Basic fluid-solid interaction experiments

Rama Govindarajan
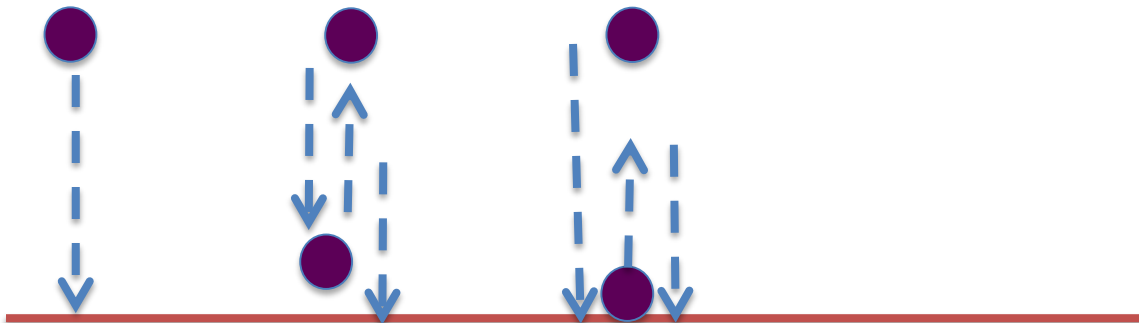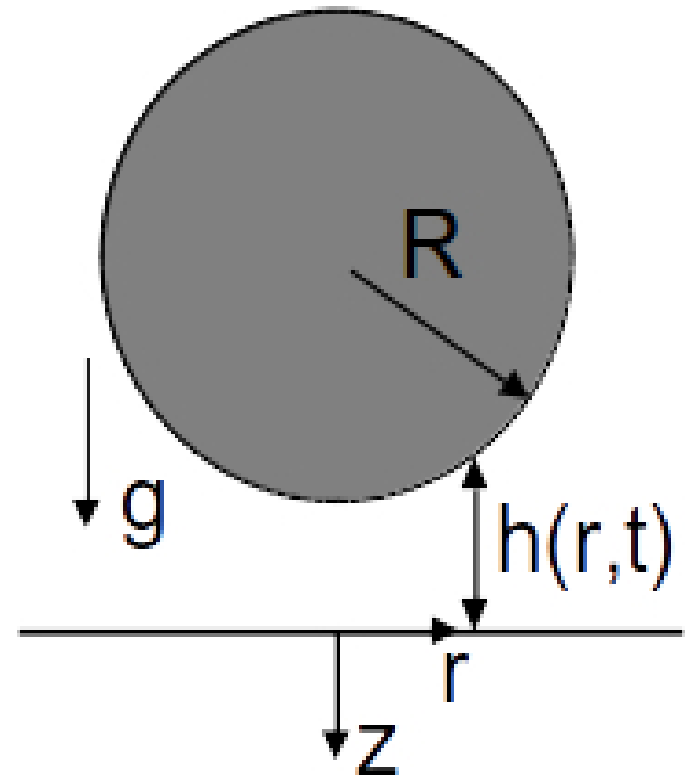
Work of Sumit Birwa and Ganga Prasath

with Narayanan Menon
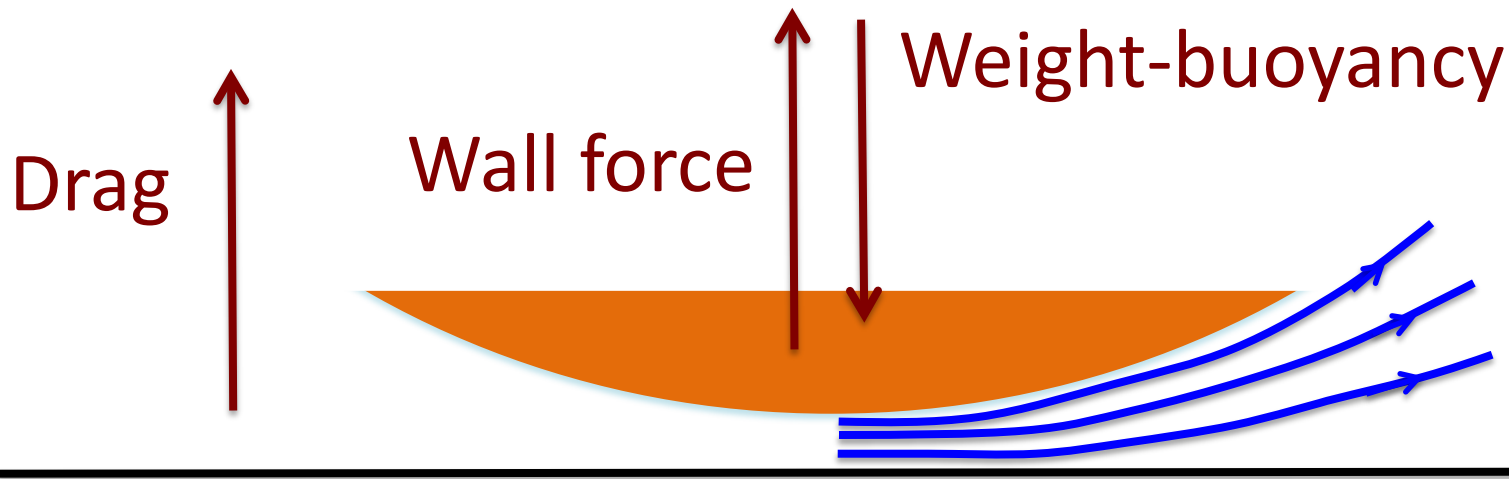
16 Feb 2018
Statphys Community

Ball falling in viscous fluid

Sumit Birwa

Will the ball touch the floor?

