From viscous to elastic sheets: Dynamics of thin free-standing smectic films

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The dynamics of droplets and bubbles, particularly on microscopic scales, are of considerable importance in biological, environmental, and technical contexts. Soap bubbles, vesicles and components of biological cells are well known examples where dynamic features are significantly influenced by the properties of thin fluid membranes enclosed by fluids. Two-dimensional membrane motions couple to 3D shape transformations.

Smectic mesogens form liquid crystal phases with internal molecular layer structure, which allows easy preparation of thin free-standing films. Those represent simple model systems for membrane dynamics and pattern formation in quasi two-dimensional fluids. The literature mostly deals with planar films, spanned over a frame, with static or only slowly changing shapes and surface areas. Smectic films can also be easily generated as bubbles or catenoids as well.

We study rapid shape transformations of smectic films and bubbles. Any change of surface area of closed objects requires an adaption of the film thickness. Here, the films' layered structure requires the formation or removal of individual layers. Even though the film is often orders of magnitude thinner than the bubble size, this process can govern the relaxation dynamics. Bubbles transition between a quasi-elastic response and a fluid-like response, and show distinct relaxation behaviour.

The talk will demonstrate and explain the background and the distinct relaxation dynamics of smectic films using exemplary experimental situations, including shape relaxation of bubbles in micro-gravity conditions and film rupture. Finally, we present first numerical results reproducing the phenomena qualitatively.