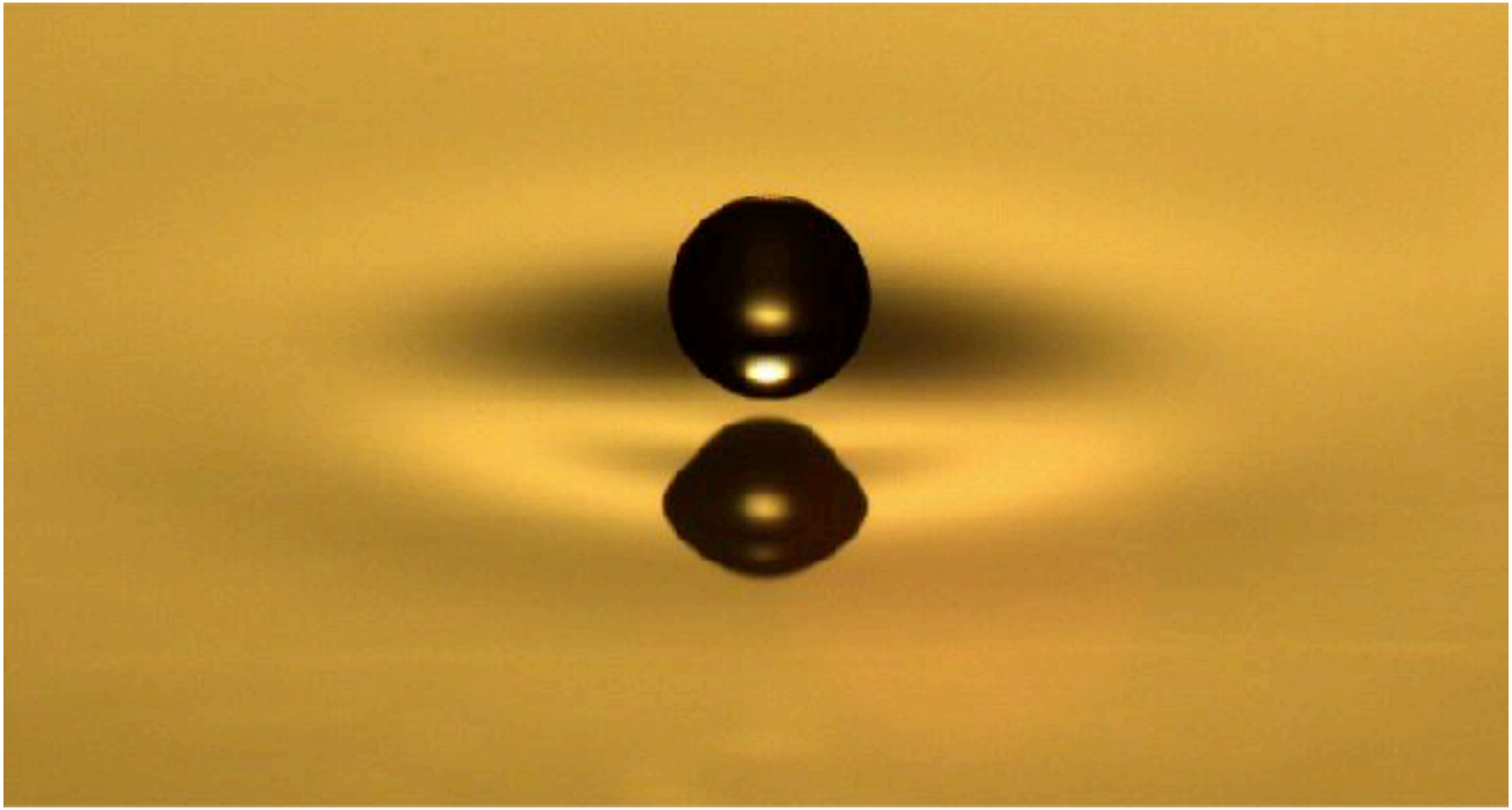
Lecture 7: Drop dynamics

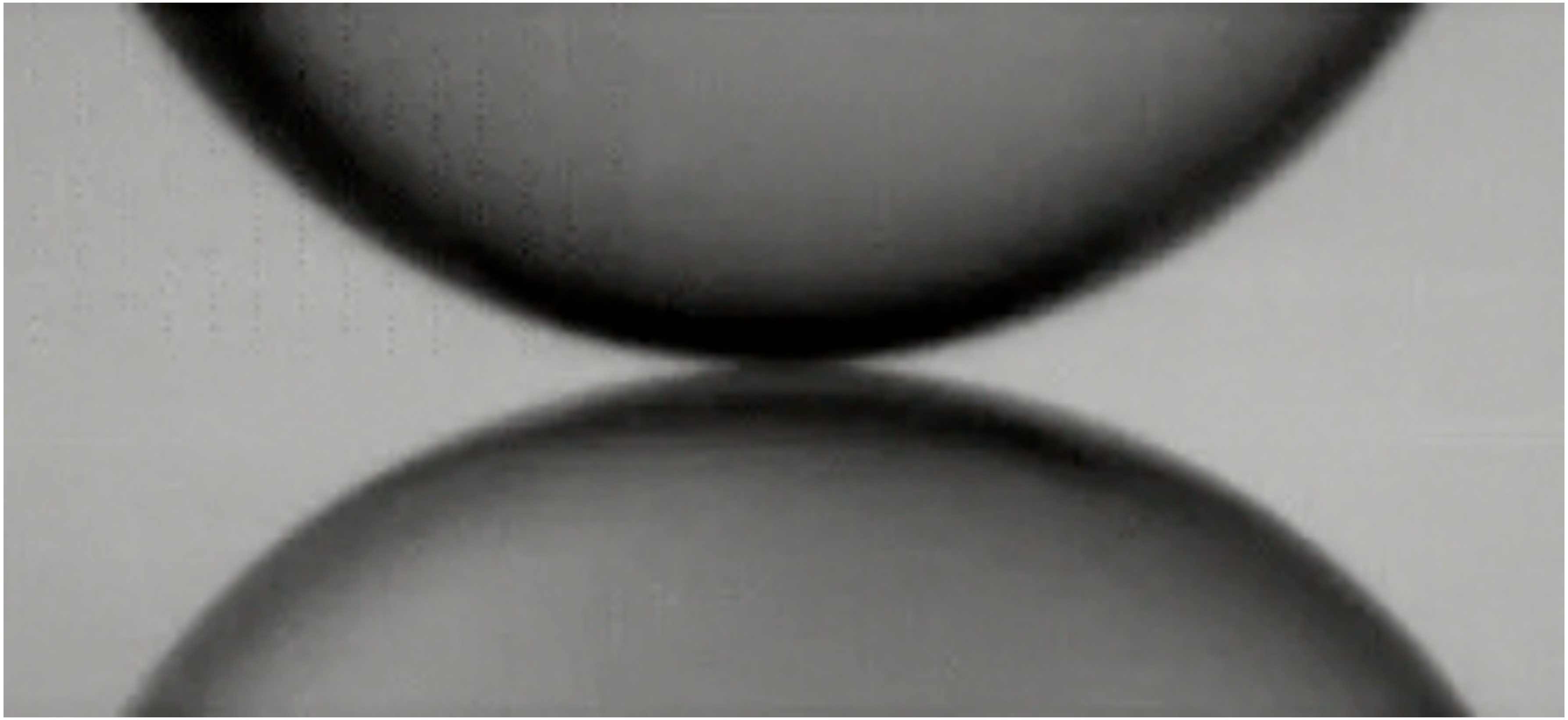
- noncoalescence
- drops bouncing on hydrophobic surfaces
- drop vibrations