Drag

Wall force

Weight-buoyancy
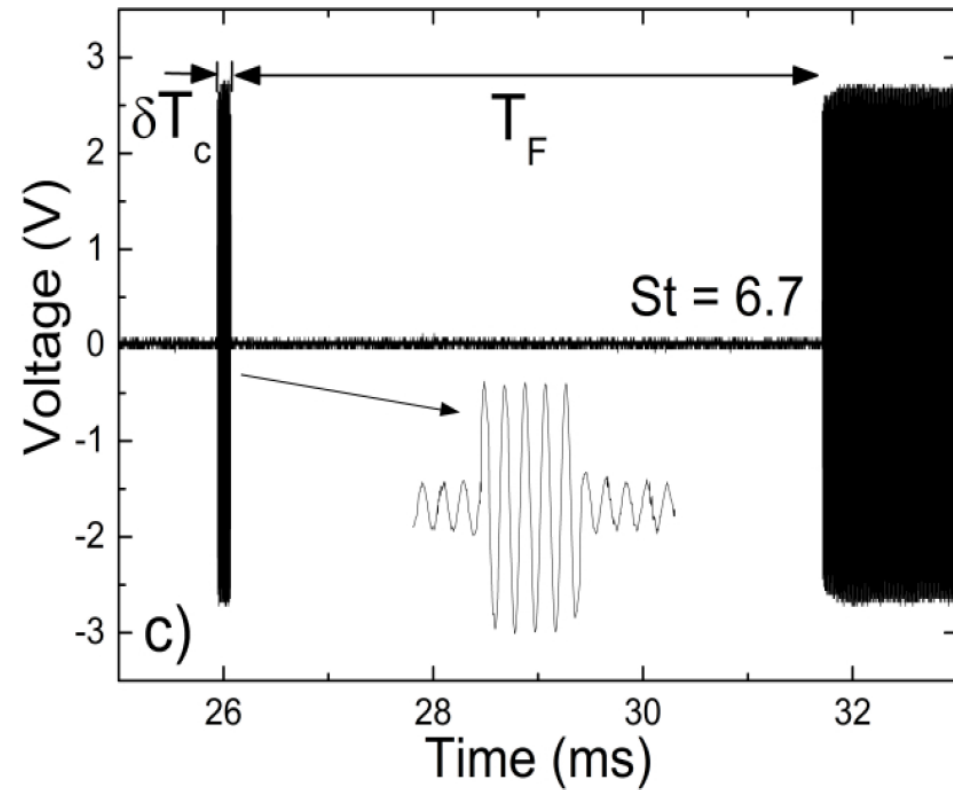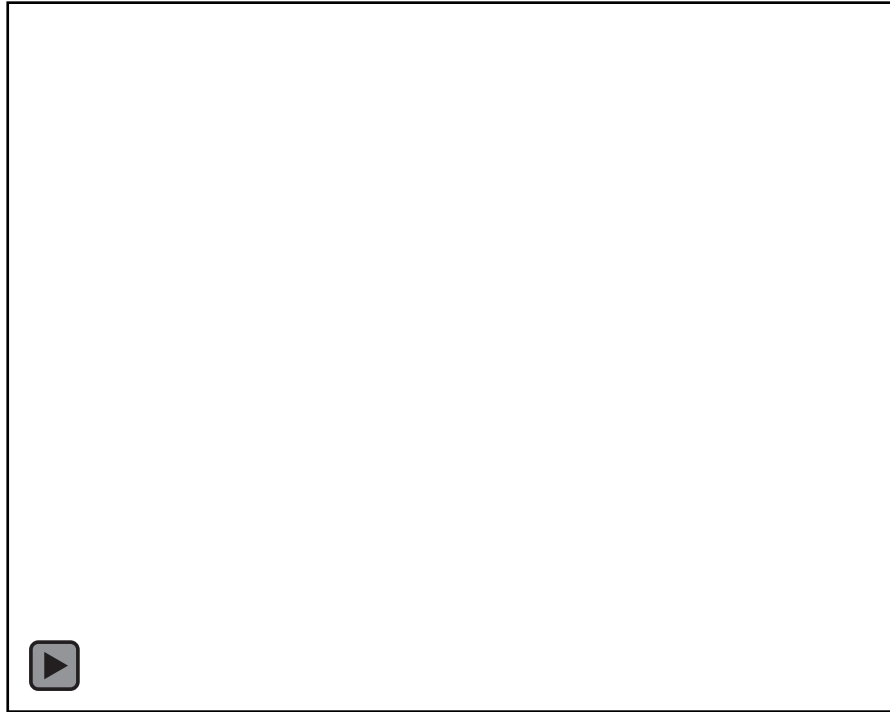
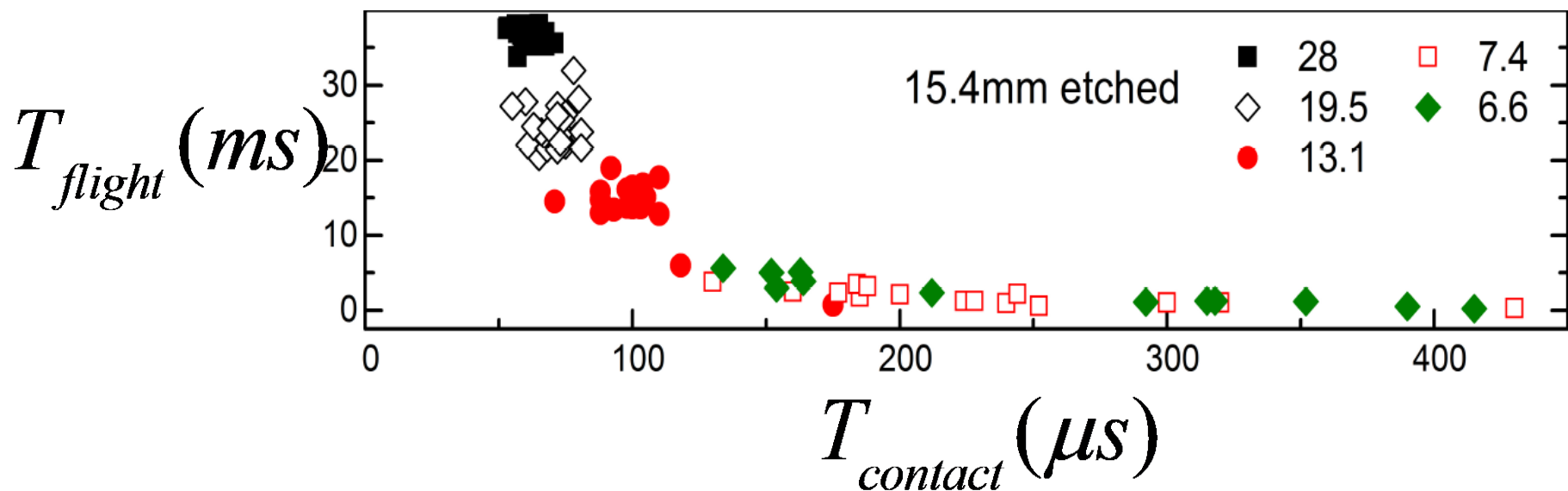*Davis et al., J Fluid Mech 1985*

