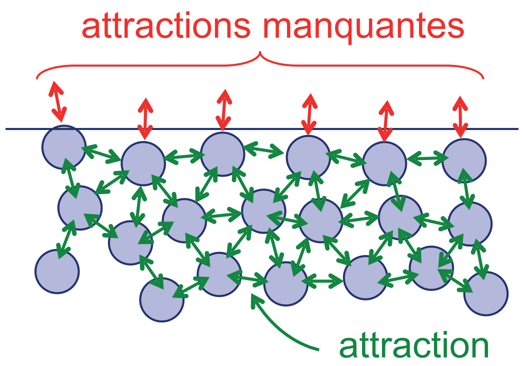
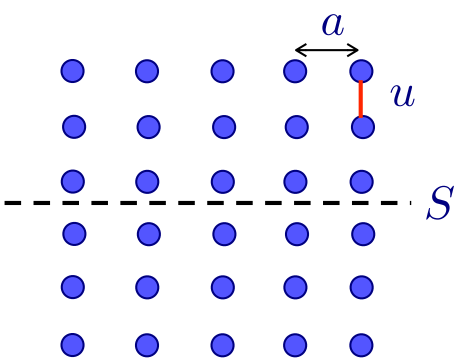
# La tension de surface et la pression capillaire

# Interfaces




$u$ énergie d'interaction entre deux molécules

Coût énergétique pour créer $S$ :

$$U_s \sim \frac{S}{a^2} u = \gamma S$$

$\gamma$ mesure ce défaut d'énergie par unité de surface

$$\gamma \sim \frac{u}{a^2} \sim \frac{kT}{a^2}$$

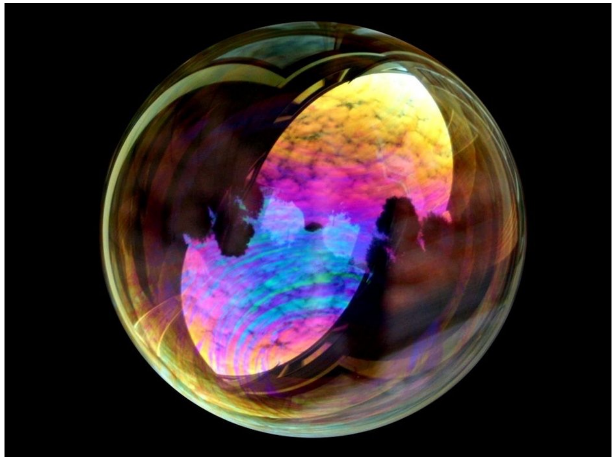
$$\left.\begin{array}{c} u \sim 2-3\,kT \sim 10^{-20}\,\mathrm{J} \\ a \sim 0.3\,\mathrm{nm} \end{array}\right\} \quad \gamma \sim 100\,\mathrm{mJ/m^2} \quad \text{ou } \mathrm{mN/m}$$

