Inertial flows in liquid foam microchannels

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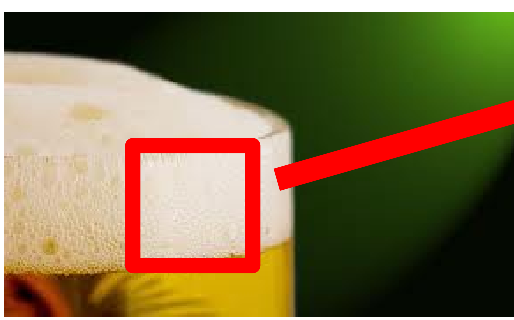
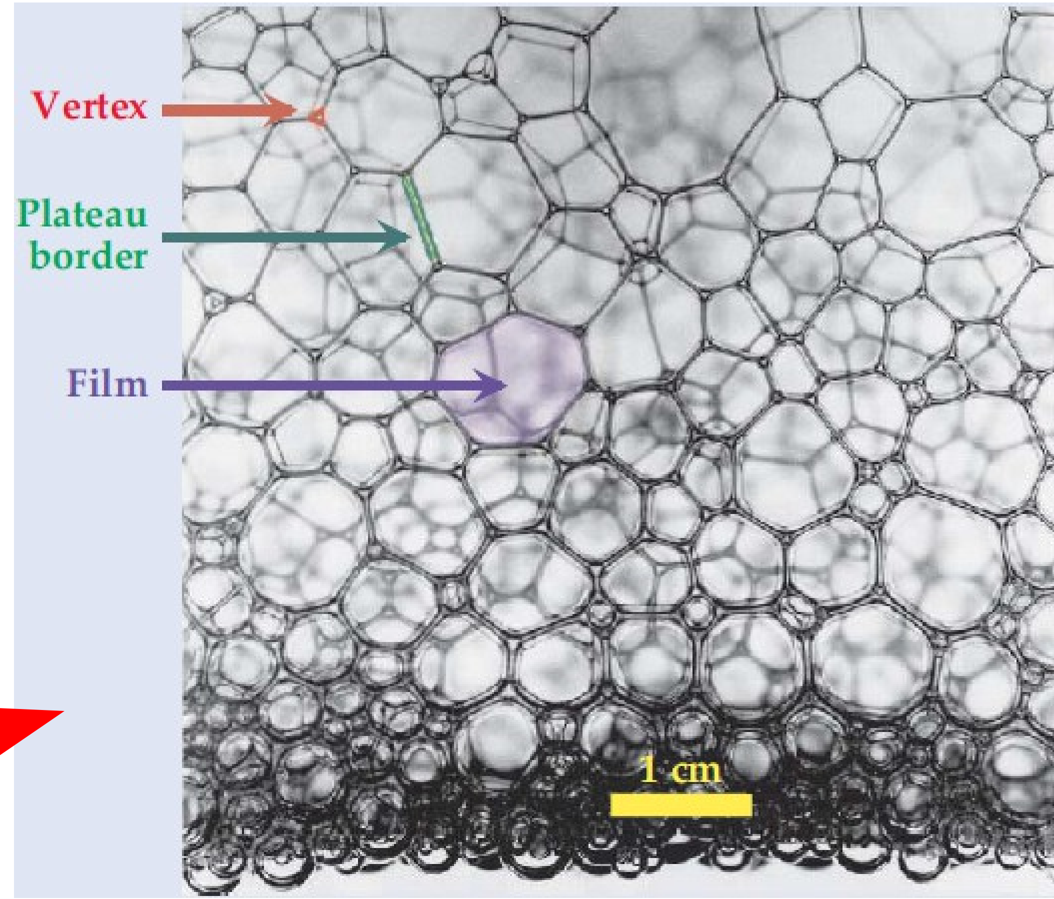
Introduction: liquid in foams

