National Aeronautics and Space Administration

Design and Development of the Observation and Analysis of Smectic Islands in Space Experiment

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Introduction

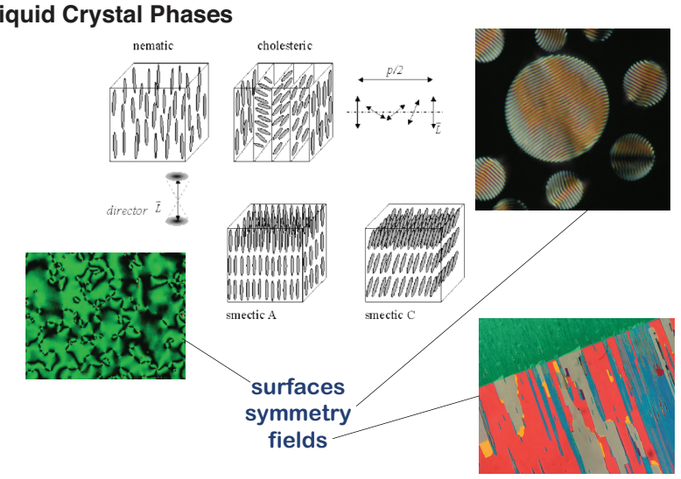
The primary objective of Observation and Analysis of Smectic Islands in Space (OASIS) experiment is to exploit the unique characteristics of freely suspended liquid crystals in a microgravity environment to advance the understanding of fluid state physics.

Background

Freely suspended liquid crystal (FSLC) films exhibit a combination of physical characteristics.

- The study of equilibrium and out-of-equilibrium phenomena in reduced dimensionality, for example, liquid crystal ordering and fluctuations in two dimensions, and the effects of finite size on liquid crystal phase transitions.
- FSLC films in microgravity present extraordinary opportunities for the study of fluid dynamic and thermodynamic behavior in reduced dimensionality, and for the exploration of fundamental nonequilibrium fluid interfacial phenomena.

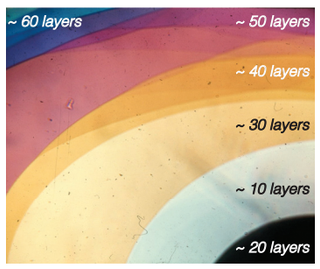
Liquid Crystal Phases



Ultra-thin FSLC Films

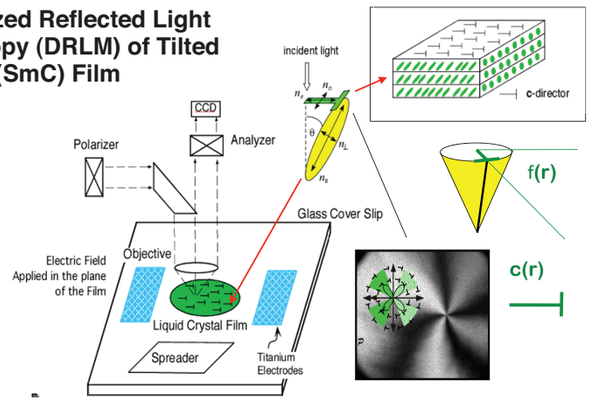
Quantized thickness
(3 nm for a single molecular layer)

- Stable fluid structures
- Largest surface-to-volume ratio
- Low vapor pressure



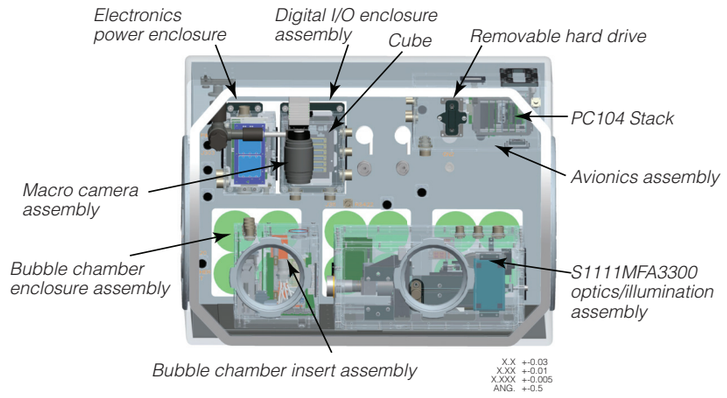
Reflection microscope image.