$$\gamma_{eau} = 72\ \mathrm{mN/m}$$

$$\gamma_{huile} \simeq 20\ \mathrm{mN/m}$$

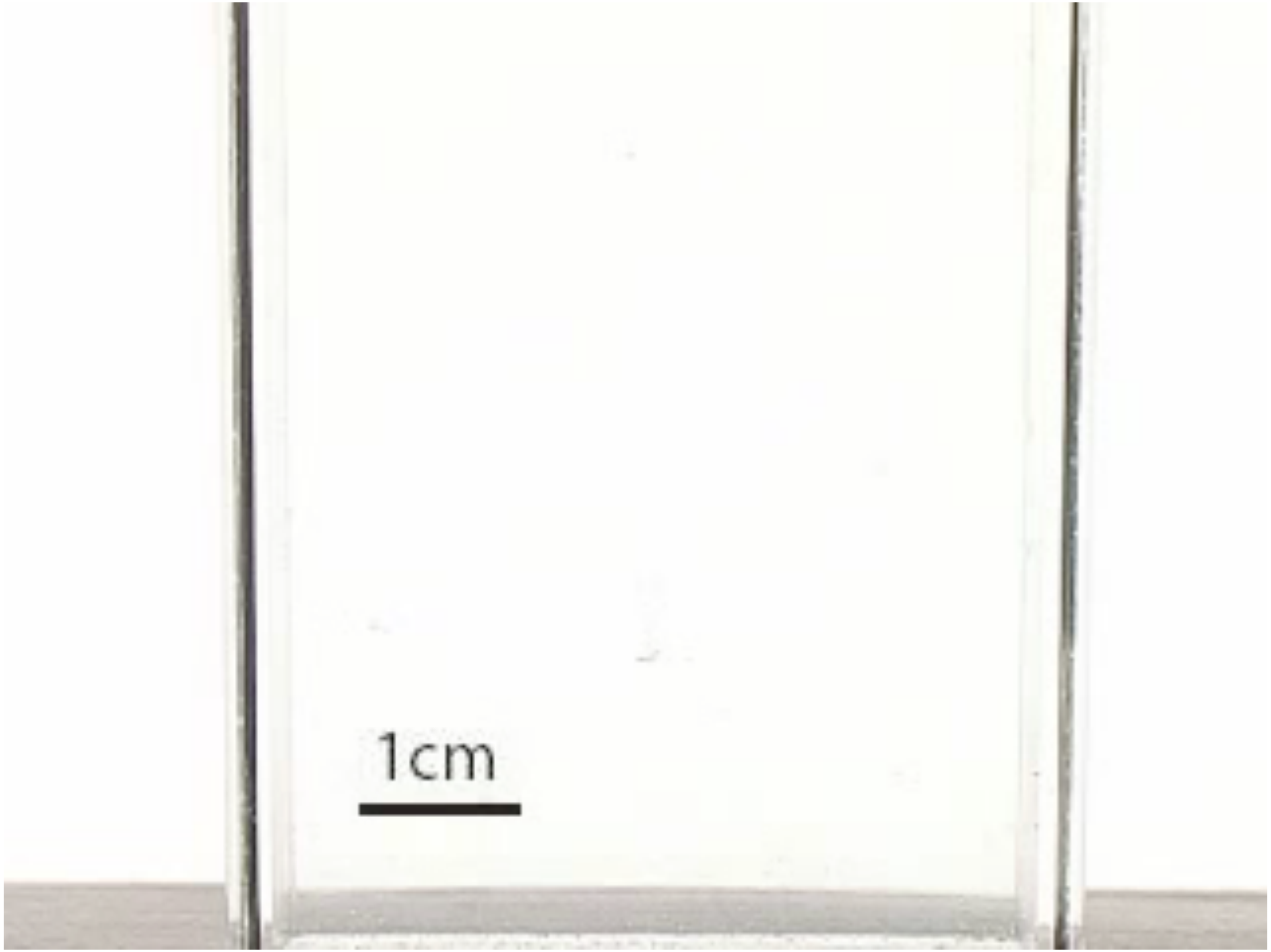
$$U_S = \gamma S$$

La sphère est l'objet qui minimise
sa surface à volume fixé

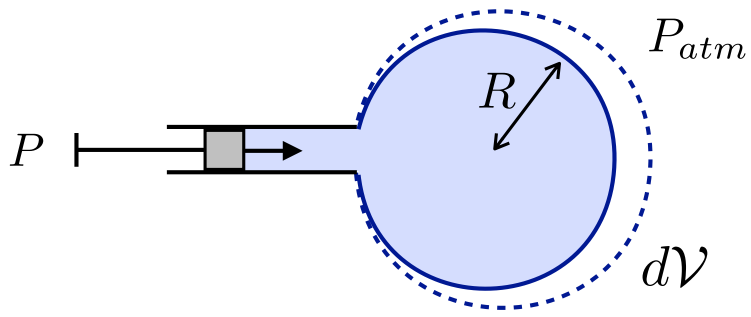


*Hergé "On a marché sur la lune"*

*Scott Kelly www.nasa.gov/station*


1cm

# Une goutte gonflée




On applique une surpression $P$ par rapport à $P_{atm}$

$$dW_{piston} = P\,d\mathcal{V}$$

$$dW_{atm} = -P_{atm}\,d\mathcal{V}$$

Travail reçu par la goutte :

$$dW = dW_{piston} + dW_{atm} = (P - P_{atm})\,d\mathcal{V}$$

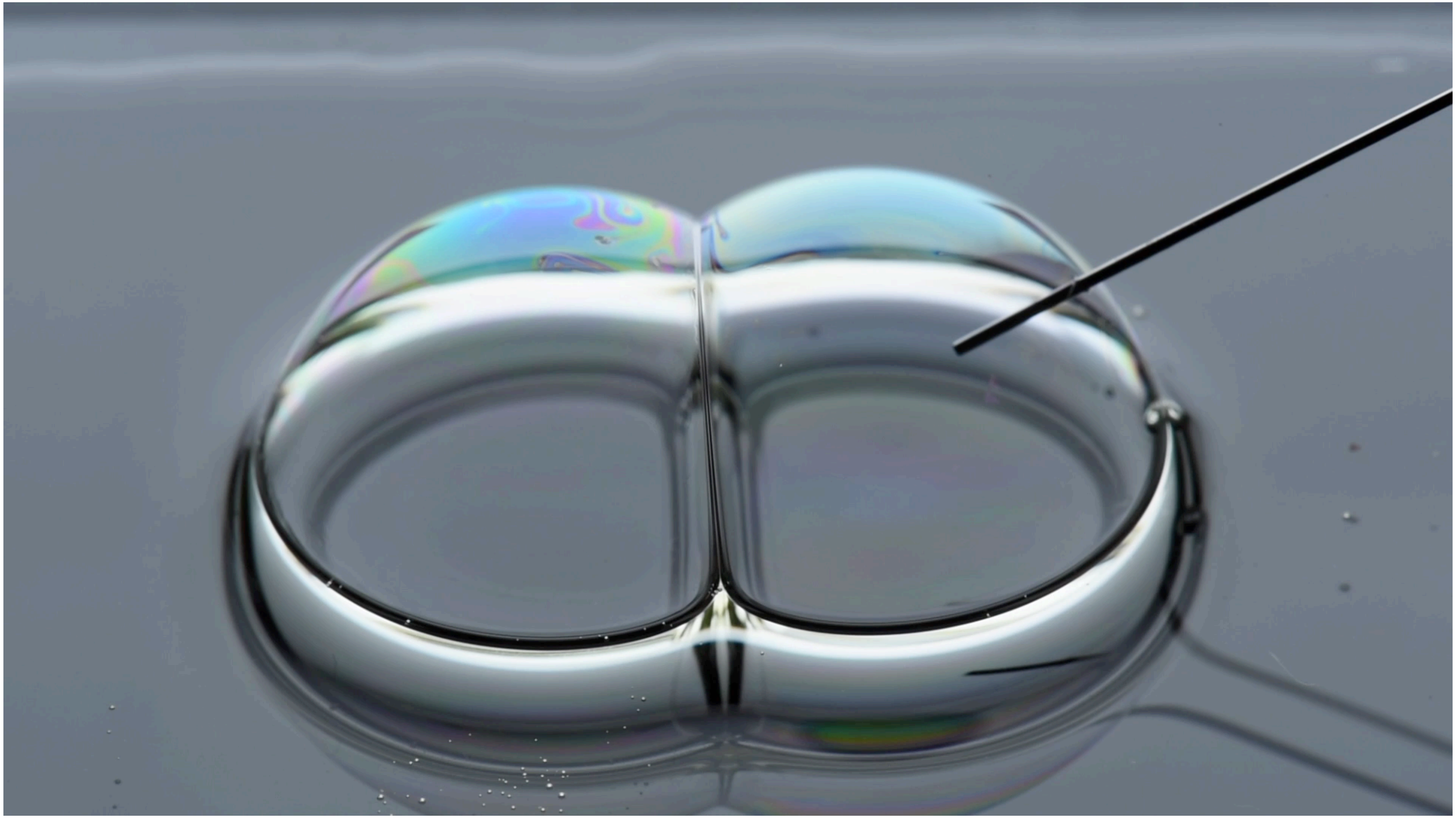
$$d\mathcal{V} = d(\frac{4}{3}\pi R^3) = 4\pi R^2\,dR$$

