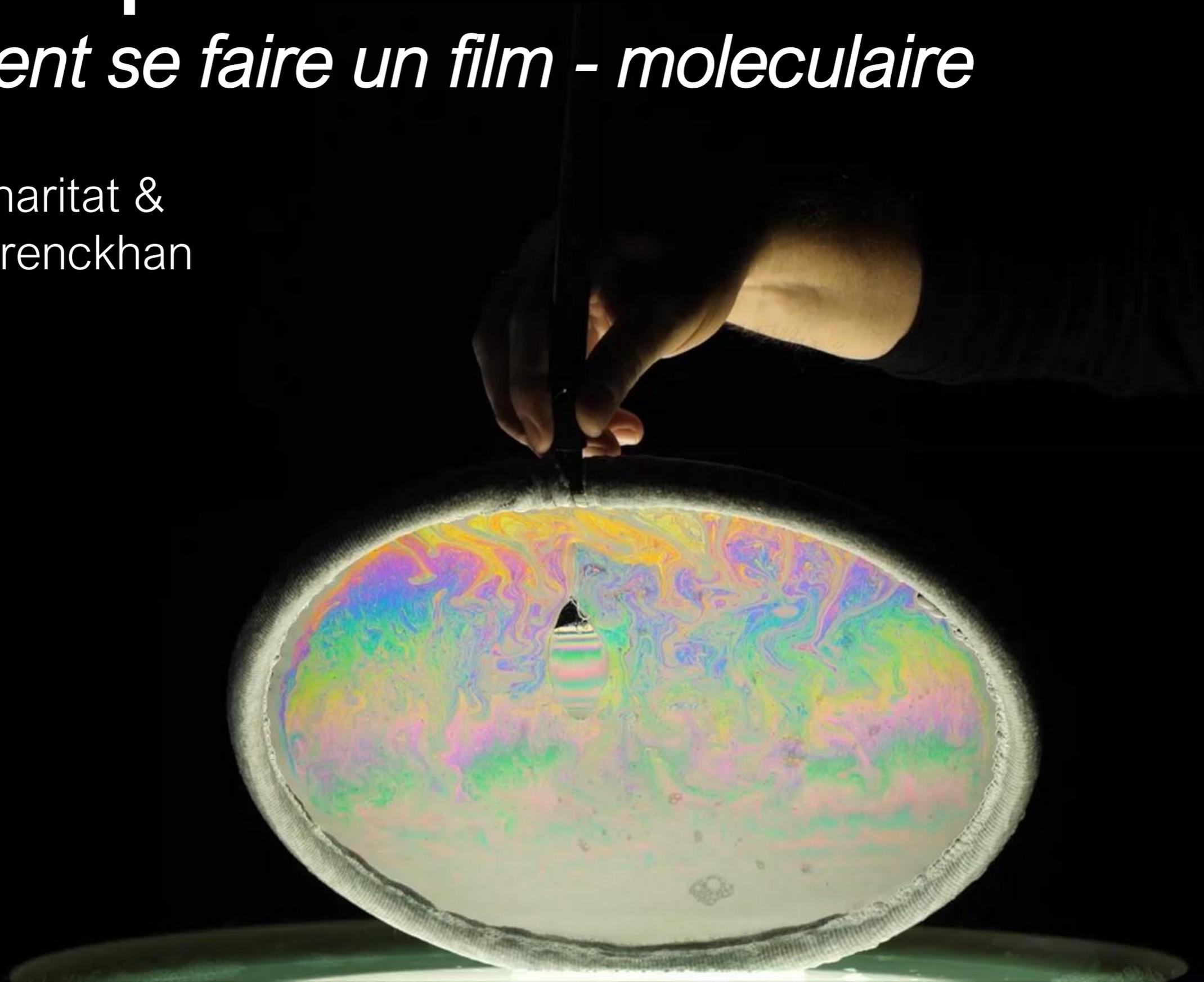


Bulles pour les nuls II :