Lubrication theory: <u>it will not</u>

$$p(r,t) = -\frac{3\mu R \dot{h}_0(t)}{h^2(r,t)}$$
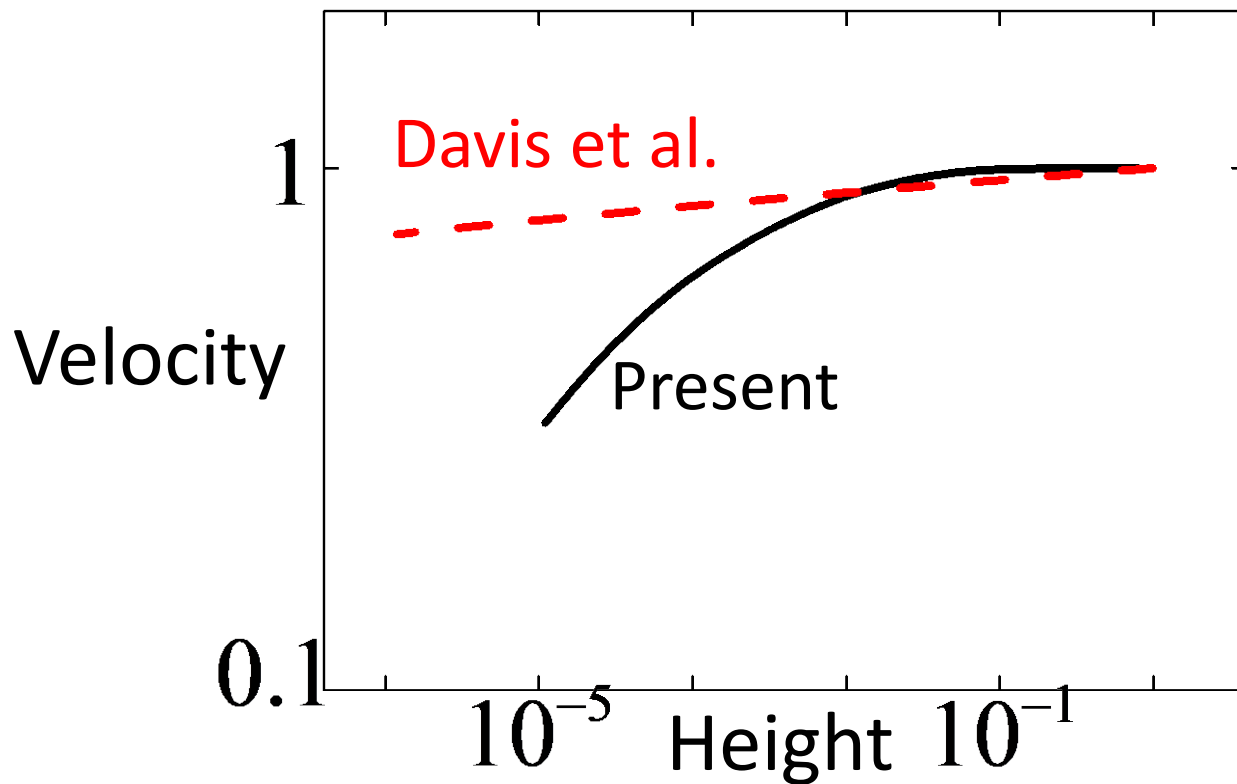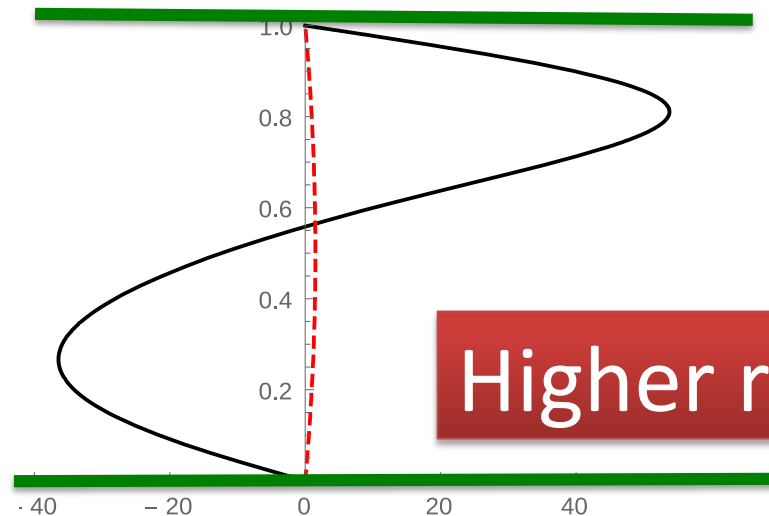
Experiment: electrical contact