$$dU_s = d(4\pi R^2\gamma) = 8\pi R\gamma\,dR$$

$$dU = dU_s = dW$$

$$(P - P_{atm})\,4\pi R^2\,dR = 8\pi R\gamma\,dR$$

$$\boxed{P - P_{atm} = \frac{2\gamma}{R}}$$



$$P_{in} - P_{atm} = \frac{4\gamma}{R}$$

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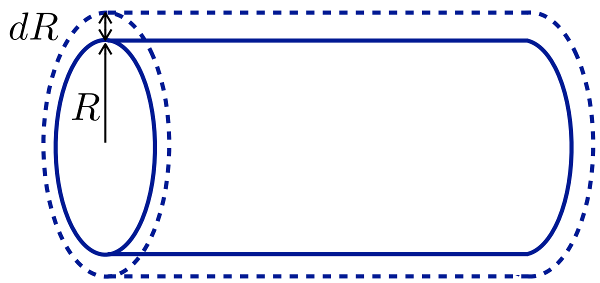



$$U_s = \gamma \, 2\pi H \, dR$$

$$d\mathcal{V} = 2\pi R H \, dR$$

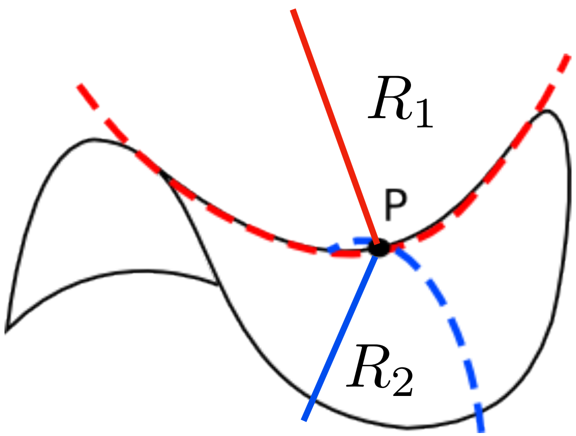
$$(P - P_{atm}) \, 2\pi R H \, dR = 2\pi H \gamma \, dR$$

$$\boxed{P - P_{atm} = \frac{\gamma}{R}}$$

Dans le cas général :

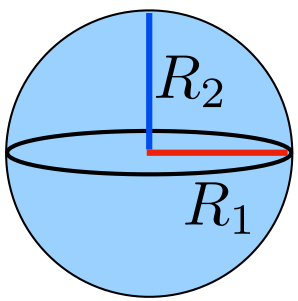
$$\boxed{\Delta P = \gamma\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \gamma \mathcal{C}}$$