Bouncing drops



- how do we rationalize the non-coalescence?

Drop-drop coalescence

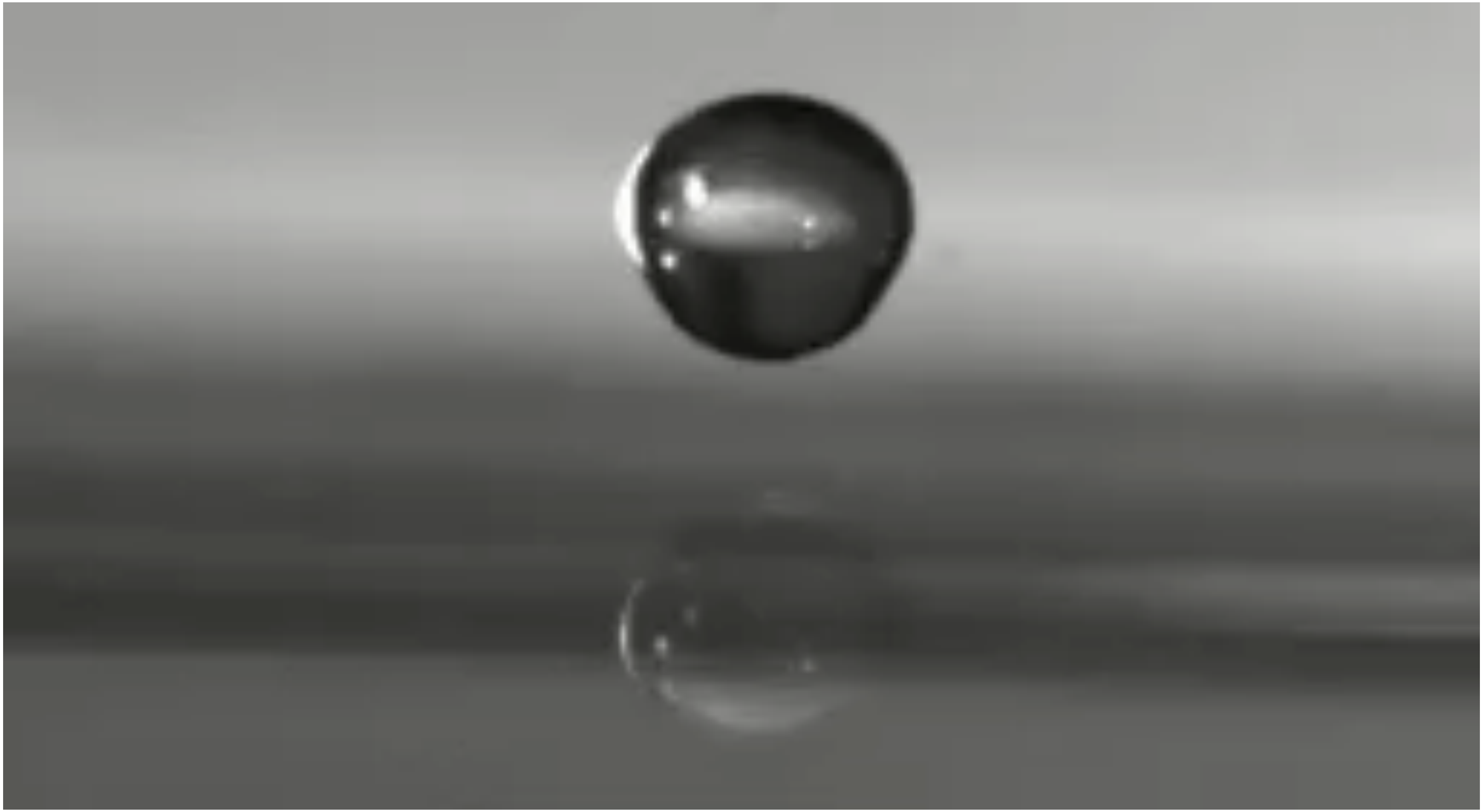


- at a scale of ~100Nm, van den Waals forces between the 2 liquids initiate coalescence

How can one avoid such coalescence?