- Composition

cf: talk by B. Dollet





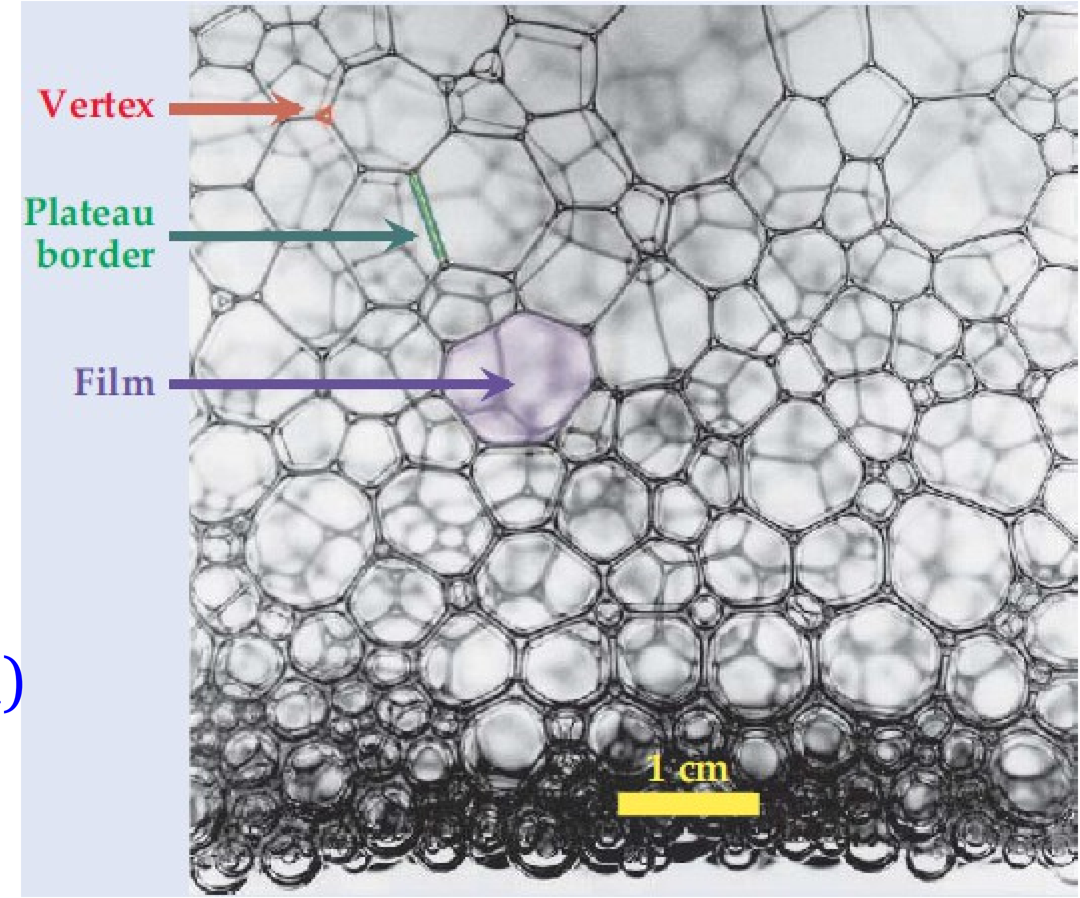
Durian & Raghavan Phys. Today 2010

Introduction: liquid in foams

- Composition

dispersion of gas (bubbles, 100µm-1cm)

inside liquid phase:
-Plateau Border (10-100µm)
-vertex
-film (10nm–1µm)