Saut de pression de Laplace

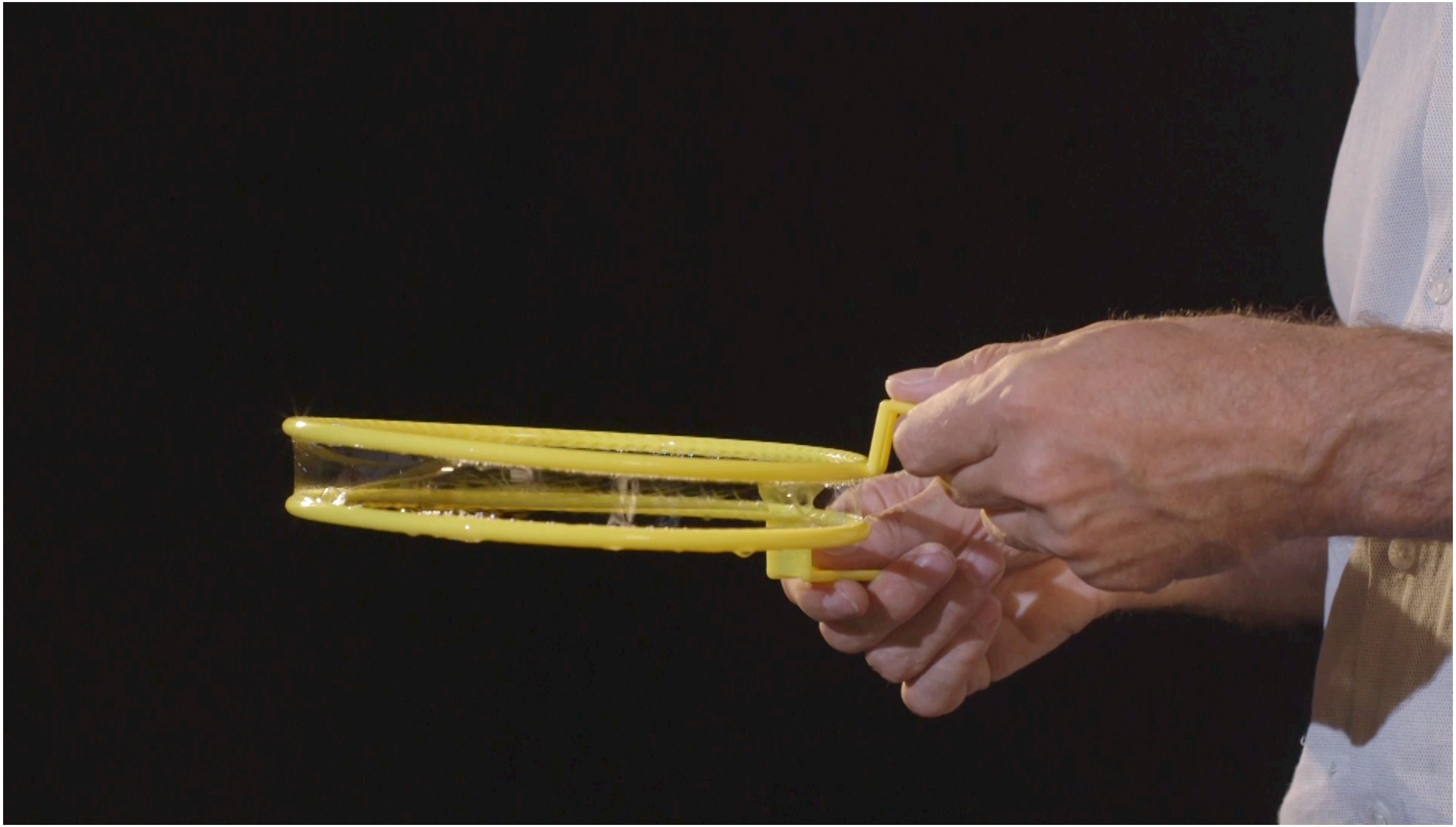


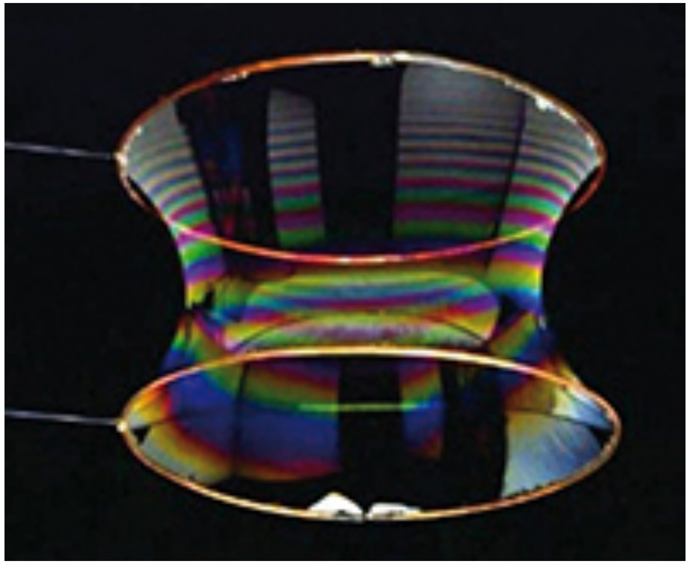

$R_1 > 0$

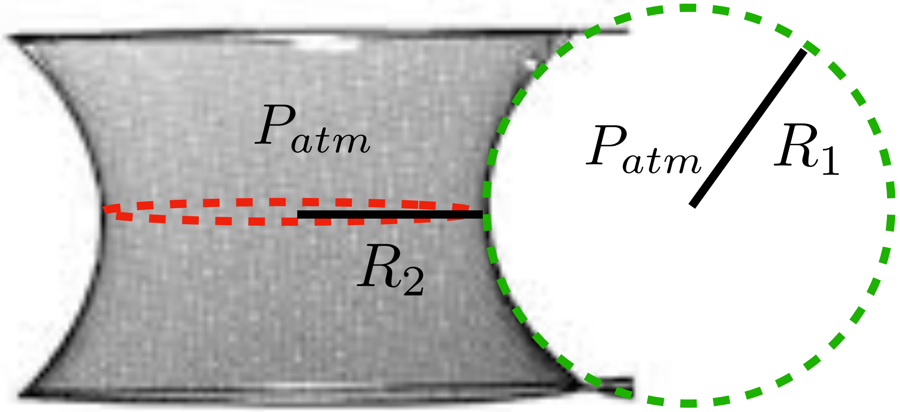
$R_2 < 0$



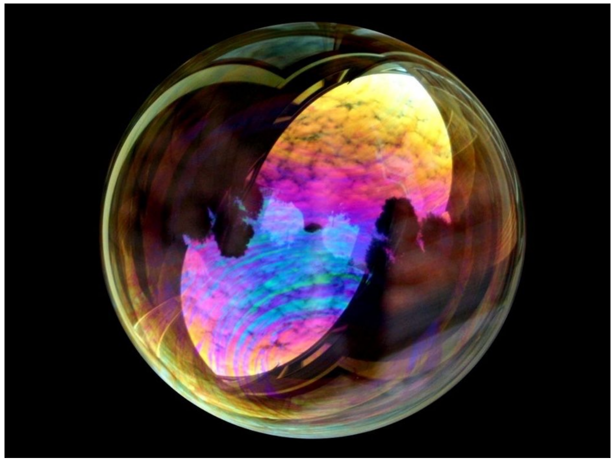

$R_1 = R_2 = R$

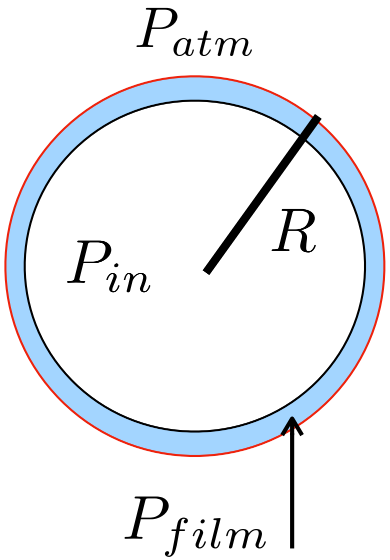







$$R_1 = -R_2$$



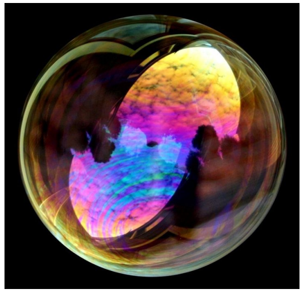



$$P_{film} - P_{atm} = \frac{2\gamma}{R}$$

$$P_{in} - P_{film} = \frac{2\gamma}{R}$$

$$\boxed{P_{in} - P_{atm} = \frac{4\gamma}{R}}$$

## Pression de Laplace : quelques ordres de grandeur…

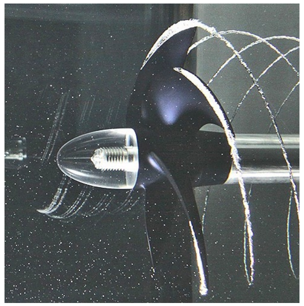


Bulles de savon : $R \sim 5$ cm, $\gamma \sim 35$ mN/m

$\Delta P \sim 3$ Pa $\sim 3.10^{-5}$ atm

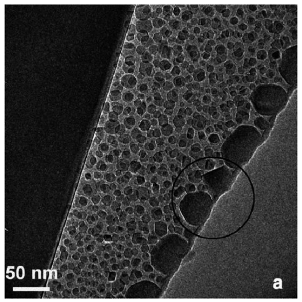
Bulles de champagne : $R \sim 0.1$ mm, $\gamma \sim 50$ mN/m