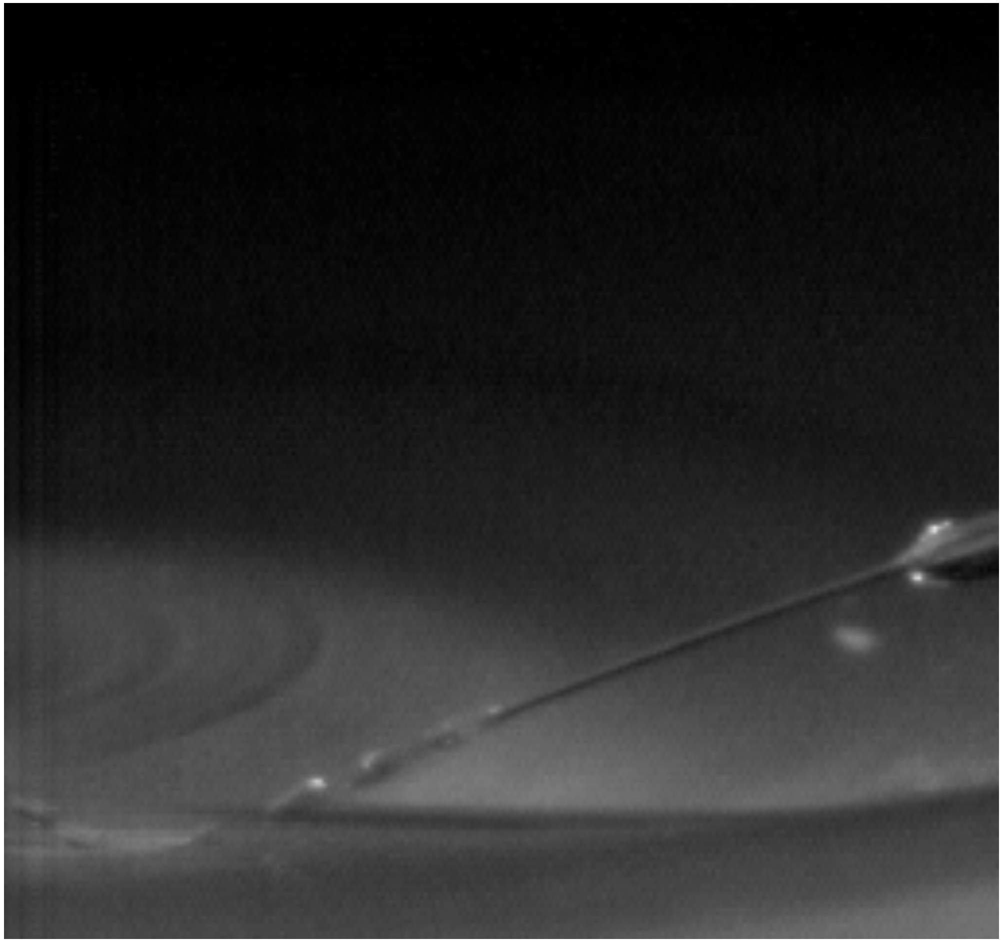
The coalescence cascade

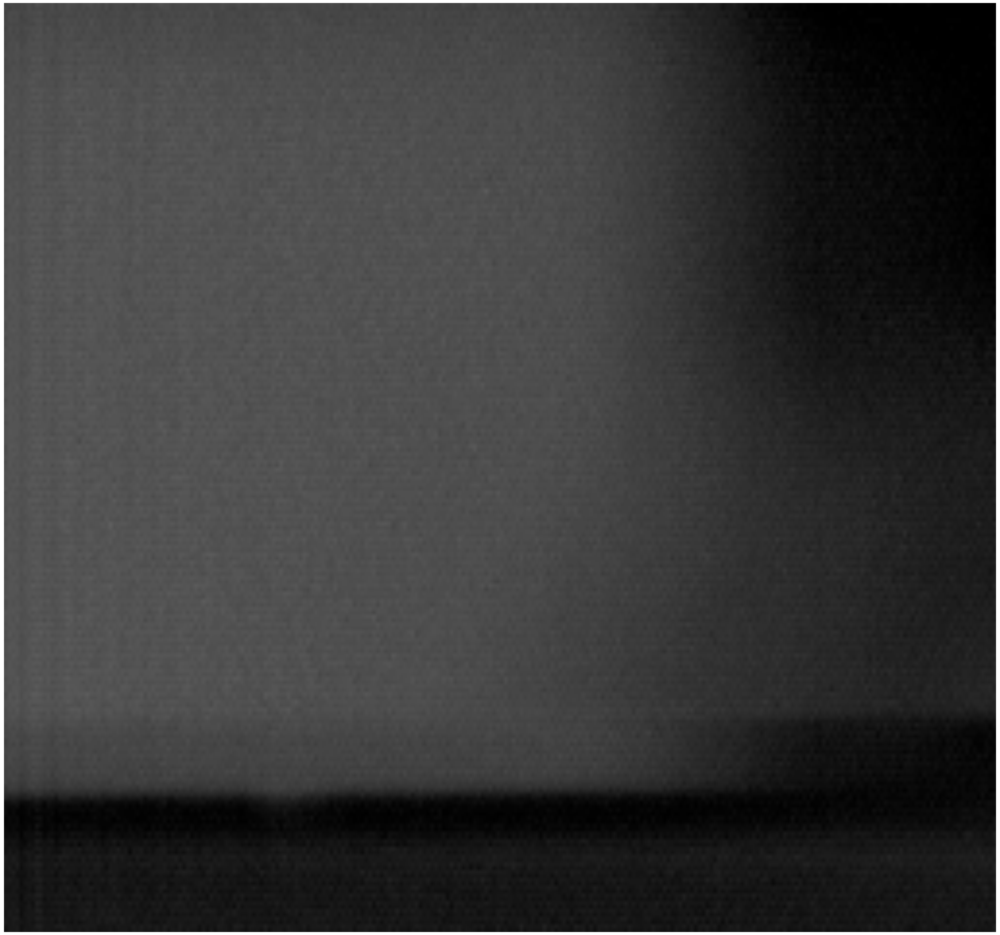
- emplace a water drop on a quiescent bath