Durian & Raghavan Phys. Today 2010

Motivations

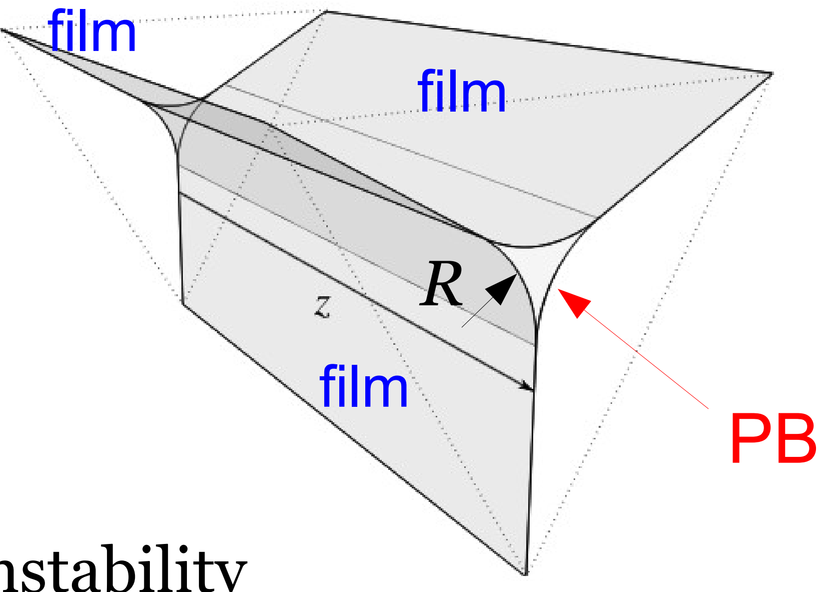
- Plateau Border

  Liquid microchannel

  Held by 3 soap films

  Sustained by capillarity
  no Rayleigh-Plateau instability
  under-pressurized: $\boldsymbol{P = P_0 - \gamma/R}$