c)

δT_c T_F

St = 6.7

Birwa et al. 2018

4

$T_{flight}\,(ms)$ vs $T_{contact}\,(\mu s)$, 15.4mm etched

Legend: ■ 28, ◇ 19.5, ● 13.1, □ 7.4, ◆ 6.6
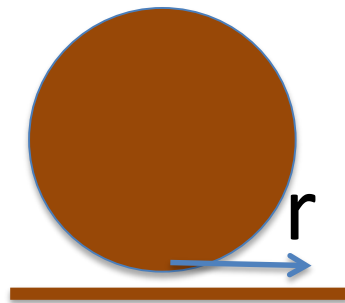
`Boundary-layer' approximation: weakly non-similar profile

$$\left[\frac{h\dot{\zeta}}{\dot{h_o}}\psi_{\eta\eta\zeta} - \eta\psi_{\eta\eta\eta} + \frac{h}{\dot{h_o}}\psi_{t\eta\eta} + \left(\frac{\ddot{h_o}h}{\dot{h_o}^2} - 2\right)\psi_{\eta\eta} - \frac{2\pi(h-h_o)}{rh}(\psi_\eta\psi_{\eta\eta\zeta} - \psi_\zeta\psi_{\eta\eta\eta})\right.$$

$$\left. -2\pi\left(\frac{h'}{r}\frac{2h_o-h}{h} - \frac{2(h-h_o)}{r^2}\right)\psi_{\eta\eta}\psi_\eta + \frac{2\pi h'}{r}\psi\psi_{\eta\eta\eta}\right] = \frac{1}{Re}\left[\frac{1}{hh_o}\psi_{\eta\eta\eta\eta} + \epsilon\right]$$

$$(119)$$

Very low r

Higher r

r

Davis et al.