- partial coalescence arises in self-similar fashion until Re ~ 1

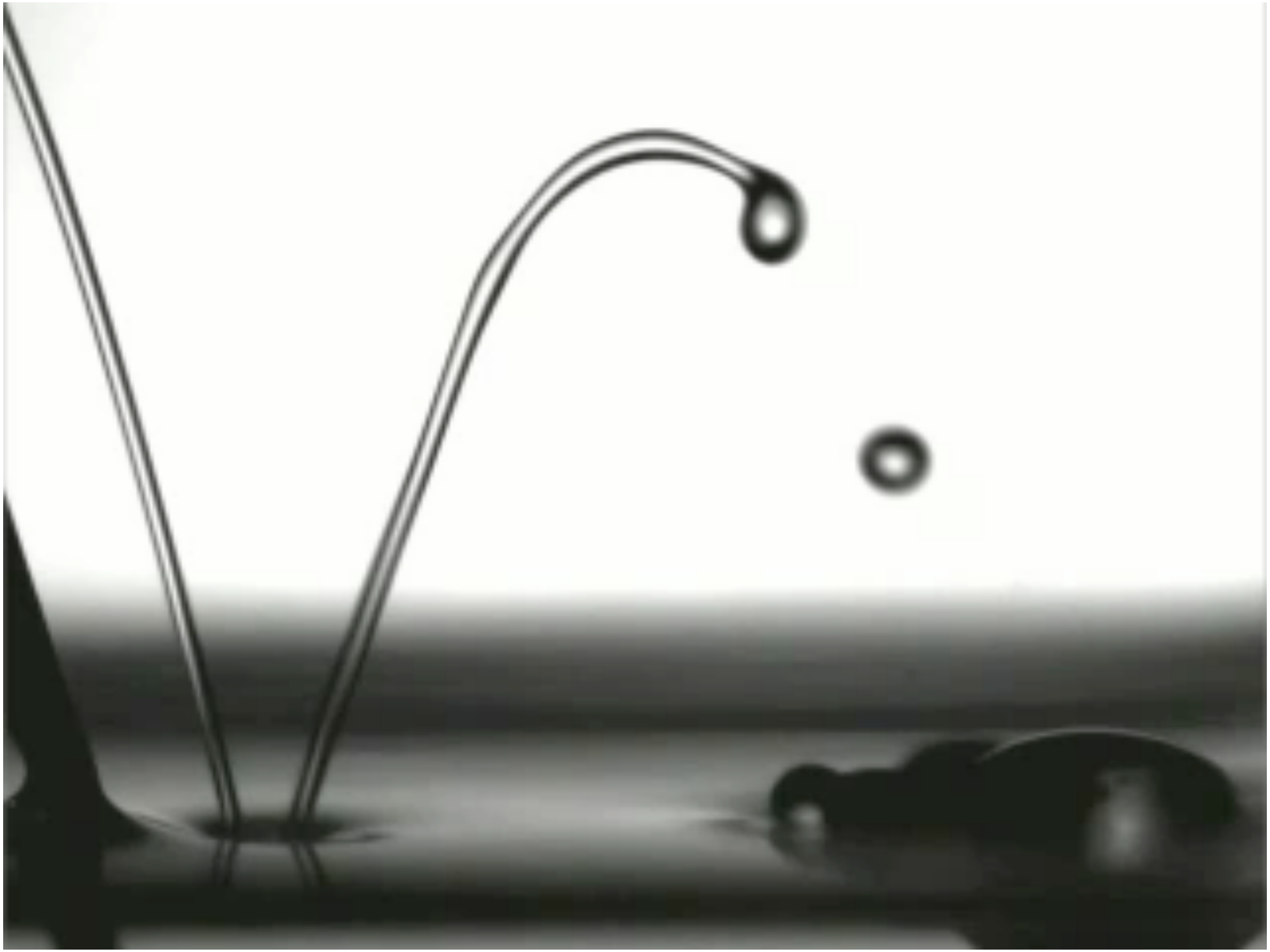
Skipping drops





- drop's skip provided contact time less than time for lubrication layer to drain