  Very flexible and deformable

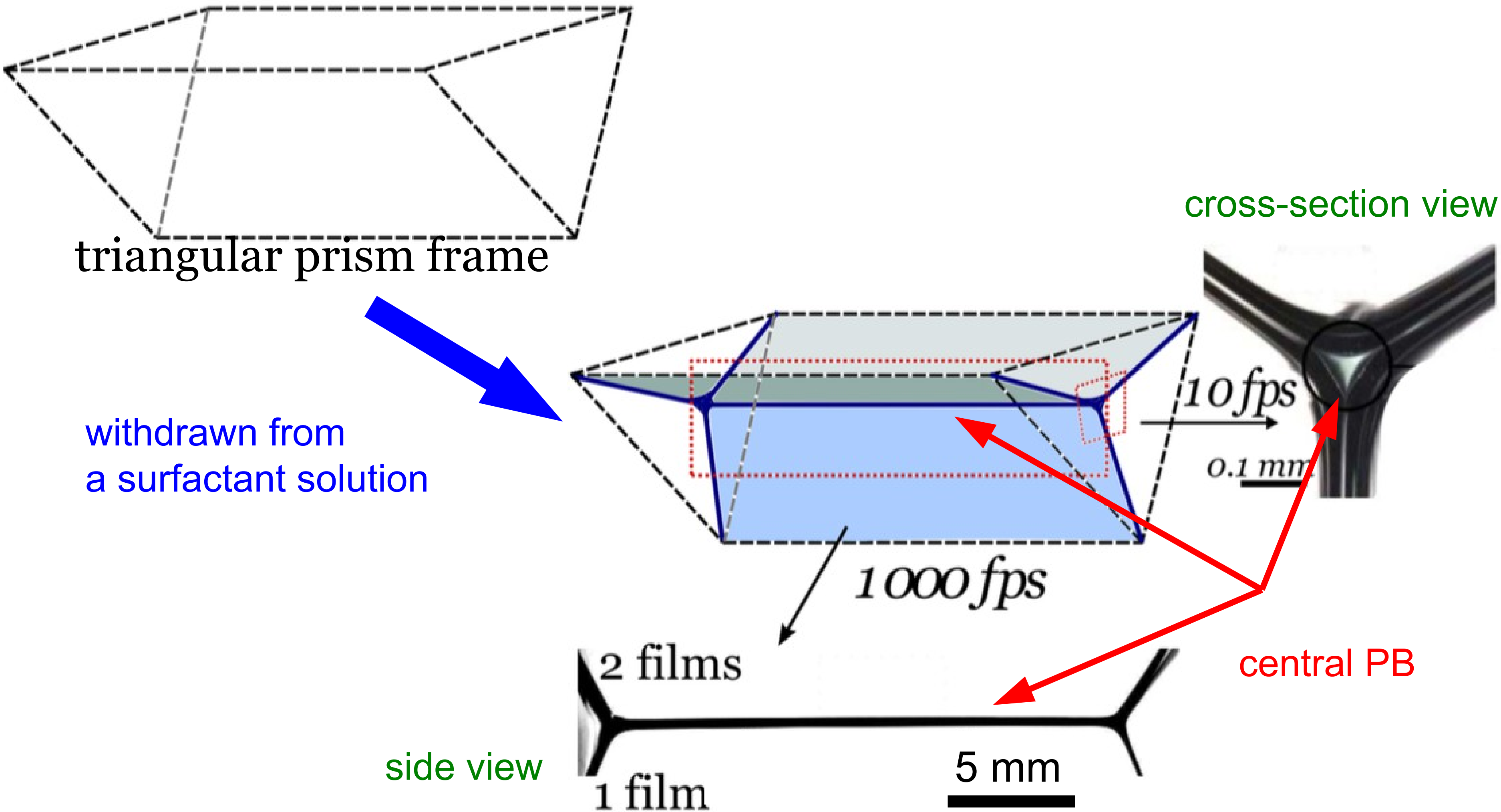


- Interest in the mechanical response of a PB
  (morphologies, flows, ...)

