



# The Physics of Soft and Biological Matter

## P.45 Out of equilibrium pattern formation in lipid membranes

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Artificial lipid bilayers are useful models of biological membranes, appealing for applicative purposes, and an interesting example of quasi-2D liquid systems on which to investigate new physics. It is well known that ternary-component lipid membranes, depending on the relevant thermodynamic parameters (composition, temperature and pressure), can show phase coexistence between two liquid phases,  $L_o$  and  $L_d$ , that can be imaged by fluorescence microscopy.

We have performed experiments observing both equilibrium and non-equilibrium morphology of lipid phases. Specifically we have investigated a new dynamical regime in which we follow the diffusive mixing of miscible phases, and observe pattern formation out of equilibrium. This has been possible thanks to the development of a method to induce rapid and spatially localized temperature changes, by infrared irradiation. In this fashion, a temperature change can be imposed faster (in about 1s) than the diffusive time over relevant lengthscales of a few microns (several 10s).

Our observations show that the line tension very rapidly vanishes upon heating the system above the miscibility transition temperature and after a few seconds the spectrum of the interface fluctuations becomes very different from the equilibrium capillary waves, growing in amplitude and losing the characteristic  $1/\text{wave-vector}^2$  equilibrium form. The initial temperature change causes the less viscous phase to expand into the more viscous one promoting the roughening of the interface with a predominant lengthscale consistent with the wavelength of maximum instability in viscous fingering. The interface from then blurs out due to diffusion until the phases are fully mixed.

The same fast temperature change also allows us to very rapidly cool the system. This extends previous measurements by other groups, giving insight into processes that take place over the first few seconds of phase separation.

Investigating the aspect of pattern formation on lipid bilayers is relevant because lipid membranes, for their remarkable physical properties, are considered an interesting building block for the design of novel soft materials. The possibility of being able to construct blocks with user-defined pattern and the ability to control pattern formation would be highly desirable for tuning their self-assembly properties.