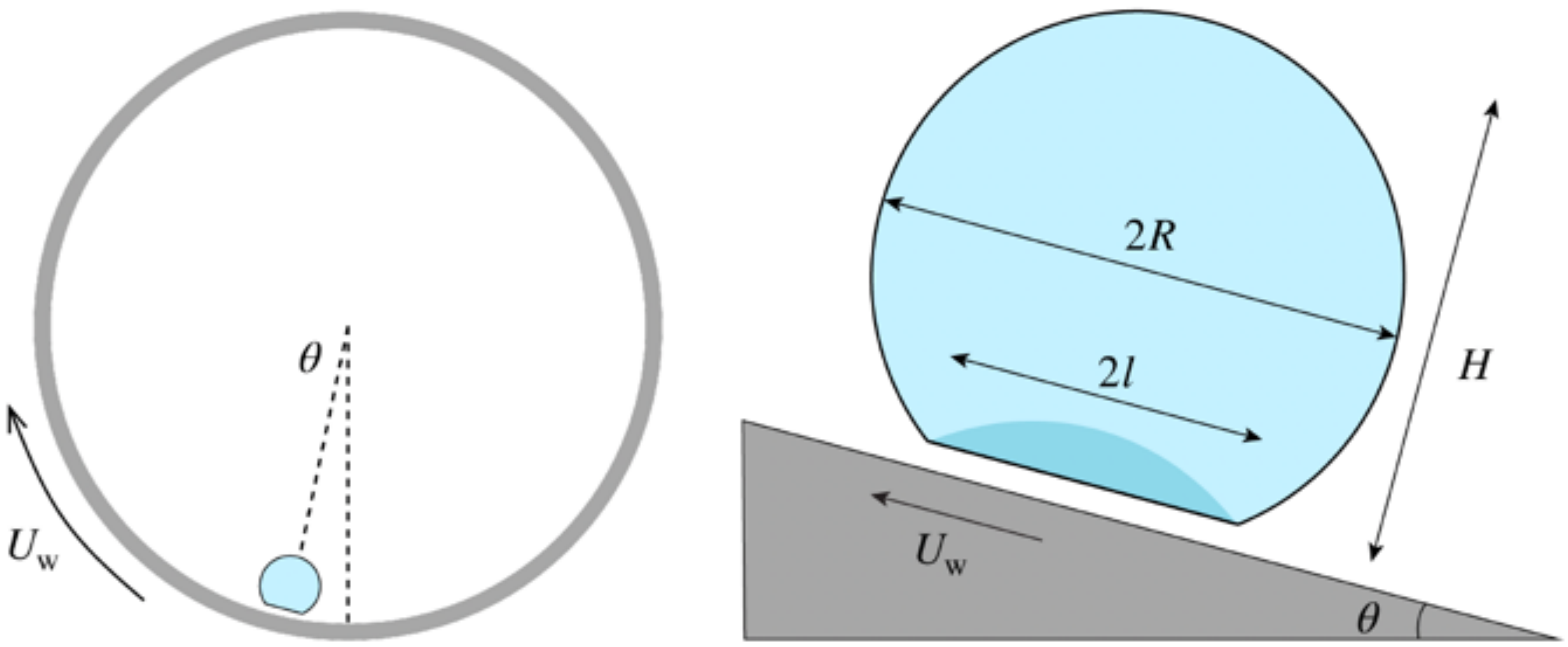
Skipping jet



- jet skips because lubrication layer is dynamically sustained

Drops rolling on a hydrophobic surface

- lubrication layer of air sustained by entrainment on lower boundary

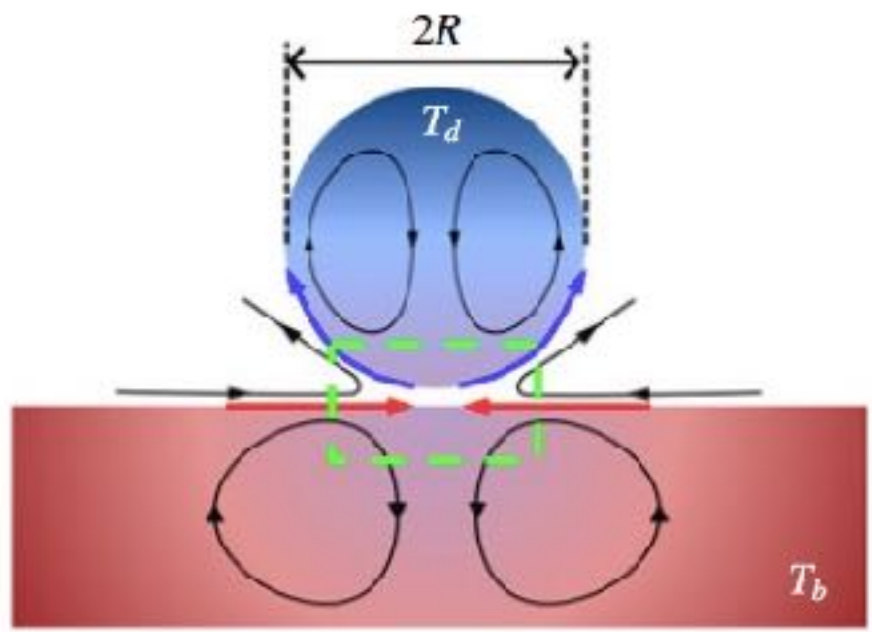


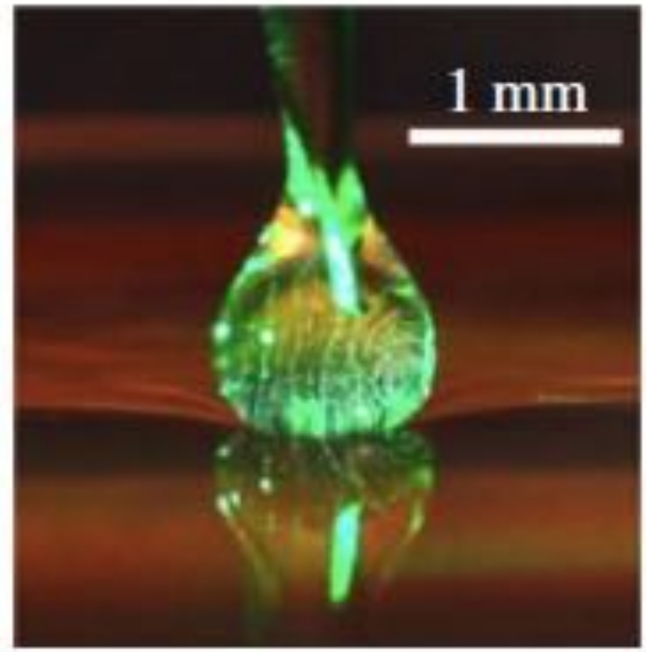
(Gauthier *et al*. 2016)

Thermal resistance to coalescence

Geri et al., JFM (2017)

