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Report:
This experiment is a continuation of SC1420.
We measured the dispersion relation of the baroclinic/undulation mode $\Omega(q_\perp)$ as a function of the scattering vector in the plane of the layers $\mathbf{q}_\perp$ in the L_α (fluid lamellar) phase of two lyotropic systems :

- $C_{12}EO_5$/hexanol/H_2O , where $C_{12}EO_5$ stands for the extensively studied nonionic surfactant penta-ethylene glycol mono-n-dodecyl-ether. The addition of hexanol as a cosurfactant results in a softening of the bilayers, leading to a bending constant $\kappa \sim k_B T$ [1].
- SDS/pentanol/H_2O+glycerol. SDS is the widely used anionic surfactant sodium dodecyl sulfate. This lamellar phase has already been characterized [2]; the addition of glycerol simply increases the viscosity of the solvent (about three times larger than that of water), facilitating the dynamical measurements.

The samples were prepared in 100 and 200 μm thick glass capillaries and oriented by thermal cycling between the lamellar and the isotropic phases. Very good homeotropic anchoring is obtained, with the exception of characteristic "comb-like" structures at the edges and of isolated defects. All measurements were performed at room temperature.
The experiments were performed using an X-ray energy of 13 keV selected by a Si (111) single-bounce monochromator. The beam was defined by a 10μm pinhole followed by a guard slit for removal of parasitic scattering.

The scattered signal was detected by a fast avalanche photodiode (APD) and the output signal was processed online by a FLEX autocorrelator. The measurements were performed in the uniform filling mode, and the time structure of the primary beam was "smooth" enough so as not to hinder the measurements.
The correlation function $g(t)$ was obtained at each $q_\perp$ value by acquiring for 1800 or 3600 s. After normalization by the autocorrelation of the monitor signal and removal of an oscillatory component due to the mechanical noise of the setup, $g(t)$ was fitted with the sum of a stretched exponential (stretching exponent $\beta \sim 0.5$) representing the relaxation of the undulation mode and a very slow exponential (decay time $\tau \sim 10$s) of unknown origin: $g(t) = 1 + \left[a_1 \exp\left[-(\Omega t)^\beta\right] + a_2 \exp(-t/\tau) + a_3\right]^2$.

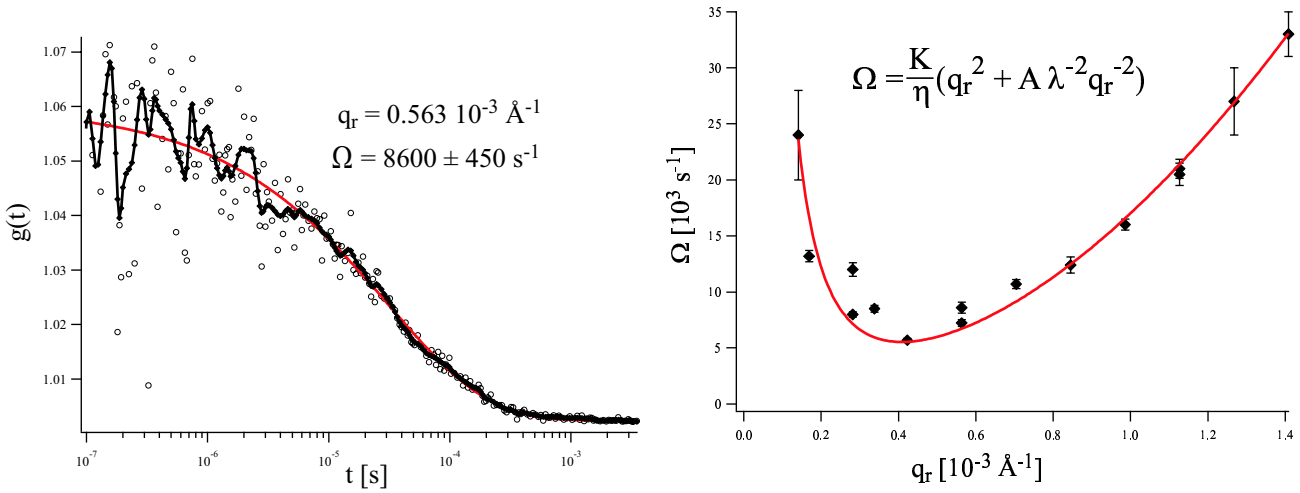

Fig. 1 : Results obtained for the SDS/pentanol/H_2O+glycerol system (left) Correlation function $g(t)$ measured for ($q_\perp = 0.563\,10^{-3}$Å^{-1}). (right) Dispersion relation of the undulation mode $\Omega(\mathbf{q}_\perp)$, fitted with equation (1).

The dispersion relation $\Omega(\mathbf{q})$ for fluctuations in the lamellar phase is well known [3]. In the limit of the undulation mode, $\mathbf{q} = (\mathbf{q}_\perp, q_z = q_{\rm Bragg})$, it reduces to $\Omega(q_\perp) = \frac{\kappa/d}{\eta_3} q_\perp^2$, with κ the bending stiffness, d the lattice spacing and η_3 the layer sliding viscosity. However, the finite size of the capillary (thickness D) imposes a finite q_z component that must be taken into account when describing the dispersion relation, which becomes [4] :

$$\Omega(q_\perp) = \frac{\kappa/d}{\eta_3}\left[q_\perp^2 + \left(\frac{\pi}{\lambda D}\right)^2 \frac{1}{q_\perp^2}\right] \qquad (1)$$

The fit quality is actually very good, yielding parameters $\kappa/(d\eta_3) = 1.66\,10^{-10}$m^2/s and $\lambda = 20$Å. Limited by scattering intensity, in this experiment we were able to reach a maximum wave vector $q_{\rm max} = 1.4\,10^{-3}$Å^{-1}, about half of the range accessible in dynamic light scattering. Using more contrasted systems with slower dynamics, we hope that in the future we will be able to exceed the DLS range.

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