Competition between wall anchoring and yielding of nematic platelets under LAOStress and Strain, revealed by 3D Rheo-SAXS

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Introduction

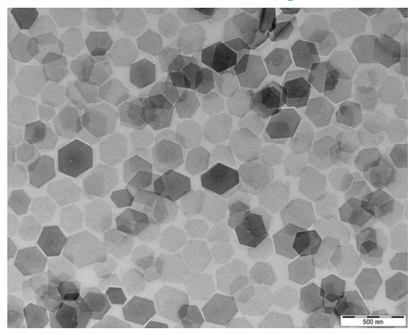
Nematic dispersion of colloidal gibbsite platelets show yielding behavior

- **Goal:**
  Study the structural response underlying the yielding behavior
- **Tool:**
  Large Amplitude Oscillatory Strain/Stress measurements combined with a vertical small angle X-ray scattering set-up to probe structure
- **Novelty:**
  3D re-orientational motion and local information

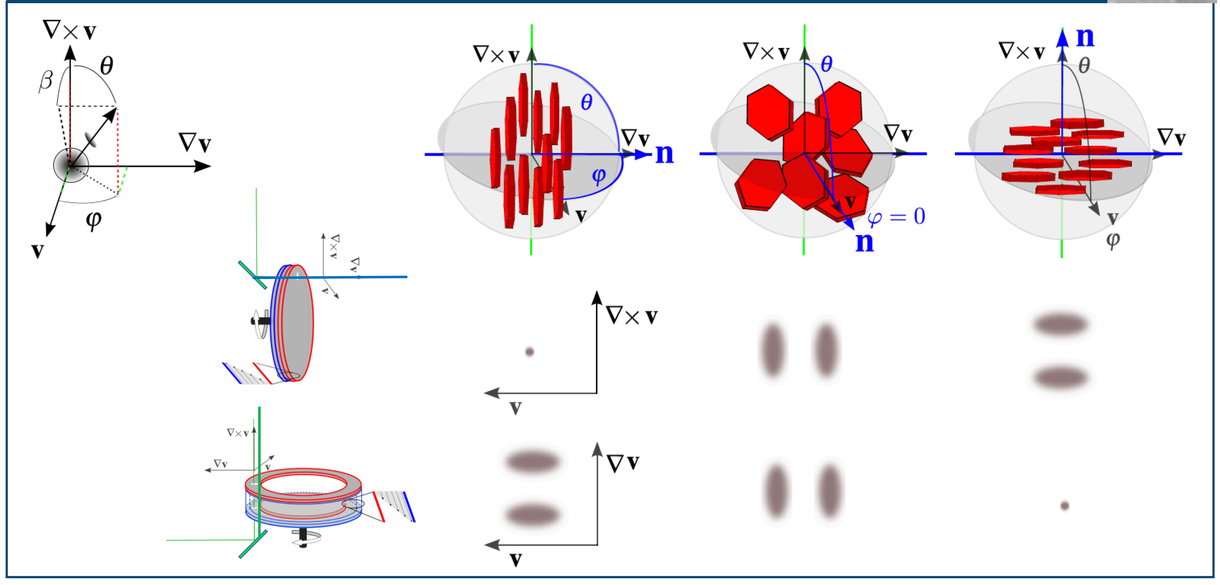
Materials

- **Gibbsite platelets (AlOOH):**
  - Charged, sides and faces carry the same charges (positive)
  - Relatively thick (R=125 ± 16 nm, d=11 ± 4 nm)
  - Relatively monodispersed (~13-20%)
  - Dispersed in glycerol