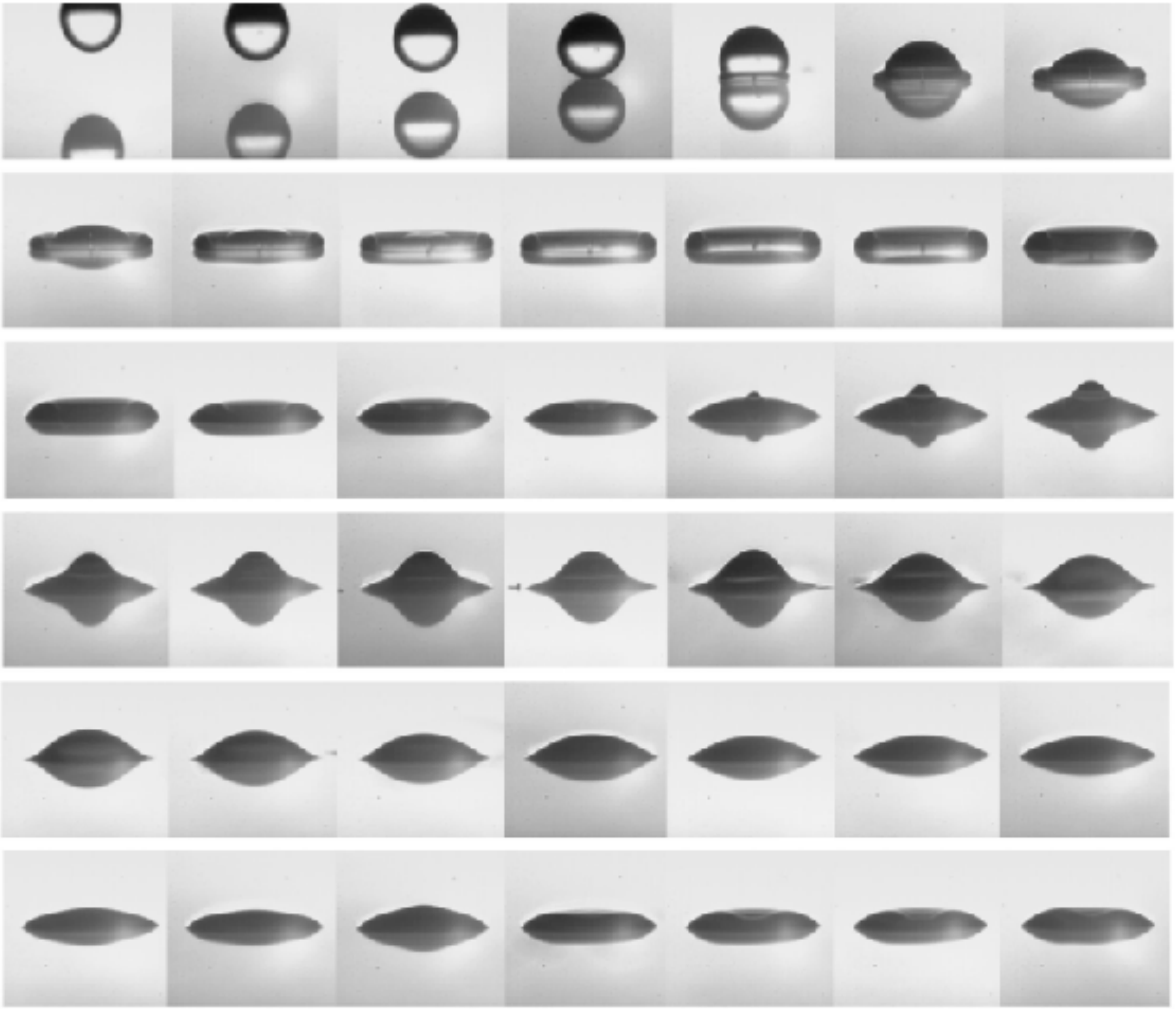
- a milk drop can be suspended on coffee by its temperature difference





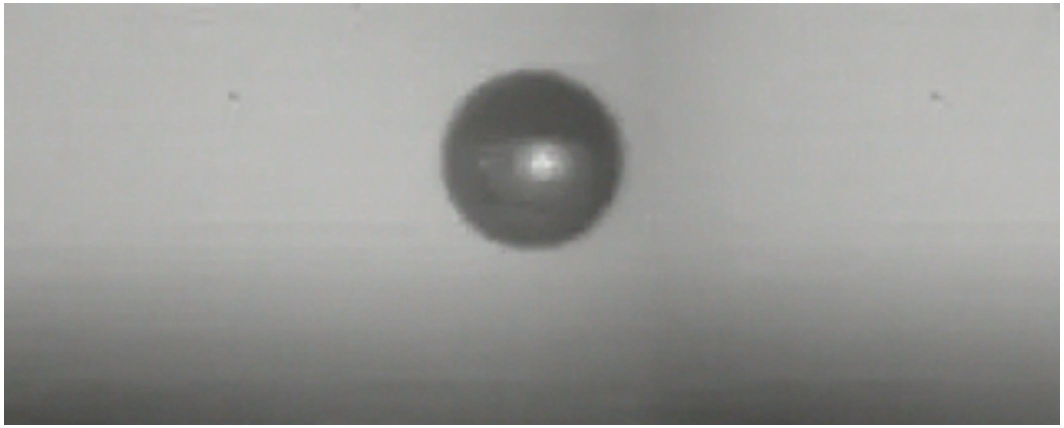
- surface tension decreases with increasing temperature
- Marangoni stresses cause circulation within drop and underlying bath
- Marangoni flows generate lubrication pressures that resist coalescence
- non-coalescence effect independent of sign of temperature difference

Drop impact on a rough surface



Vandam et al. (2004)

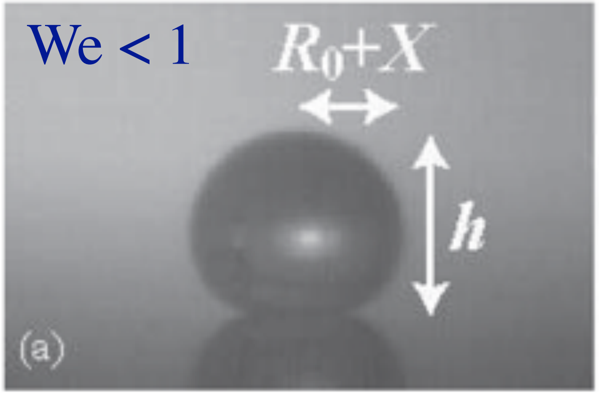
Drop impact on a hydrophobic solid

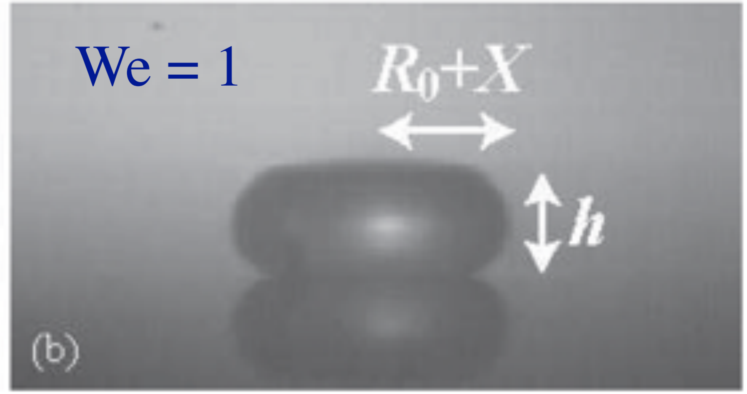


$$W_e = \frac{\rho U^2 a}{\sigma} = \frac{\text{INERTIA}}{\text{CURVATURE}} = \text{Weber number}$$

