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Author: Mr. Torsten Trittel
Otto von Guericke University of Magdeburg, Germany

Dr. Kirsten Harth
Otto von Guericke University of Magdeburg, Germany
Mr. Christoph Klopp
Otto von Guericke University of Magdeburg, Germany
Prof. Ralf Stannarius
Otto von Guericke University of Magdeburg, Germany

MARANGONI FLOWIN A FREE-STANDING THIN FLUID FILM

Abstract

Liquid crystals (LCs) are fluids that have, besides their liquid-like rheological behavior, also characteristic properties of crystals, such as anisotropic optical and electrical properties. This makes them excellent materials for electro-optical display applications. In addition to this important role in everyday life, liquid crystals are enormously attractive in the field of fundamental physics. Freestanding liquid crystal films can be prepared with aspect ratios (width to thickness) well above 10^6. In our study we focus on thermodiffusion and thermally driven convection within these unique, quasi-twodimensional fluid structures. While the influence of gravity on the shape of such films is negligible, it is hardly possible to avoid the effect of buoyancy driven airflow on films in thermal gradients under normal gravity. We minimize such distortions exploiting the microgravity phase during a TEXUS suborbital rocket flight for our experiment. We prepared a smectic film of uniform film thickness. This film was in contact with two thermoposts by which we could apply thermal gradients up to 10 K/mm in the film plane. It was observed with a CCD camera, and the flow profile in the film was identified by the observation of the displacement of smectic textures in polarized light. Our observations shows Marangoni flow from the warm contact towards the cold contact for temperature gradients up to 8 K/mm. LC material collects at the cold side. We present evidence that a temperature-sustained surface tension gradient drives the flow. At higher temperature gradients of around 10 K/mm, laminar flow converts into convective motion. We discuss our experimental results and compare them to earlier investigations in the gravitational field by Godfrey et al. [1]. Our experiment represents the first study of liquid-crystalline materials in space. The study was supported by the German Aerospace Center (DLR) within projects 50WM1127, 50WM1430 and 50WM1744.

[1] M. I. Godfrey and D. H. van Winkle, Physical Review E 54, 3752 (1996).