→ Inertial flows at the micron-scale

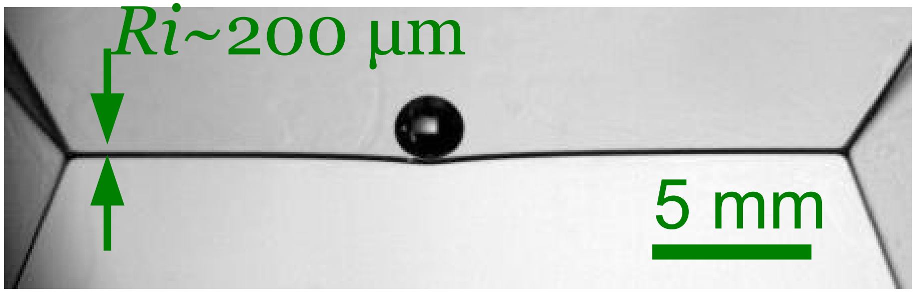
Setup

- Single-PB experiment



I - Drop-injected experiment

☐ Inertial regime

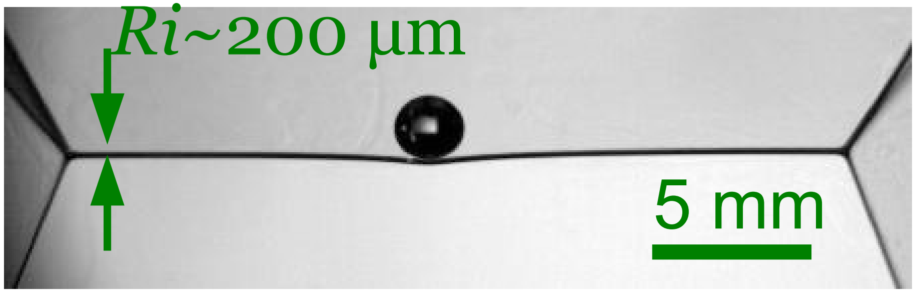


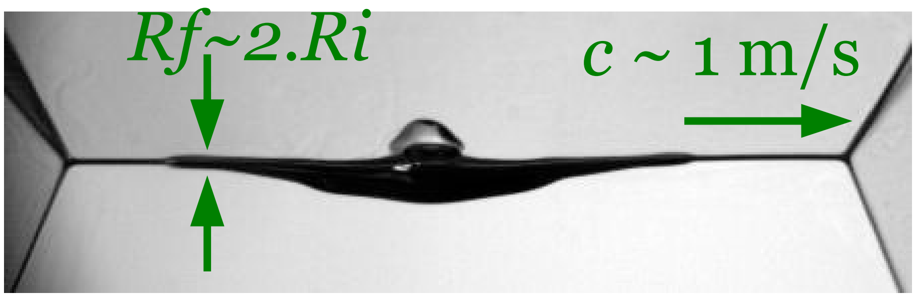
slowed down x100

bulk properties ~ water
surface tension γ~30mN/m

I - Drop-injected experiment

- Inertial regime



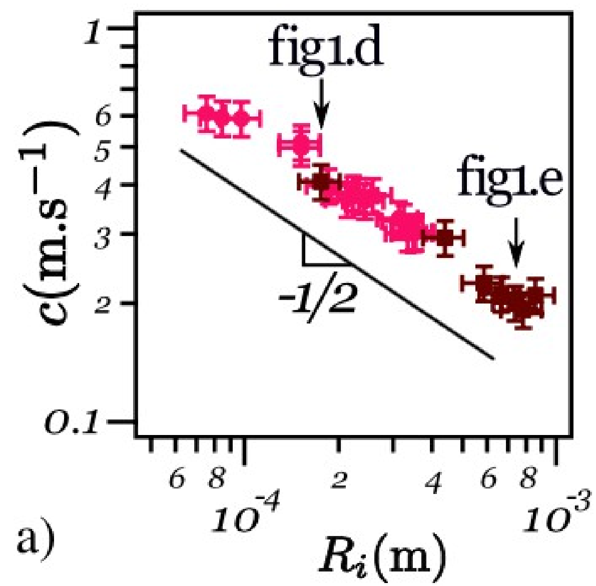


Cohen et al., PRL 2014
Argentina et al., JFM 2015

Re = ρ *Ri c*/η ~ 200

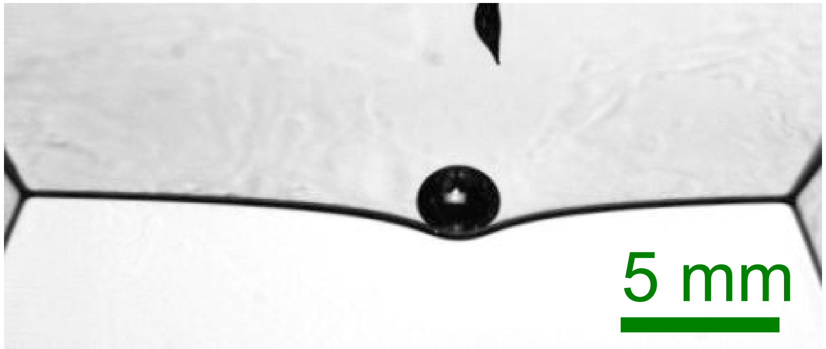