Gibbsite TEM Image

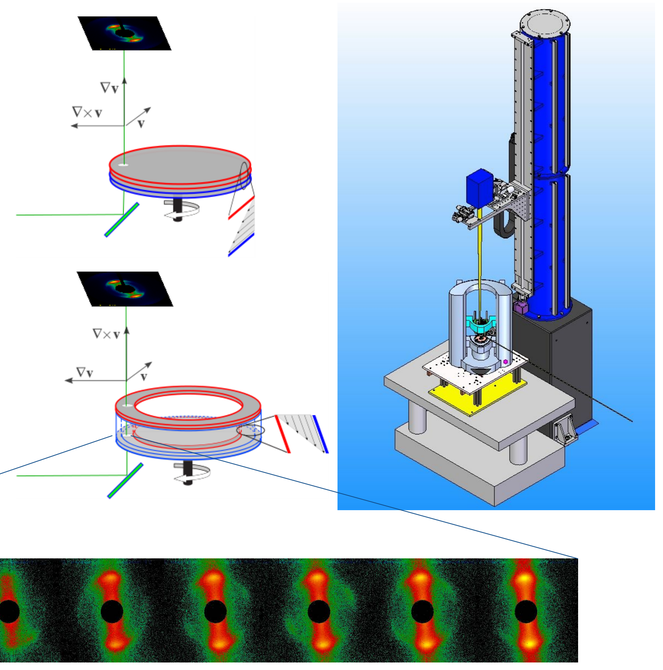


Possible configurations



Setup

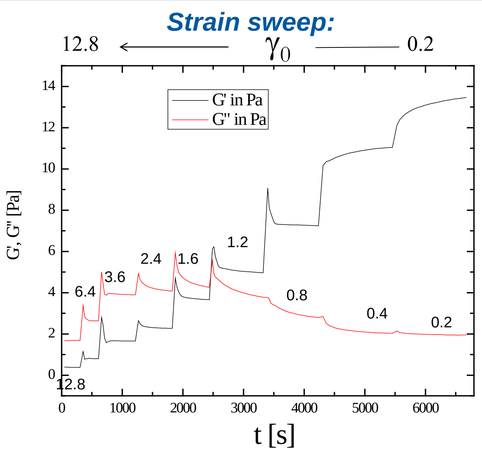
- **Rheo-SAXS [2]**
  Vertically deflected X-ray beam is passed through plate/plate or couette geometry of a Haake Mars stress controlled rheometer.
- **Advantage**
  Simultaneous Small Angle X-ray Scattering and Rheological measurements
- **Probe**
  - Flow-vorticity plane
  - Flow-gradient plane, plus gap scanning



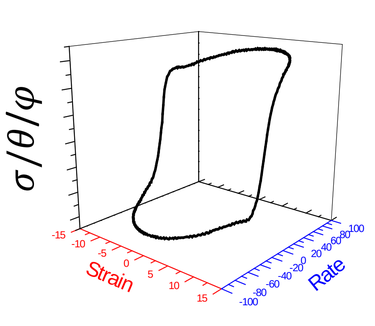
Gap scanning

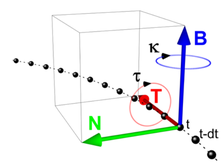
t-resolved mechanical and structural response

Strain sweep:



"continuous local measures" [4]:





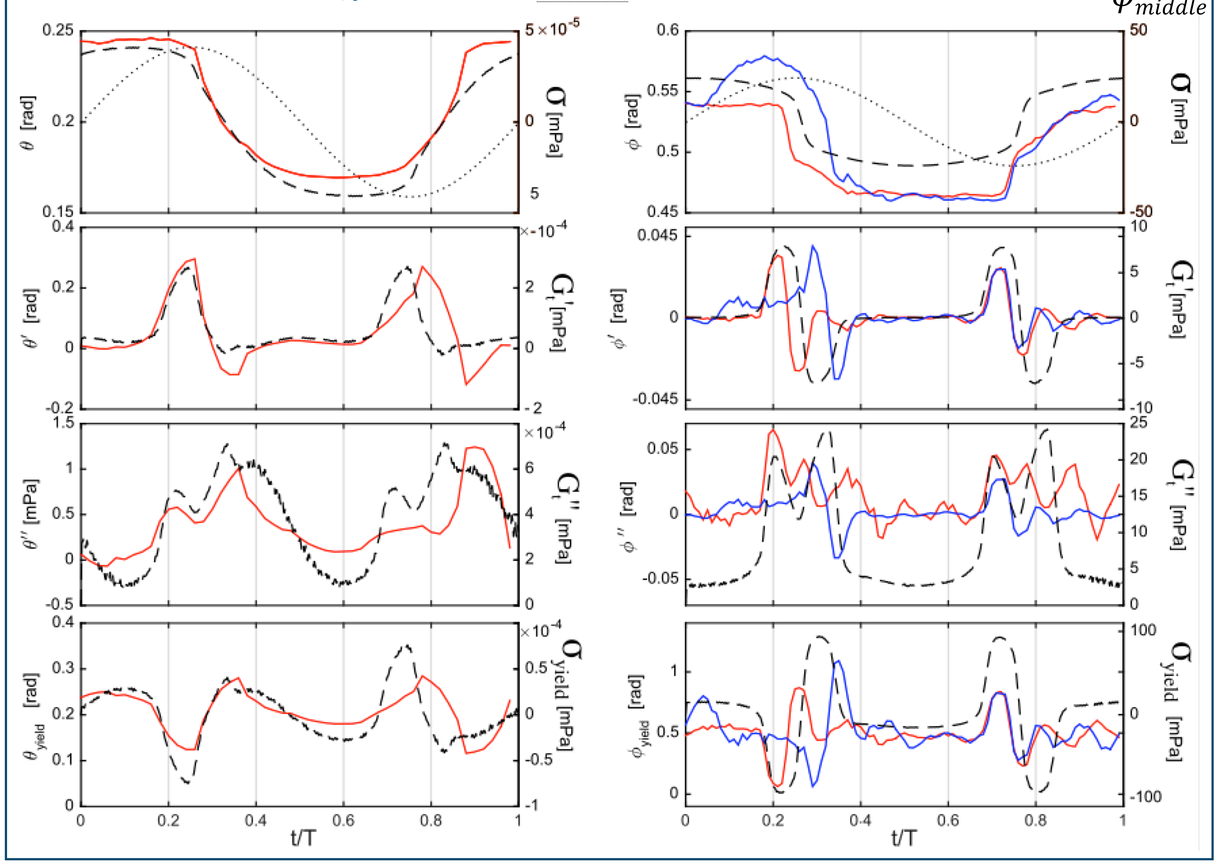
Transient moduli:

$$G_t' = -\frac{B_\gamma}{B_\sigma}$$

$$G_t'' = -\frac{B_{\dot\gamma}}{B_\sigma}$$

Same for angle! (replace σ by θor φ)

θ ***At low strain*** $\gamma_0 = 0.4$: ..... σ ——— γ ***At high strain*** $\gamma_0 = 12.8$: ——— φ_{wall} ——— φ_{middle}



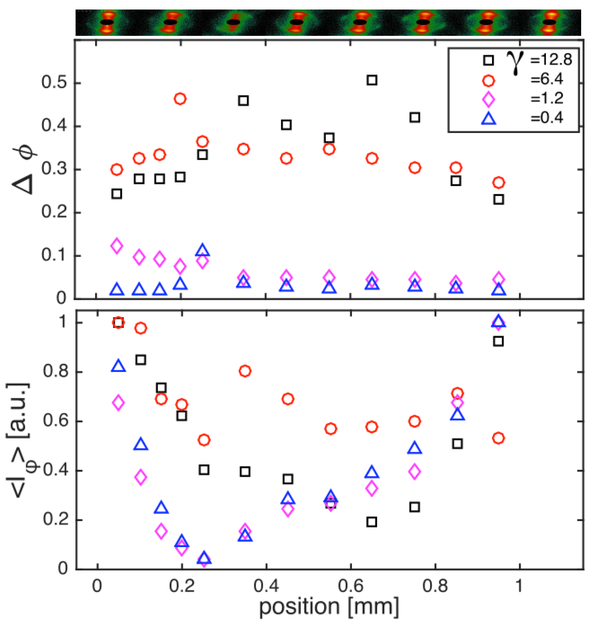
Wall anchoring vs. Director motion

LAOStrain:

- Full 3-D reorientational motion
- Structural response at low strain: no propagation throughout the gap
- Structural response at high strain: full response through gap, but erratic in the middle
- Stress response mainly due to wall response

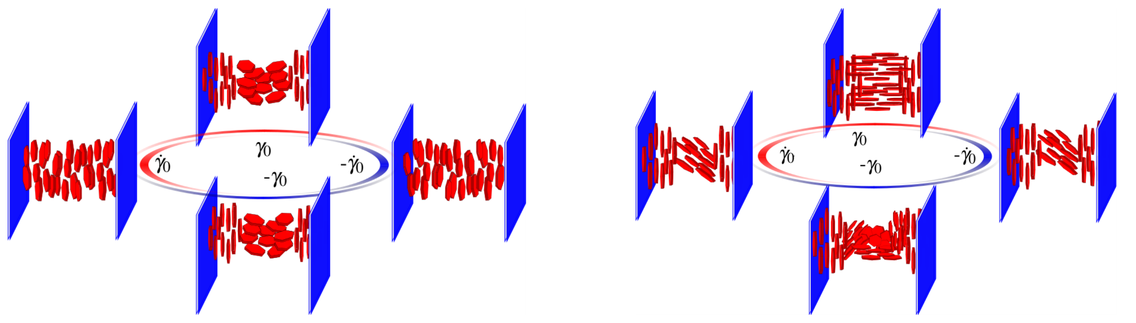
LAOStress:

- strong asymmetrical behaviour both in the rheological and the microscopic response [3] (not shown).



Cartoon of the dynamic behavior

- **Response at low strain:**
  - 1st harmonic response ⇨ Dynamic bifurcation
  - High effect of wall anchoring
- **Response at high strain:**
  - 2st harmonic response
  - Widening followed by flipping
  - Smaller effect of wall anchoring



[1] Lettinga, M.P., et al.,. Phys. Rev. Lett., 2012.; [2] Struth, B. et al.,. Langmuir, 2011, 27 (6), pp 2880–2887; [3] Korculanin et al. Phys. Fluids, 2017 29, pp. 023102; [4]Lee and Rogers. Korea-Australia Rheology J., 29(4), 2017