Depolarized Reflected Light Microscopy (DRLM) of Tilted Smectic (SmC) Film



OASIS International Space Station (ISS) Flight Experiment

The OASIS spaceflight experiment comprises a series of experiments that will probe the interfacial and hydrodynamic behavior of FSLC films in space. It will be executed using four different liquid crystal materials in four separate sample chambers that will be contained in the Microgravity Science Glovebox (MSG) onboard the ISS.



Experiment Testing to be Conducted in Microgravity

Bubble Inflation
- Bubble chamber
  - Bubble film thickness
  - Bubble inflation size control

Observation by reflected light imaging
- Low resolution video (bubble chamber)
  - Bubble inflation
  - Global bubble structure
  - Global organization (islands and droplets)
- High-resolution video microscopy
  - Island structure and dynamics
  - Orientational textures
  - Island thickness

Manipulation
- Air jets (bubble chamber)
  - Island generation
  - Film hydrodynamics
- Inkjet drop ejector (bubble chamber)
  - Island and droplet generation
- Electric field (bubble chamber)
  - Induced island interactions
  - Electrohydrodynamics
- Temperature gradients (bubble chamber)
  - Thermocapillary effects
- Dynamic inflation and deflation (bubble chamber)
  - Nucleation of islands and pores

Space and Terrestrial Applications

Adaptive Optical Elements
- As diverse as inter and intra satellite communications, 3D optical switching in space optical communications, remote sensing (LIDAR), lunar landing/rendevous/docking
- Advantage of photonic devices over conventional mechanical beam steering parts, light weight, very low power
- ESA supported UPM for LC programmable blaze grating (SLM)

Space Suit Head-Mount Displays
- Very fast switching, defect free and high resolution (also military applications)

Consumer Electronics

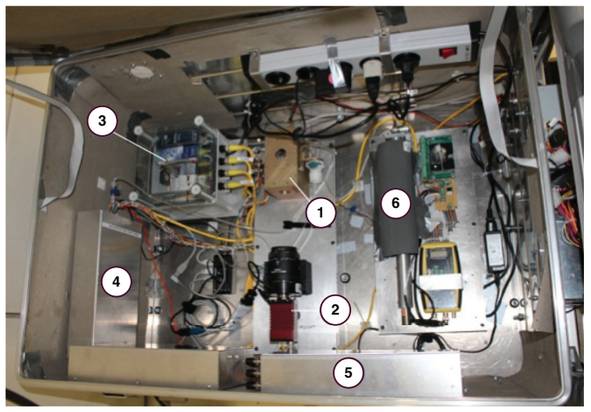
European Parabolic Flight

An engineering test unit of the OASIS experiment was tested on the DLR 20th/NOVESPACE 97th parabolic flight campaign in Merignac, France, September 10 to 14, 2012.

Right: OASIS Parabolic Flight Crew.
Below: Novespace Airbus reduced-gravity aircraft

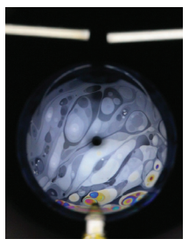
Test Objectives

- Exercise flight experiment system functions such as pressure quenching and pulsation, thermocapillary, inkjet droplet device, air jets, and E-field.
- Used two different liquid crystal samples (50/50 8CB and MX12160 type) and tested bubble inflation system in microgravity.
- Experiment flew on the OASIS Parabolic Flight System in the Zarges Container shown below.

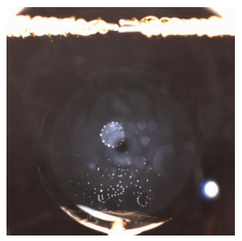


1. Bubble chamber insert
2. AVT GX1050C Macro cam
3. Power conversion/distribution system
4. Bubble inflation and LC and LED drivers module
5. IDD/E-field drivers module
6. Pressure pulsation system

Macro-Observation System Image



Inkjet Droplet Device System Image



Test Summary

- The syringe pump allowed for excellent thin film bubble formation with little to no premature island formation.
- Pressure quenching and pulsation was tested.
- Thermocapillary, inkjet droplet device, and air jets all worked well. E-field not visible with macro camera.
- Analysis continues on the data by PI team.