Present

Velocity

1

0.1

10^{-5} Height 10^{-1}

1.0

0.8

0.6

0.4

0.2

−40   −20   0   20   40

Flexible filaments on fluid interfaces

S Ganga Prasath

Prasath et al., Phys. Rev. Fluids 2016

$$\tau = \frac{8\pi\mu L_0^4}{B}$$

Drag from slender body theory
Length conserved

$$(\partial_{ss} - |r_{ss}|^2)T(s) = -(3|r_{sss}|^2 + 4(r_{ss} \cdot r_{ssss}))$$
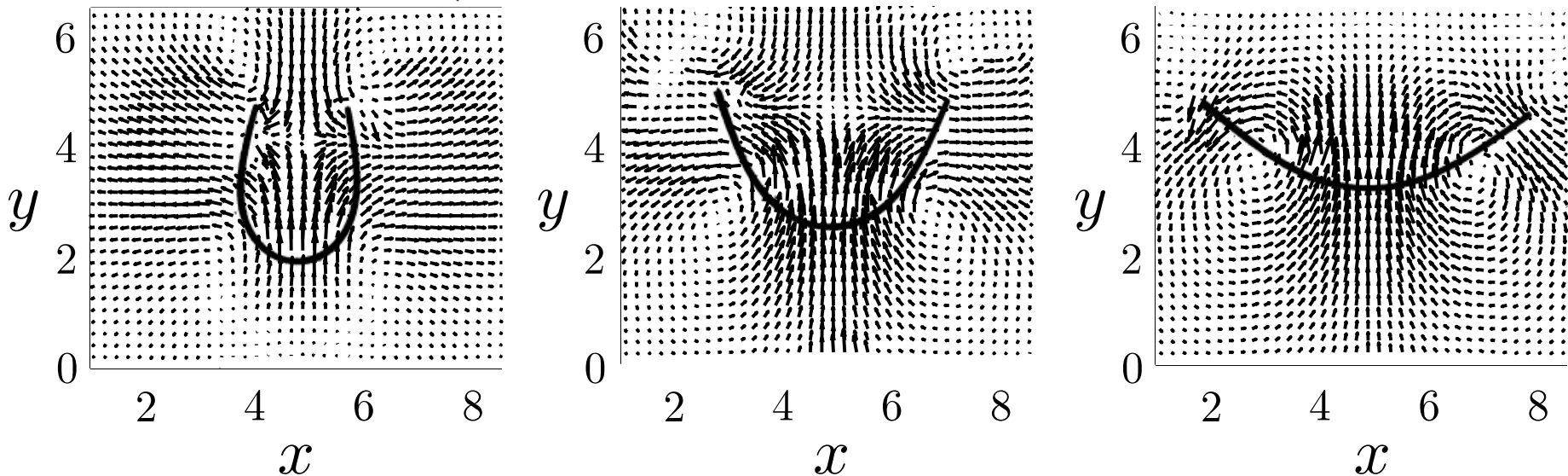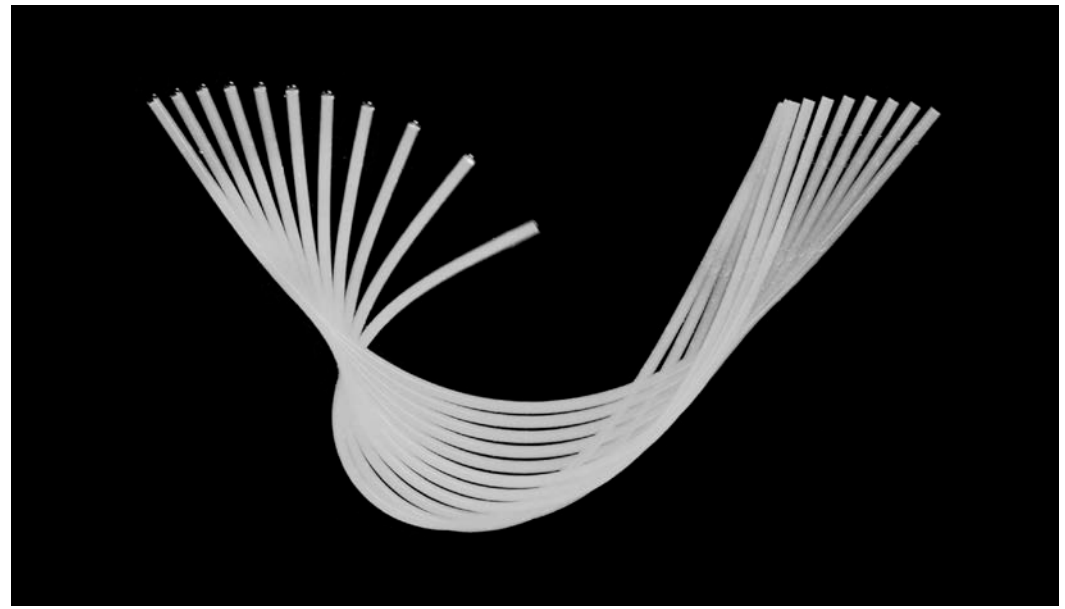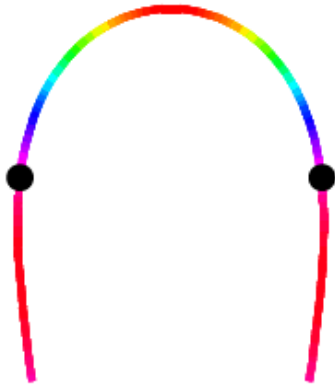
$$r_t = -r_{ssss} + \partial_s[T(s)r_s]$$