Capillary hydraulic jump

$$c = (\gamma/\rho Ri)^{-1/2}$$



I - Drop-injected experiment

- Viscous Regime



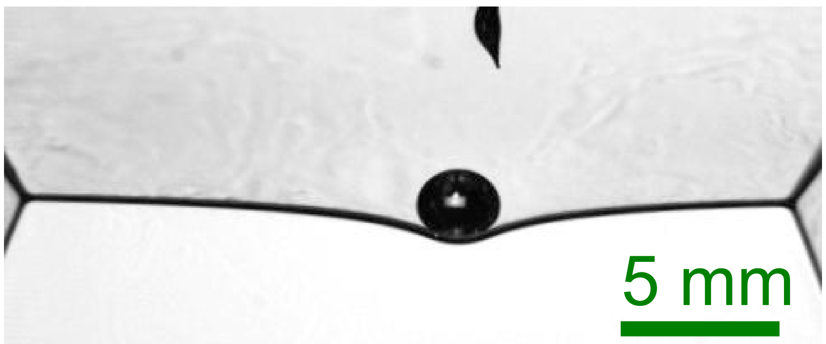
slowed down x200

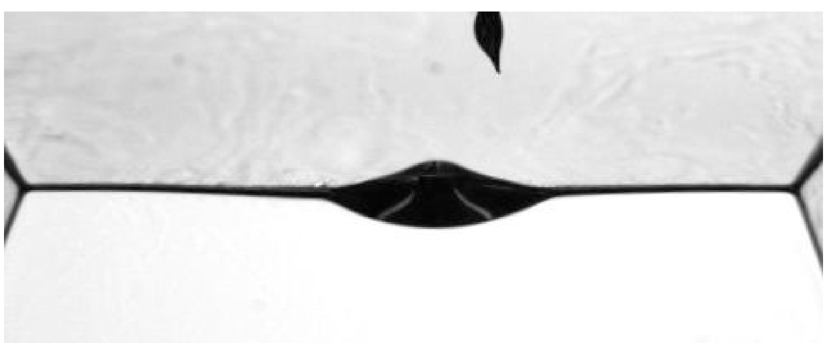
Increasing $\boldsymbol{\eta}$
Decreasing $\boldsymbol{Ri}$

$$\mathbf{Re} = \rho\, Ri\, c/\eta$$

I - Drop-injected experiment

☐ Viscous Regime





Increasing η
Decreasing Ri

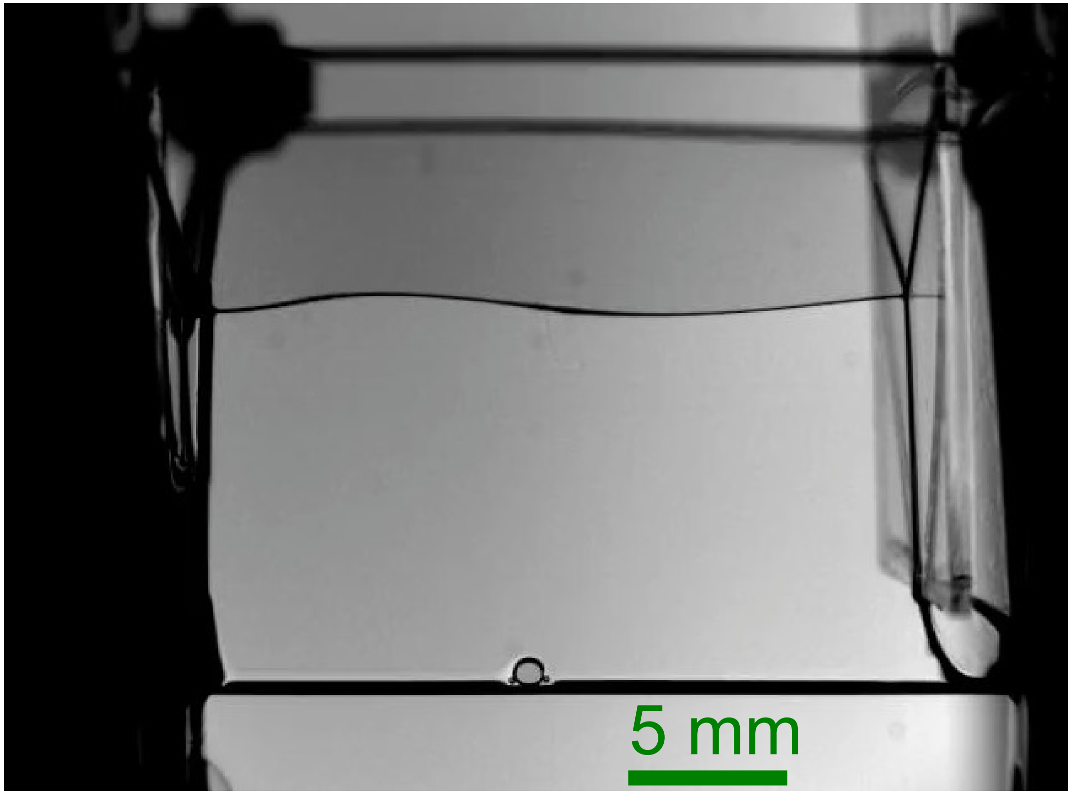
$\mathbf{Re} = \rho\, Ri\, c/\eta$
Transition **Re~20**

