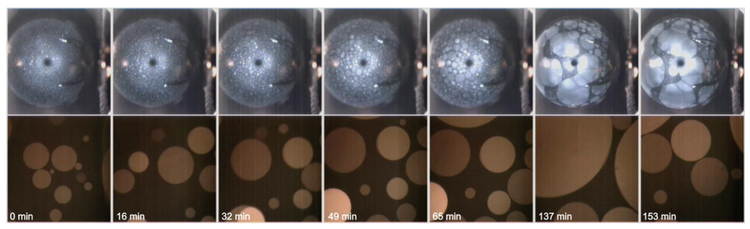
- Development of small sample modules that are imaged within the OASIS experiment chamber. The setup makes use of the Microgravity Science Glove Box aboard the ISS.



Microgravity Science Glovebox (left) and OASIS specific hardware (right).

The OASIS Experiment on ISS

- Exploitation of the unique characteristics of freely suspended liquid crystal films in a microgravity environment, to advance the understanding of fluid state physics.
- Microgravity suppresses island sedimentation, this allows long time observations of droplets or smectic islands on LC-bubbles.



Coarsening of a smectic island emulsion under microgravity (ISS).

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