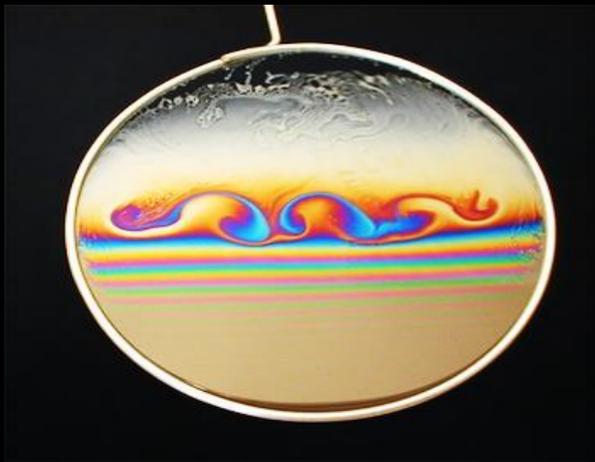
Comment se faire un film - moléculaire

Thierry Charitat &
Wiebke Drenckhan

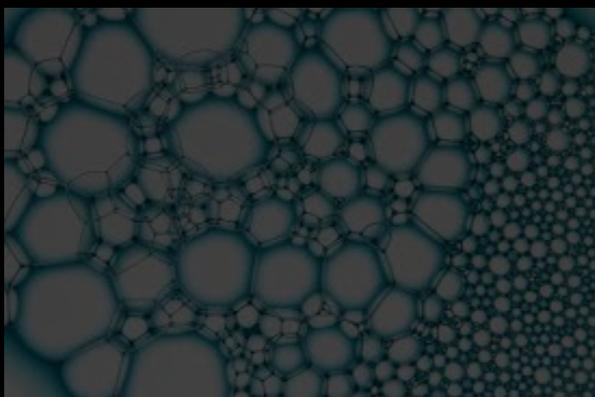




Mardi 30/05
Marcher sur l'eau



Mardi 07/06
Comment se faire un film... moléculaire



Mardi 14/06
**Et pour finir ...
une petite mousse**



Thierry CHARITAT
Professeur de Physique
à l'Université de
Strasbourg
Institut Charles Sadron



**Wiebke
DRENCKHAN**
Directrice de
Recherche en physique
au CNRS
Institut Charles Sadron



Ce que l'on a appris la semaine dernière

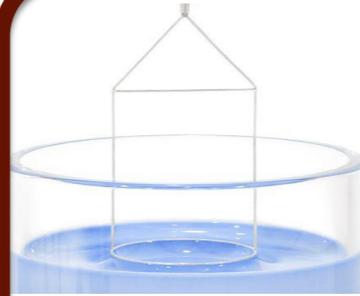
gaz

liquide

Chaque interface à une
“**tension interfaciale γ** ”

→ énergie interfaciale
 E , proportionnelle à
l'aire A de l'interface

$$E = \gamma A$$



La **tension interfaciale**
peut être mesurée
(en N/m)

Les effets capillaires



La **tension interfaciale** a
des conséquences très
importantes dans notre
vie quotidienne

Comment faire couler un bateau capillaire ?