Smooth spreading profile
Slower dynamics

II - Oscillation experiment

- Melde's experiment with a liquid string

$\omega \sim 400$ rad/s

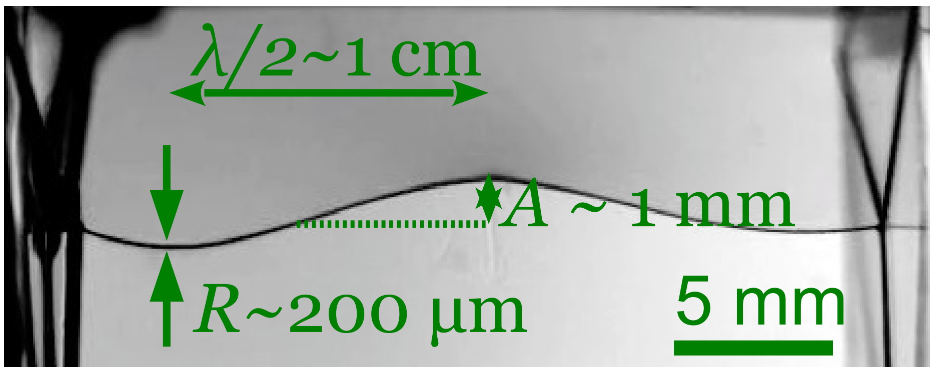


slowed down x100

II - Oscillation experiment

- Melde's experiment with a liquid string

ω ~ 400 rad/s



Dispersion relation $\boldsymbol{\lambda(\omega)}$

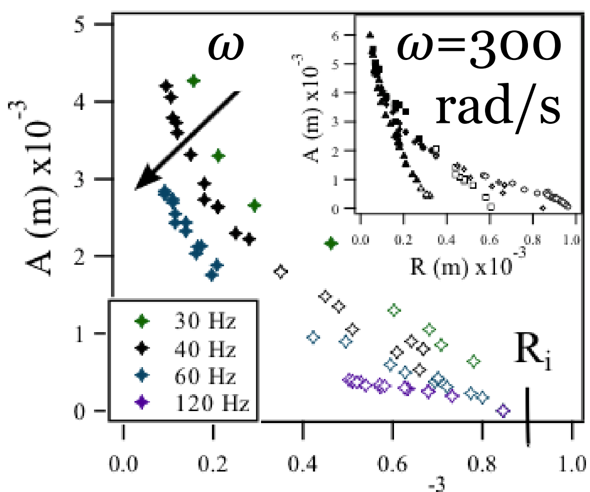
Inertial regime

Re = $\boldsymbol{\rho R_i A\omega/\eta}$ ~ *100*

1 Bernoulli equation

$$\frac{1}{2}\rho\frac{(A\omega)^2}{2} - \frac{\gamma}{R} = -\frac{\gamma}{R_i}$$