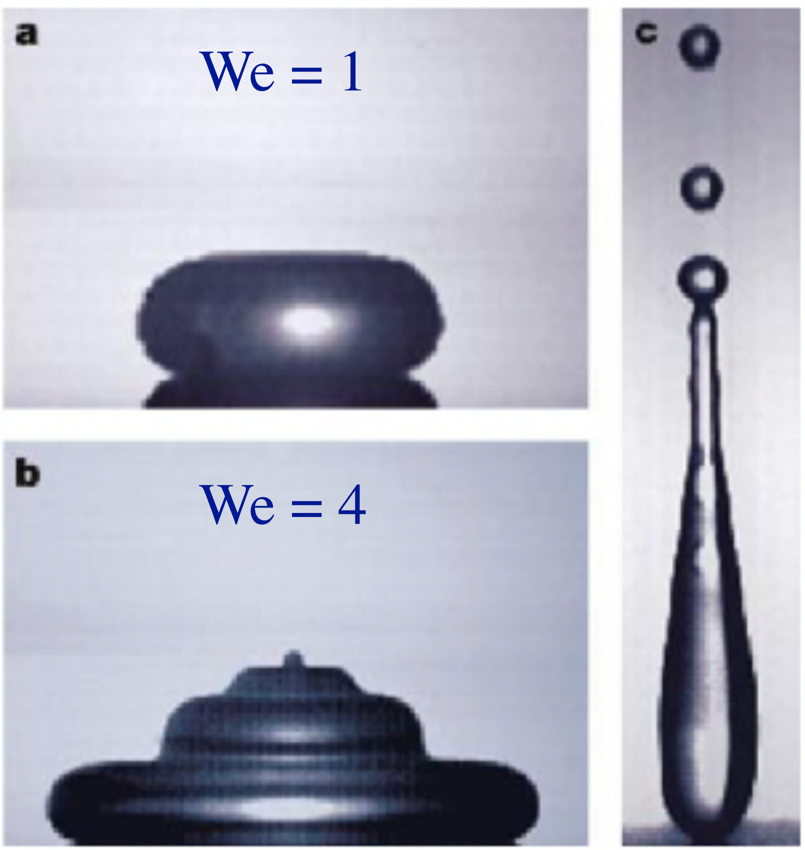
Bouncing drops

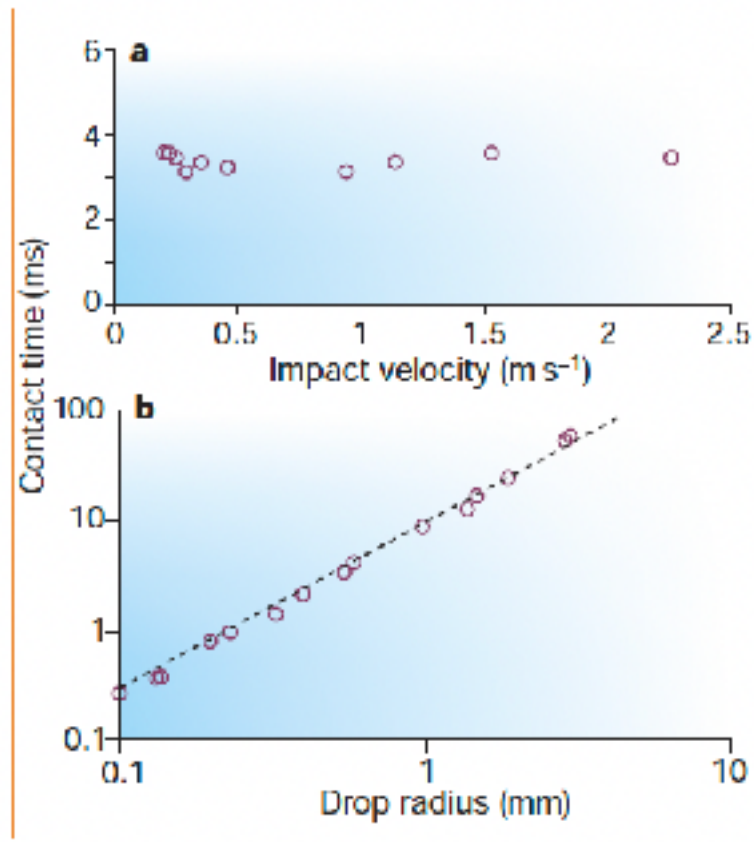
(Richard *et al*. 2002, Okomura *et al*. 2003)