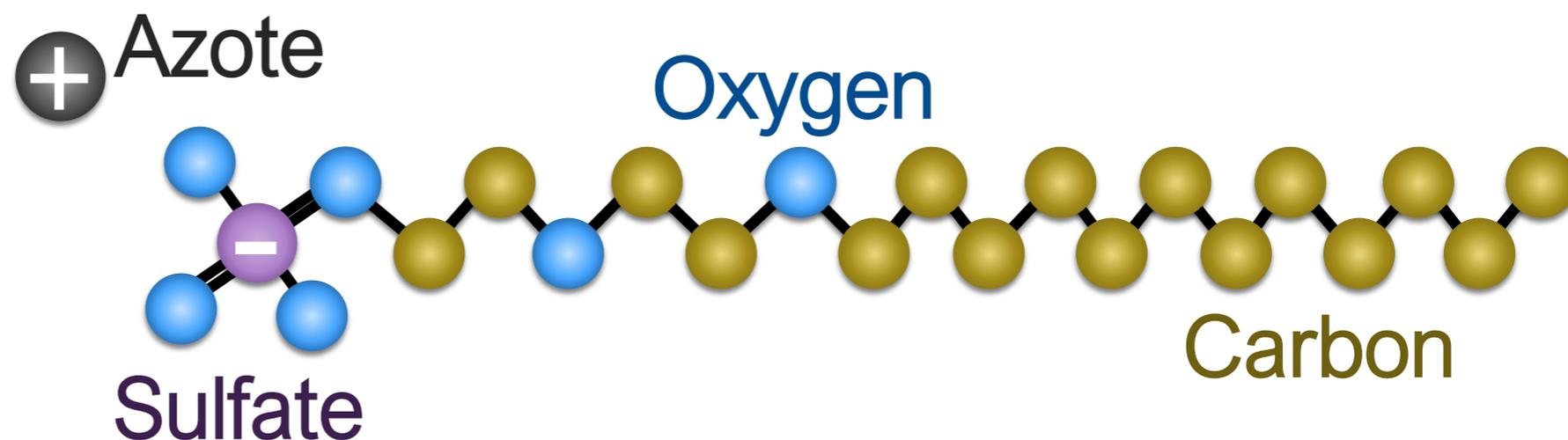


Les tensioactifs

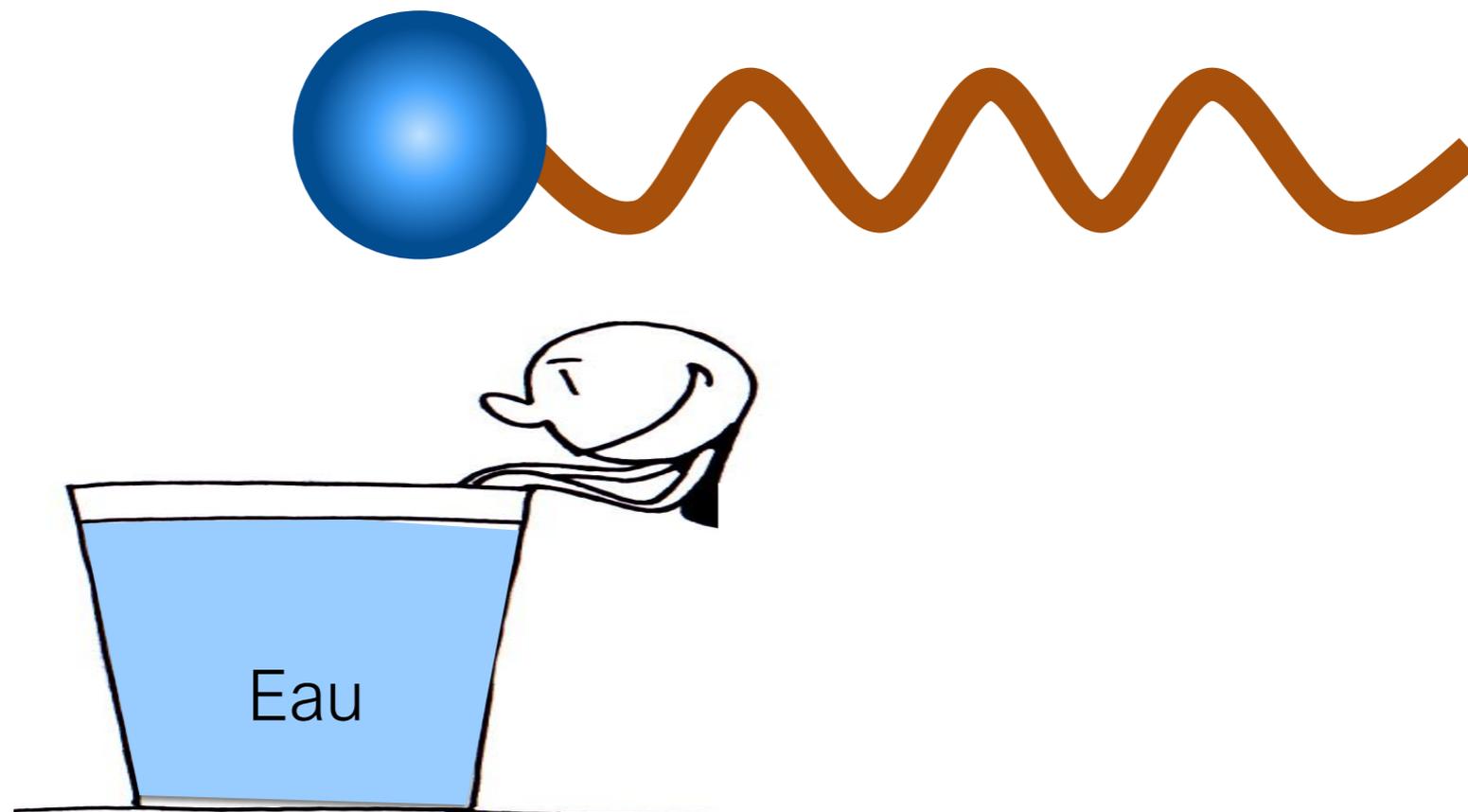
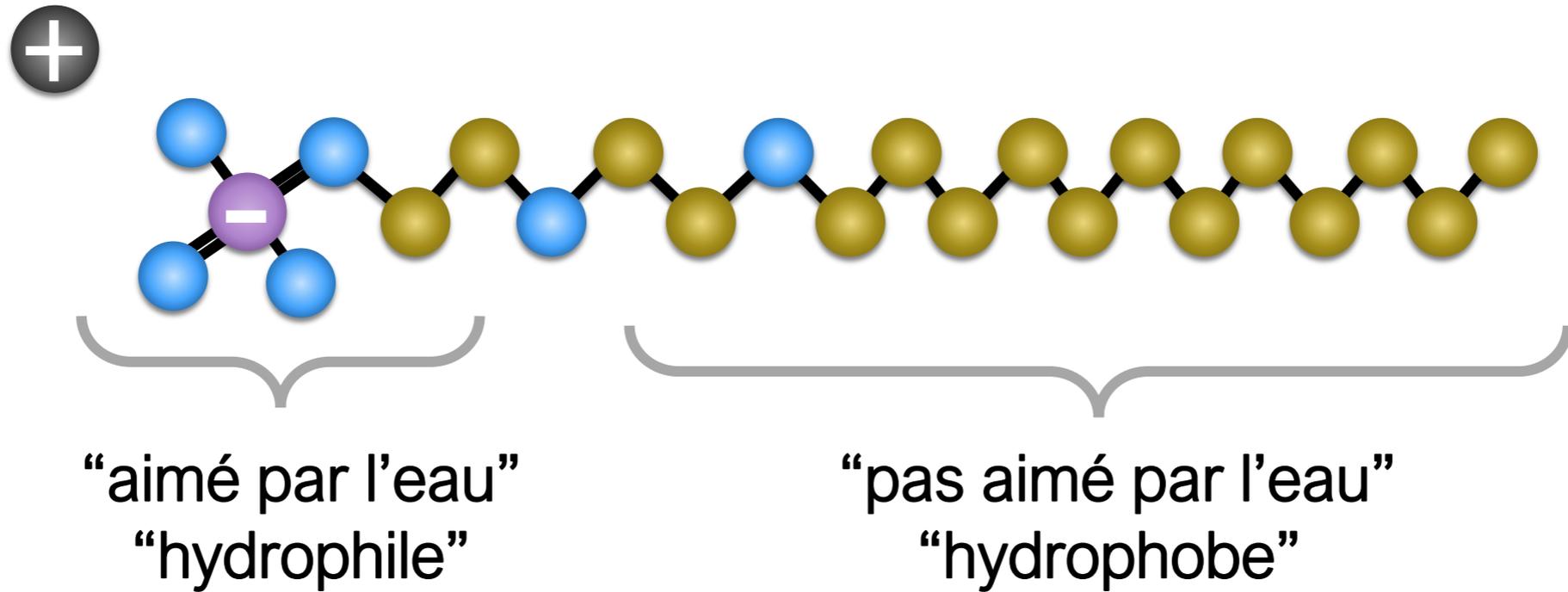


