Rheological Properties of Quasi-2D Fluids in Microgravity

Ralf Stannarius,1 Torsten Trittel,1 Alexey Eremin,1 Kirsten Harth,1 Noel Clark,2 Joseph MacLennan,2 Matthew Glaser,2 Cheol Park,2 Nancy Hall,2 and Padetha Tin4

1Otto-von-Guericke University Magdeburg (Germany), 2University of Colorado (Boulder, CO), 3NASA Glenn Research Center (Cleveland, OH), 4Universities Space Research Association (Cleveland, OH)

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](image)

Some thermotropic LC-phases

- Solid
- Smectic phase (Sm)
- Nematic phase (N)
- Temperature

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.](image)

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) was built in cooperation with German Space Agency (DLR) and Astrium.

![The OASIS-Tex Marangoni setup.](image)

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).](image)

OASIS-Tex Early Results

- Freely suspended smectic film with thermocontacts

![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.](image)

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).](image)

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).](image)