(a)
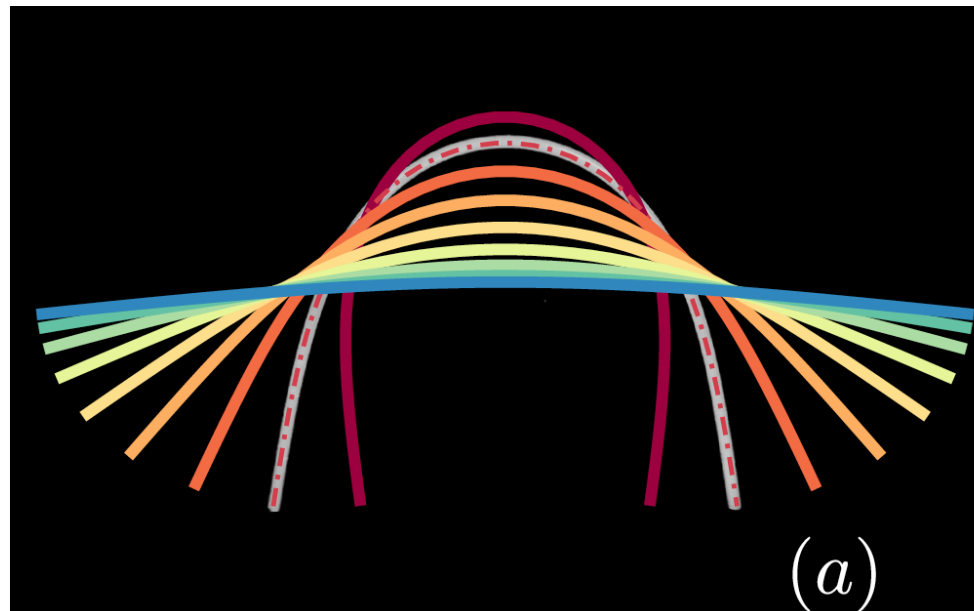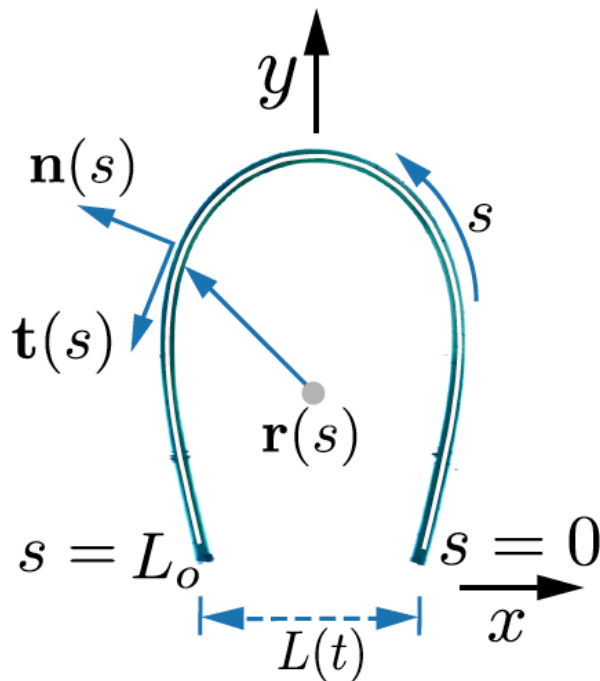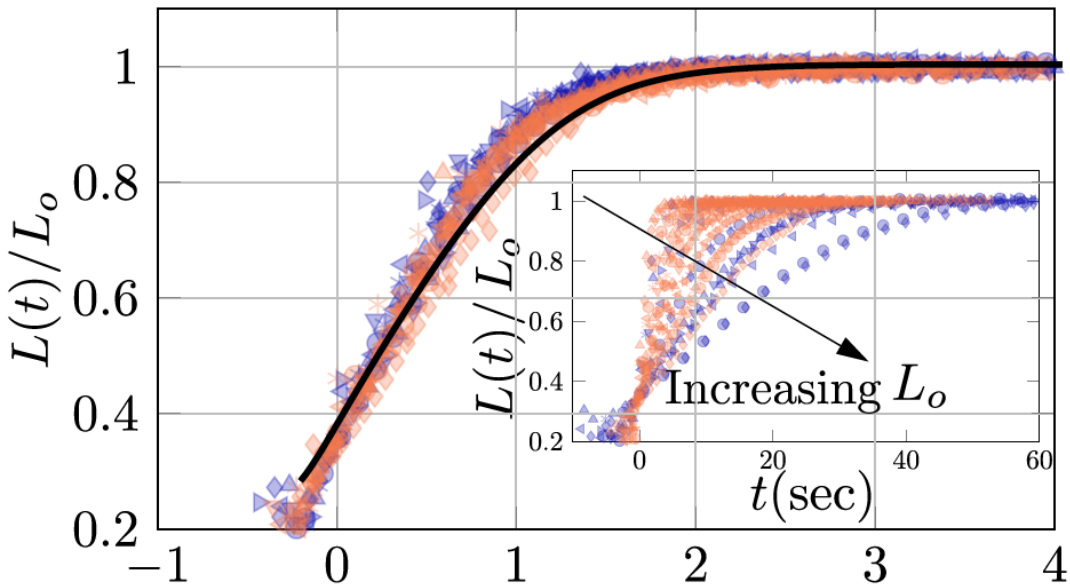
Expt. relaxation faster than theory
Both much faster than τ

