Optical Analysis of Smectic Islands in Space

OASIS is a collaboration between partners at the University of Colorado in Boulder, at the University of Magdeburg, and at NASA. It is directed by Principal Investigator Noel Clark from the University of Colorado. Within the OASIS project, we plan experiments with free-standing smectic films under microgravity conditions. Such films can be prepared similar to soap films, they have thicknesses of a few molecular layers and can reach lateral extensions of several square centimeters. Inclusions (Islands and droplets) on free-standing films will be investigated by optical observation techniques. In the quasi-twodimensional geometry of these films hydrodynamic phenomena and self-organization processes under microgravitaty are observed and analyzed.

These experiments are tentatively scheduled for the International Space Station ISS in 2011. For these experiments, a module for the preparation of the films and the controlled positioning of the inclusions is being developed and tested.

One line of preliminary ground based research is performed in Magdeburg within the project OASIS-CO (DLR). In this project, we prepare two-dimensional colloids by shooting picoliter droplets on freely suspended flat films.

A parabolic flight experiment will be performed in March 2010 within the 15th campaign of the DLR. It serves as a test of the vital components of the unit that is designed for work in the ISS under microgravity. In the parabolic flight setup, we will produce planar and spherical free-standing smectic films and place droplets on these films by means of a commercial dispenser unit. A polarizing microscope and fast videocamera will be used for the observation of the droplets.

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Objective:
Exploitation of the unique characteristics of freely suspended liquid crystals in a microgravity environment, to advance the understanding of fluid physics

Development Approach:

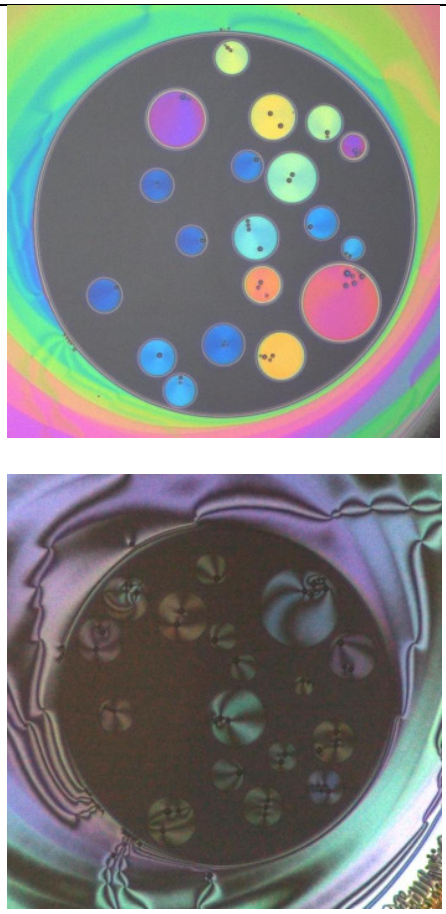
- The OASIS flight instrument is designed to optimize use of the LMM.
- The OASIS/LMM will be designed for autonomous operation through scripts and ground commanding.
- Crew time is required for initial installation, checking sample loading and bubble/island formation.
- The OASIS is being designed to utilize the FIR capabilities to the maximum extent possible.

Tasks and Strategies:

- Automatic inflation of smectic bubbles with coaxial syringe injection setup
- Observation with low resolution video, high resolution polarizing microscopy
- Laser reflection for size control and film thickness determination
- Study of 2D hydrodynamics on spherical surfaces by means of tracer particle tracking
- Self-organization of inclusions, spherical crystallography (packing and defects on non-planar surfaces)
- Ostwald-ripening of island arrays
- Study of thermocapillary effects

Justification for microgravity experiments:

- No sedimentation under microgravity,
- Perrin length at 1µg ~ 1 m, system dimensions ~0.01



top: microscope image of islands on a smectic film in white unpolarized light
bottom: microscope image of islands under crossed polarizers
(image widths approx. 1 mm)

OASIS-CO : Colloids on liquid crystal films

Topic:
Design and test of a module for the optical investigation of droplets on smectic films under microgravity conditions
The investigation of hydrodynamic processes and mechanisms of pattern formation in microscopic systems is gaining increasing importance. Fluid dynamics on small scales and in restricted geometries brings about new phenomena and requires new concepts of their description. Microfluidics has established as a new rapidly growing research field.
The scientific aim of this project is the investigation of thin liquid crystalline films. The property of small solid or liquid inclusions in such films to self-organize into regular one- or two-dimensional structures is interesting particularly for the preparation of microscopic patterns (similar to photonic crystals). In the OASIS-CO project we develop the hardware for experiments with two-dimensional colloids, formed by spherical inclusions in smectic free-standing films.
Ground based experiments as well as tests under low gravity conditions are planned.
The project duration is scheduled from Jan. 2009 to June 2011. It is funded by the German Bundesministerium für Wirtschaft und Technologie (BMWT).

Method:
high-resolution, high-contrast optical imaging of particles and droplets on smectic bubbles

µg-test:
AIRBUS ZERO G flight by DLR in March 2010
- test of of bubble dispenser (University of Colorado,NASA) and
- test of pico-liter colloid dispenser (University of Magdeburg)

The project duration is scheduled from Jan. 2009 to June 2011. It is funded by the German Bundesministerium für Wirtschaft und Technologie (BMWT).

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