$\Delta P \sim 1000$ Pa $\sim 10^{-2}$ atm



Bulles de cavitation : $R \sim 0.5$ µm, $\gamma \sim 50$ mN/m

$\Delta P \sim 10^{5}$ Pa $\sim 1$ atm

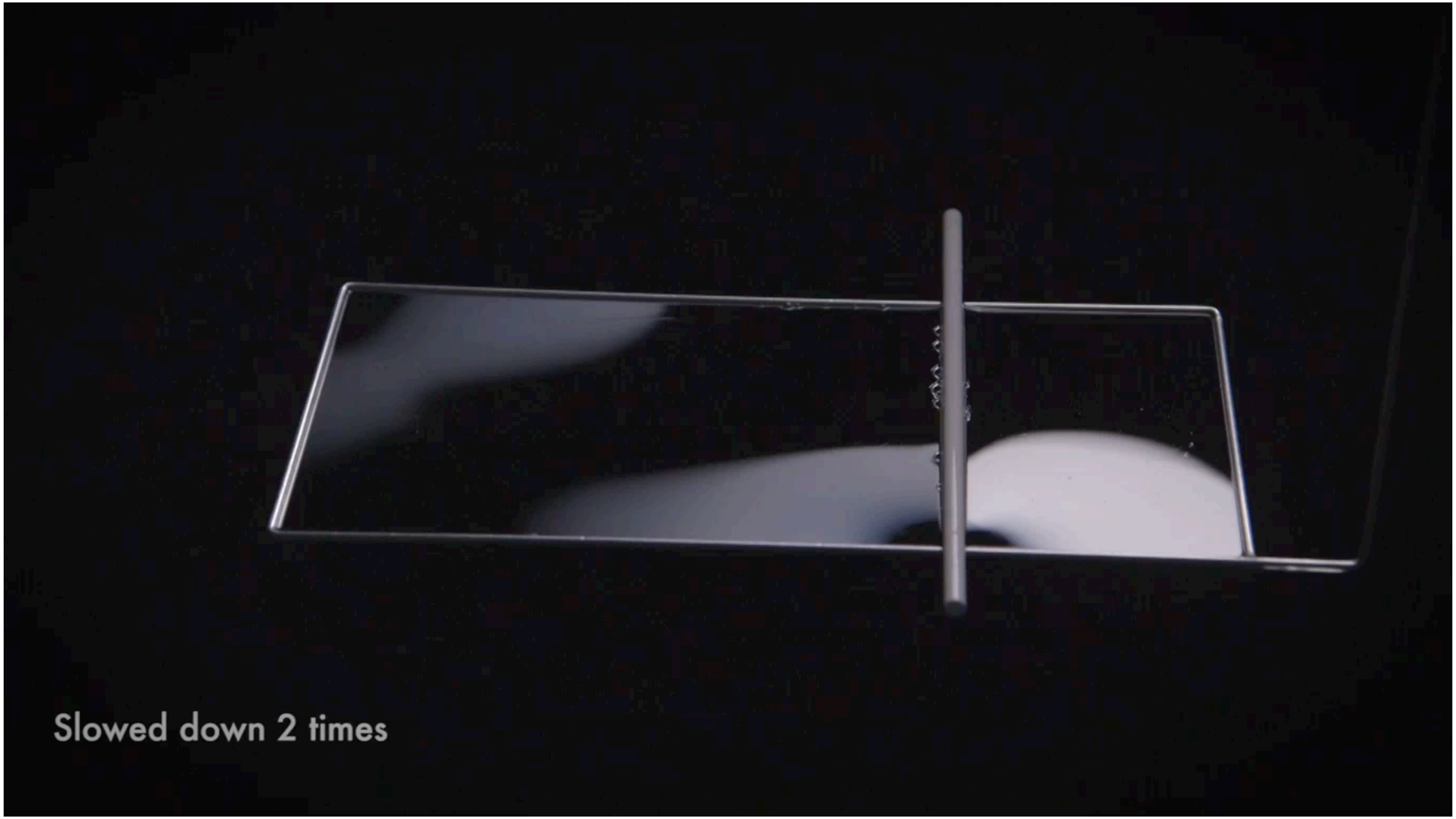



Bulles d'hélium (métal irradié): $R \sim 10$ nm, $\gamma \sim 10^{3}$ mN/m

$\Delta P \sim 2.10^{8}$ Pa $\sim 2000$ atm

*Glam et al., J. Nuclear Mat. (2009)*

# 1.2 Surfaces sous tension

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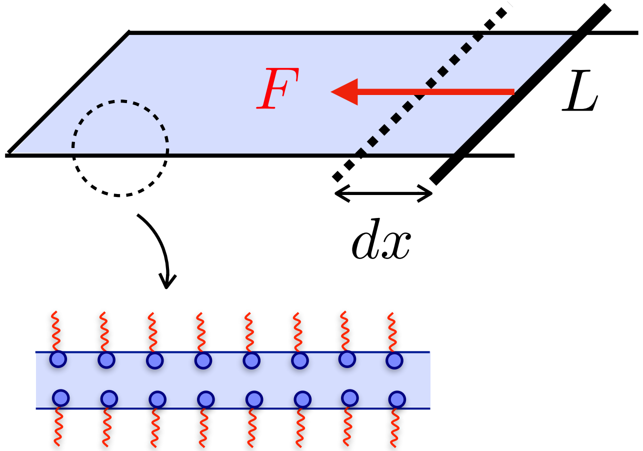


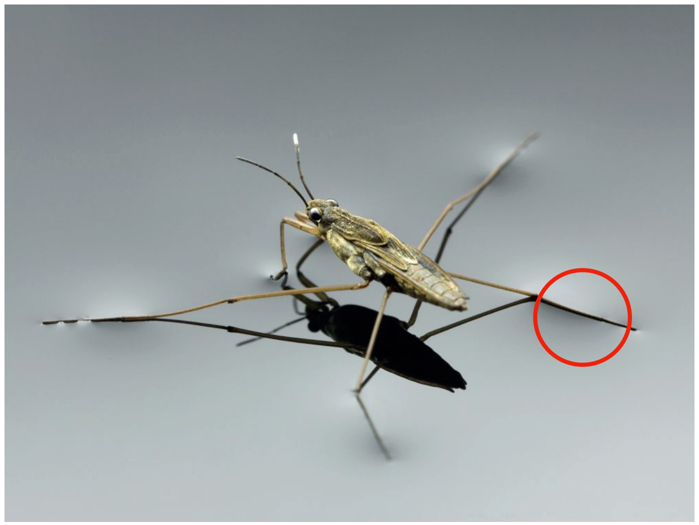

$$dU_s = 2\gamma\, L\; dx \;\; = dW = F dx$$

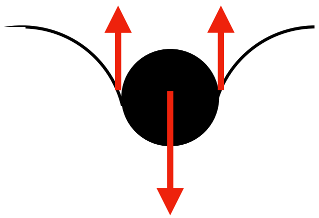
$$\boxed{F = 2\gamma L}$$

$\gamma$ est bien une force par unité de longueur!