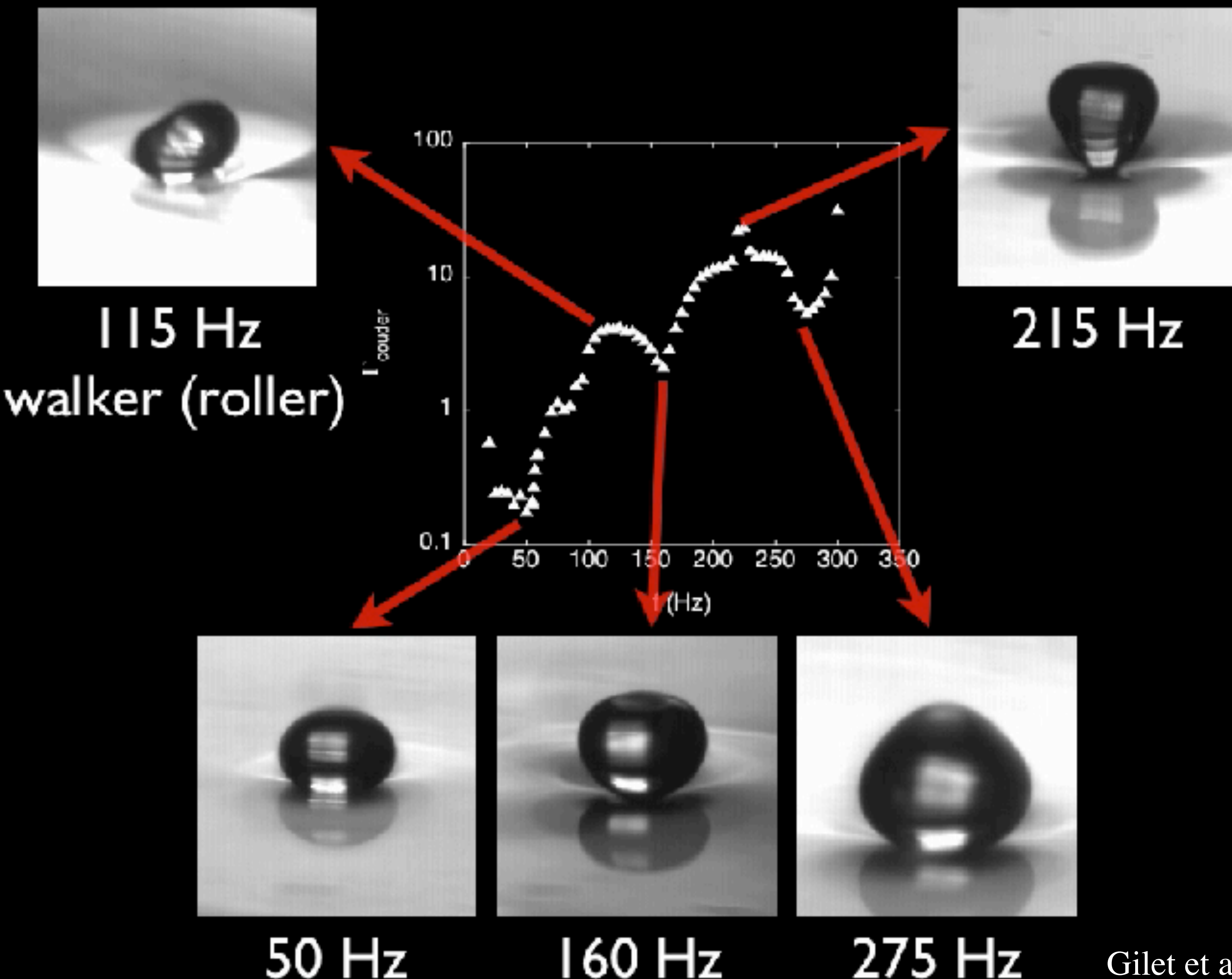


We = 18





Vibrational modes of a low viscosity drop on a viscous bath

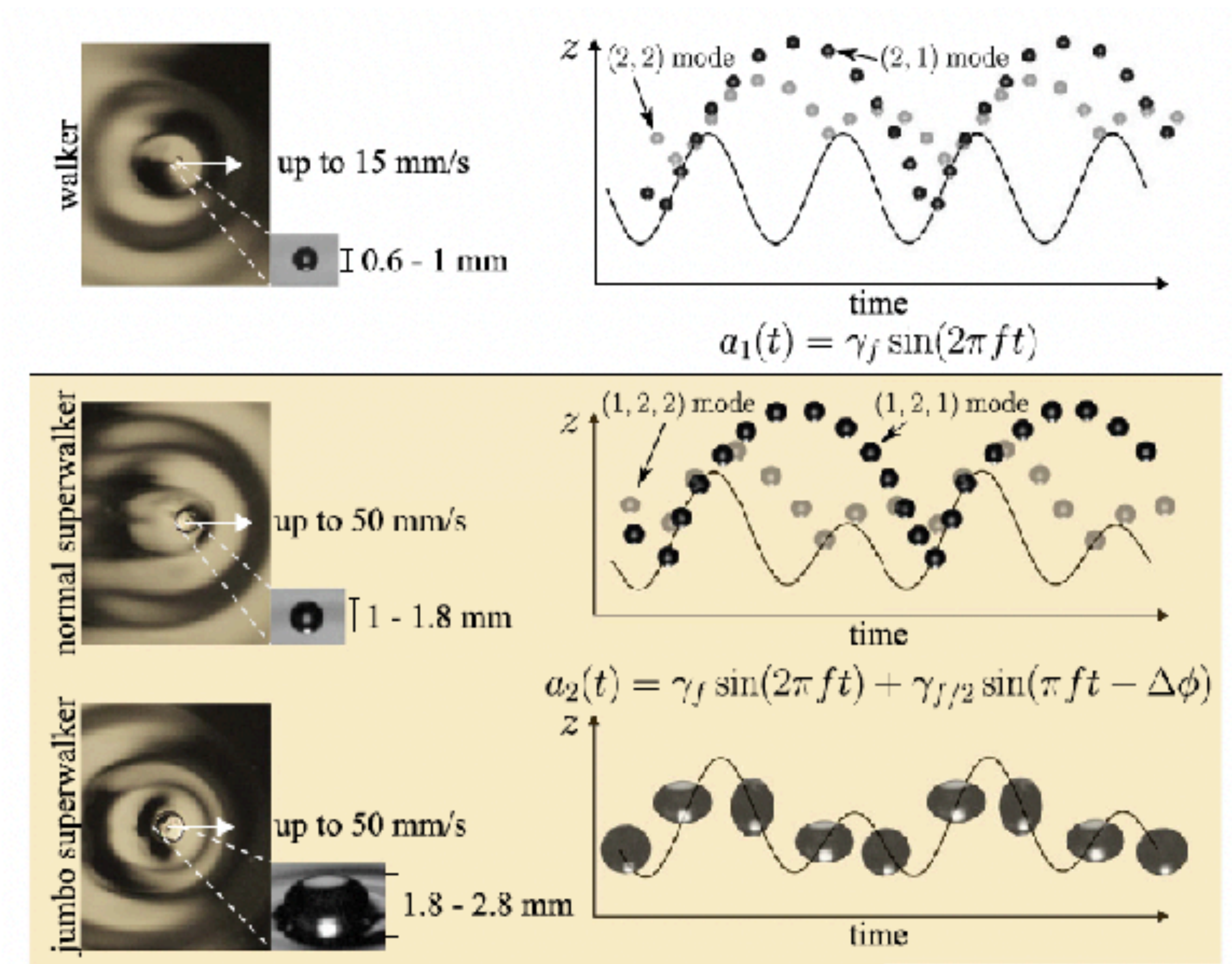


Gilet et al. (2008)

Superwalkers

(Valani, Slim & Simula, PRL, 2019)

- drive bath at two frequencies: $a_2(t) = \gamma_f \sin(2\pi f t) + \gamma_{f/2} \sin(\pi f t + \Delta\phi)$
- enables walking of larger radius (R ~ 1.4mm), higher speed (v ~ 5cm/s) drops



Superwalkers

(Valani, Slim & Simula, PRL, 2019)

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