A ↗ ***R*** ↘

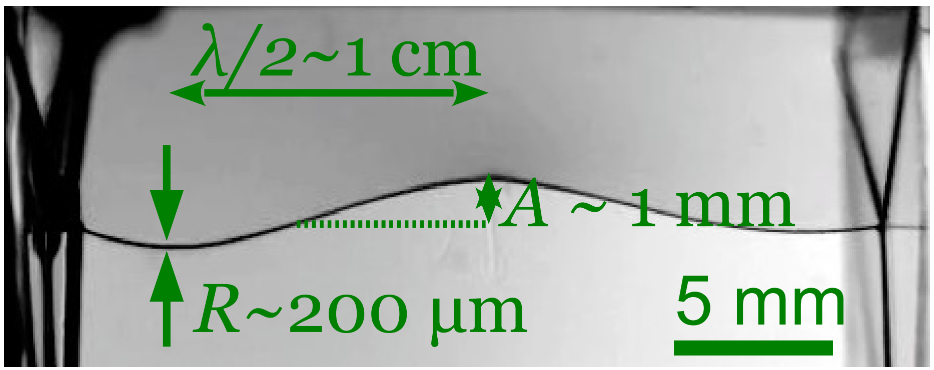


a)

II - Oscillation experiment

- Melde's experiment with a liquid string

$\omega \sim 400$ rad/s



Dispersion relation ***λ(ω)***

Inertial regime
Re = *ρ Ri Aω/η* *~ 100*

1 Bernoulli equation

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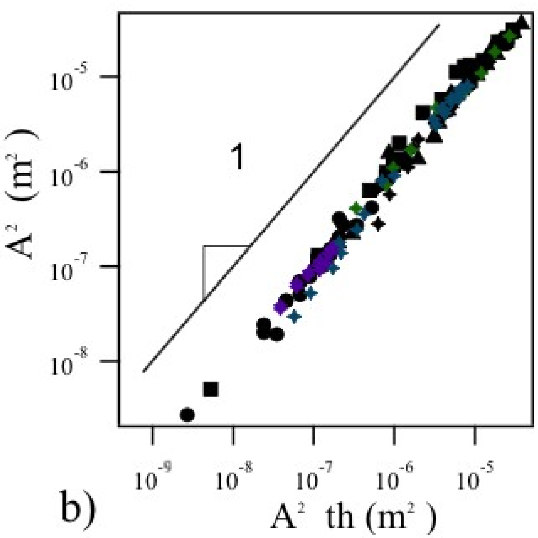


II - Oscillation experiment

- Melde's experiment with a liquid string

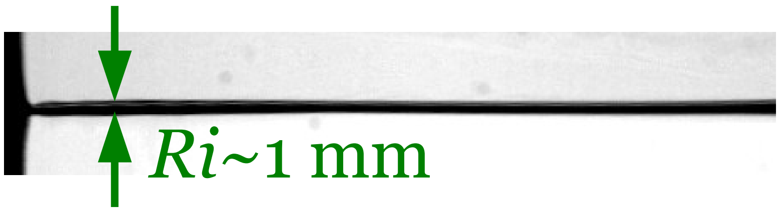
$R_i \sim 1$ mm

slowed down x20

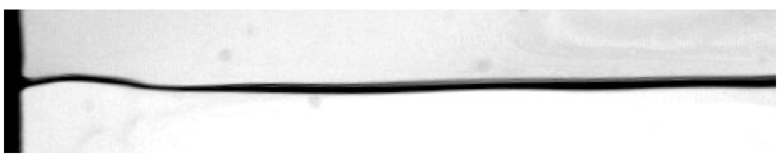
High amplitude regime

II - Oscillation experiment

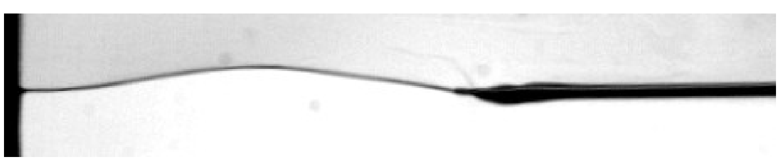
- Melde's experiment with a liquid string



High amplitude regime



Bernoulli
Non-linear effects



Transition to a bi-sized system

Conclusion

- Inertial flows at the microchannel scale
- Non-linear effects and specific morphologies
- Coupling with the three holding films