$$F = \gamma\; p$$

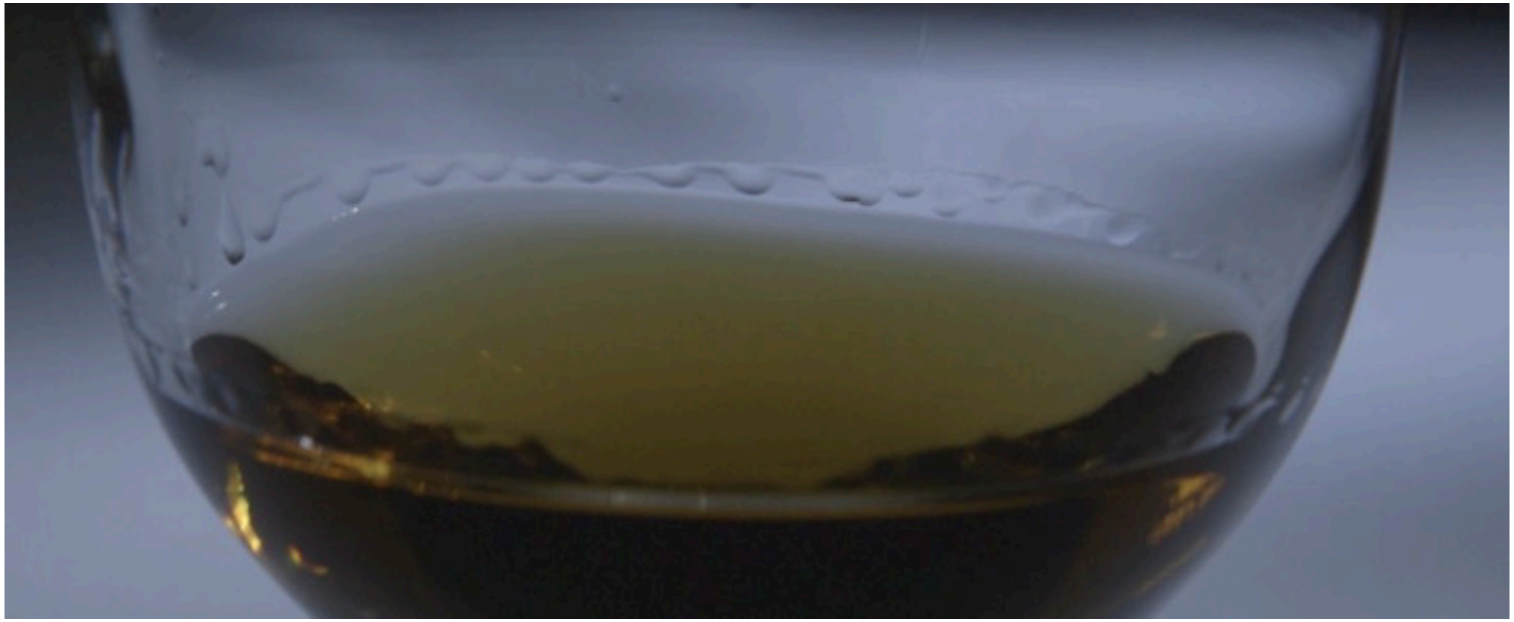
$p$ le périmètre



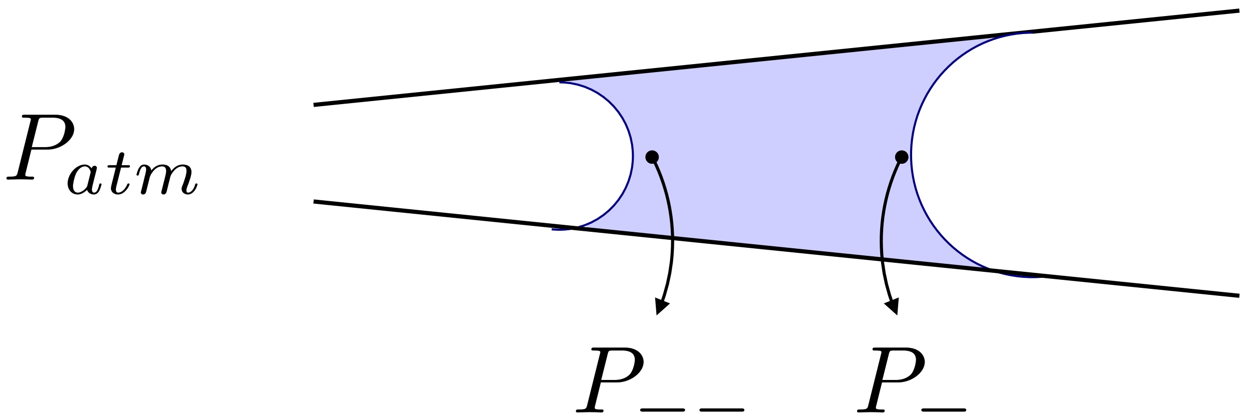


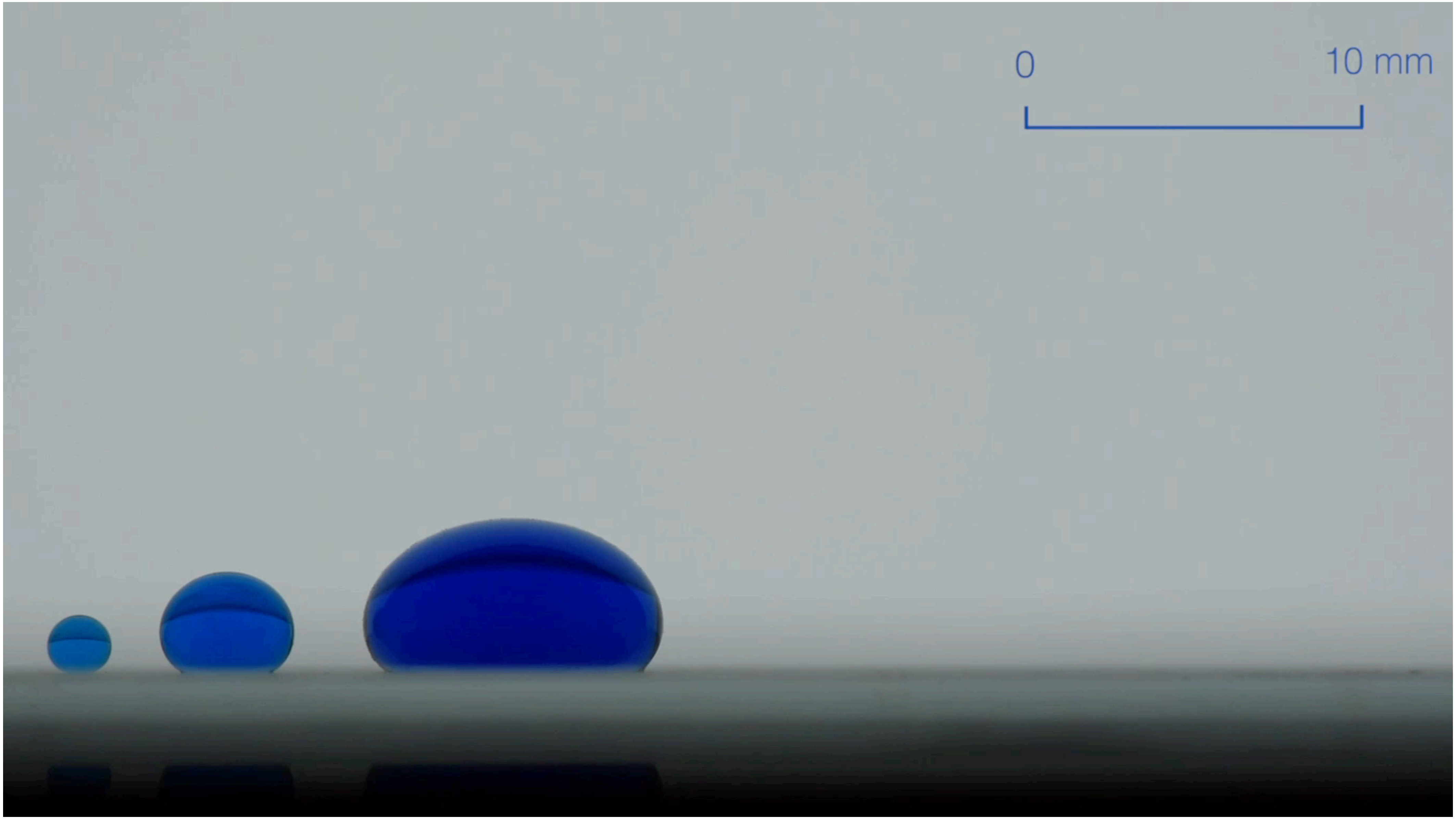
$$M_{max}\; g \sim 8\; L\; \gamma$$