Prasath et al., Phys. Rev. Fluids 2016

Unbending and tension not uniform

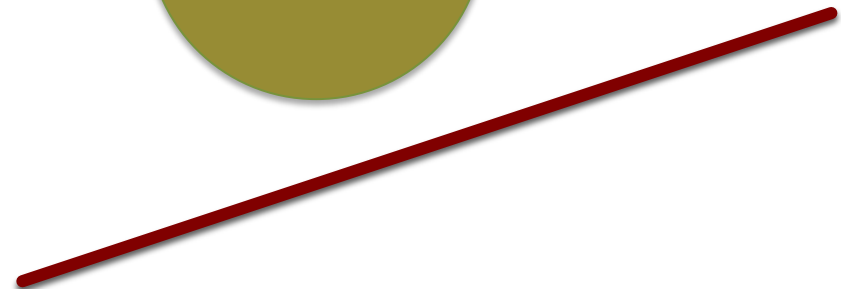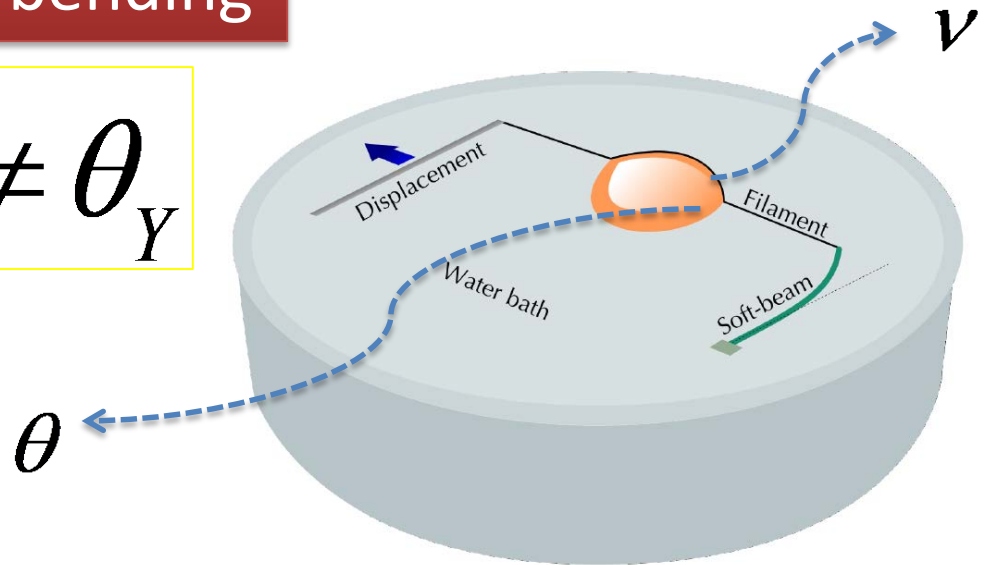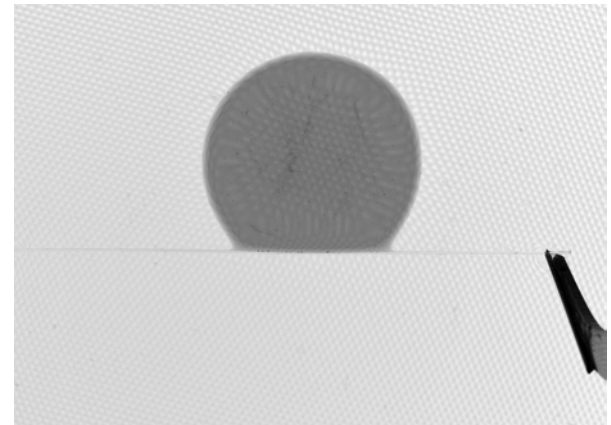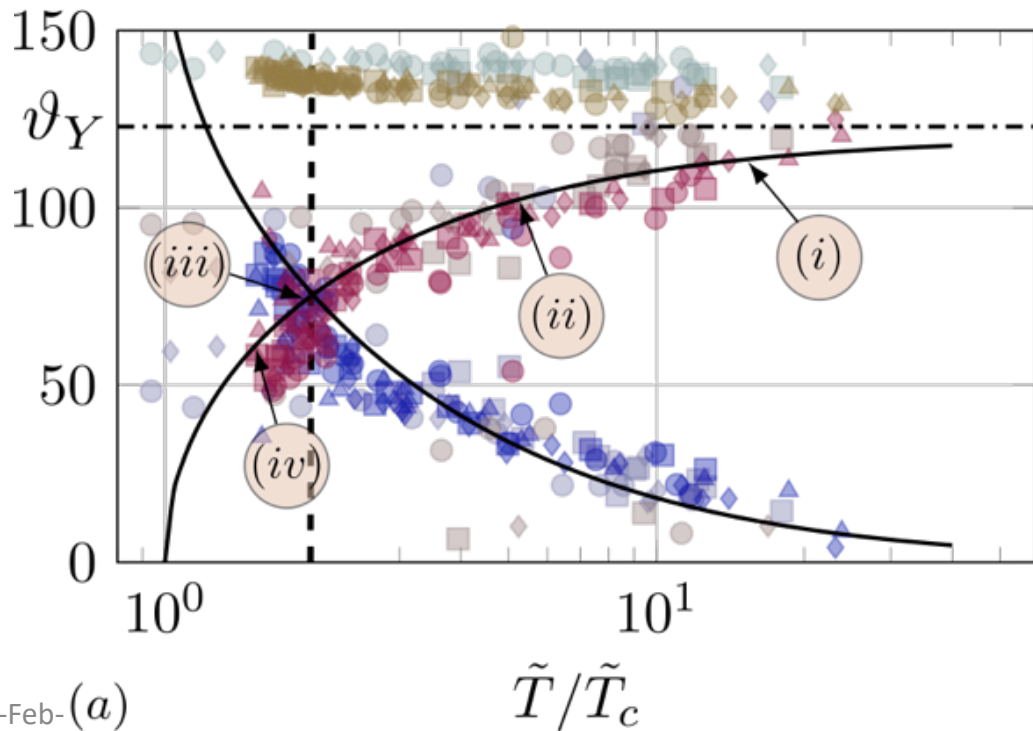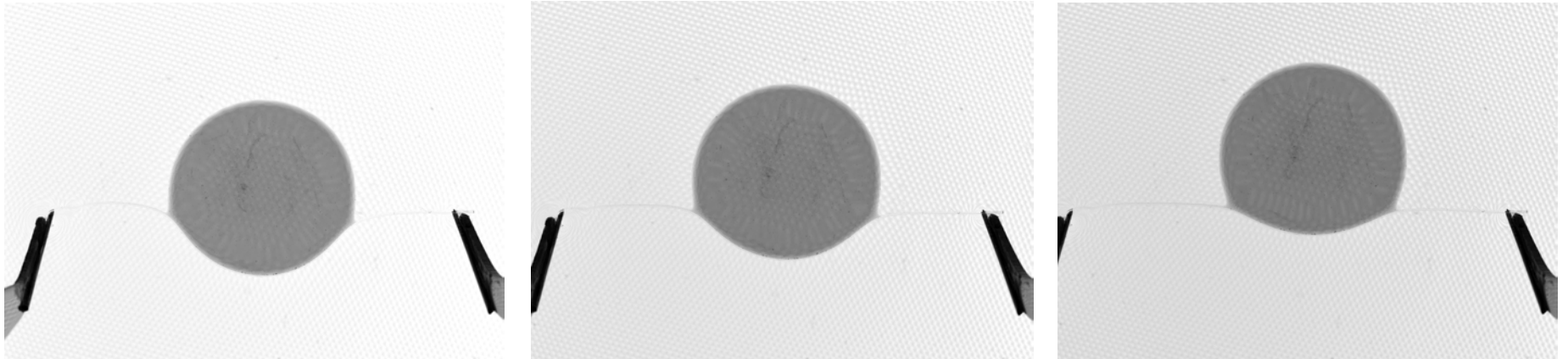Drop hates filament less than water
Filament doesn't really mind bending