# Larmes de vin : gradient de tension de surface



Attention au raisonnement en forces!



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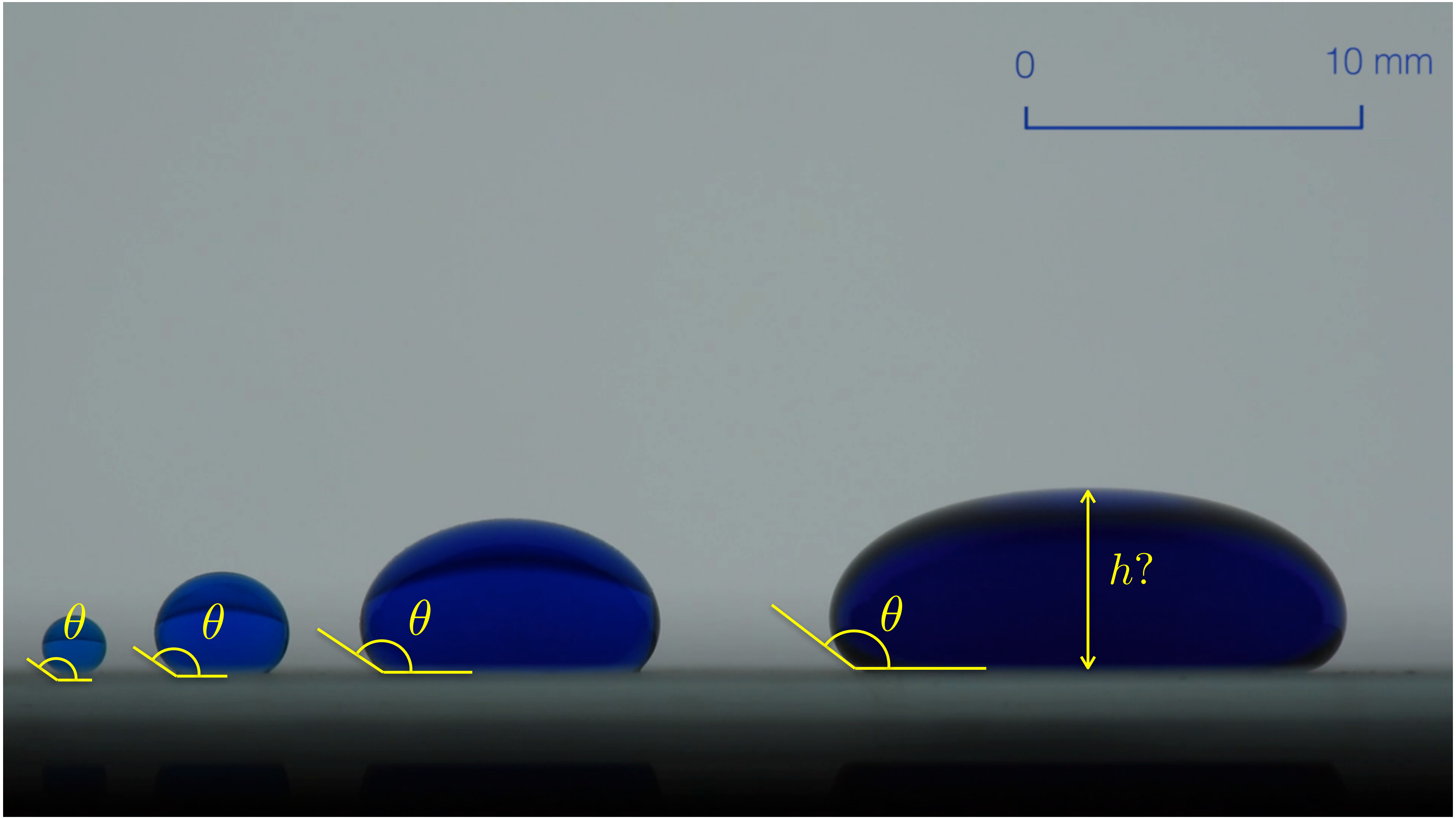


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