$$\theta + \nu \neq \theta_Y$$
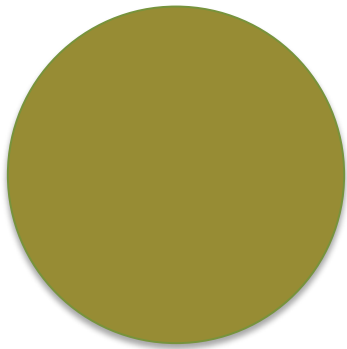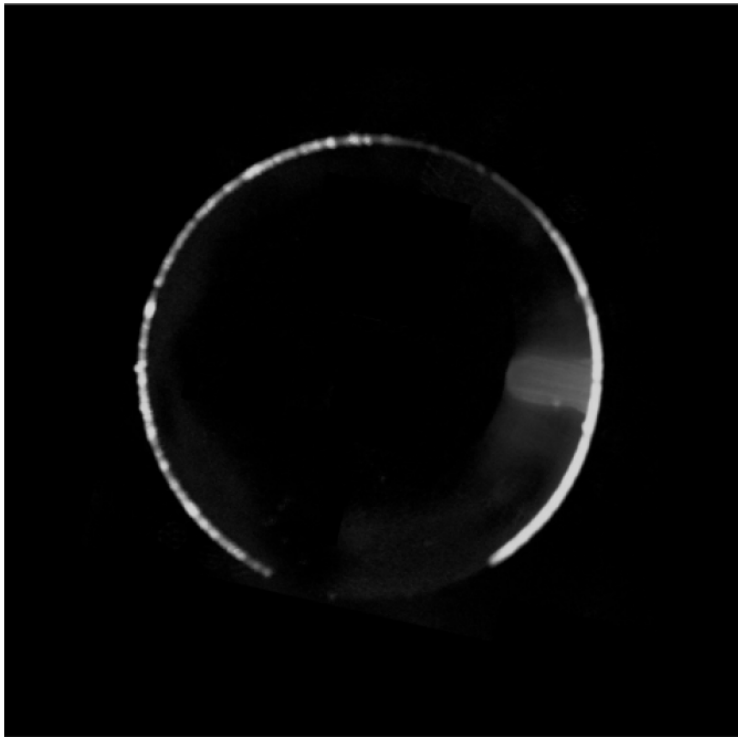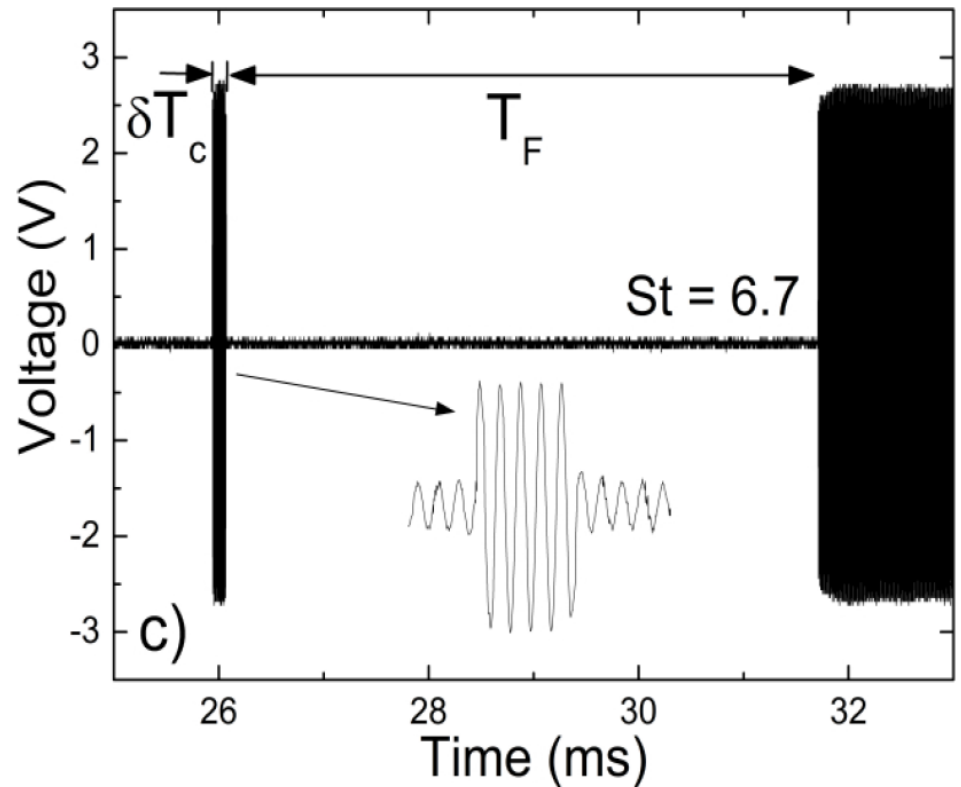
Responds to tension
Calculated exactly

Thank you and please take these home

Ganga's work

Sumit's work