Sodium C12-C14 Ethoxylated Alcohol EO 2-3/1 sulfate

Sodium Laureth Sulfate (SLES)



Les tensioactifs

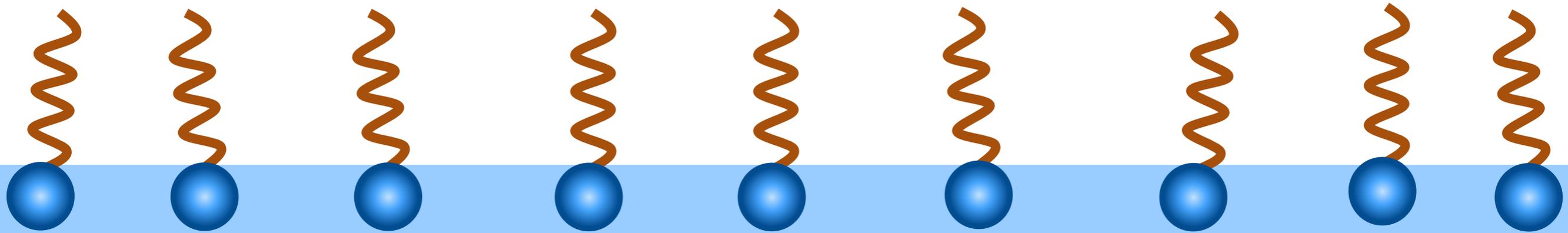


Des molécules schizophrènes : amphiphile

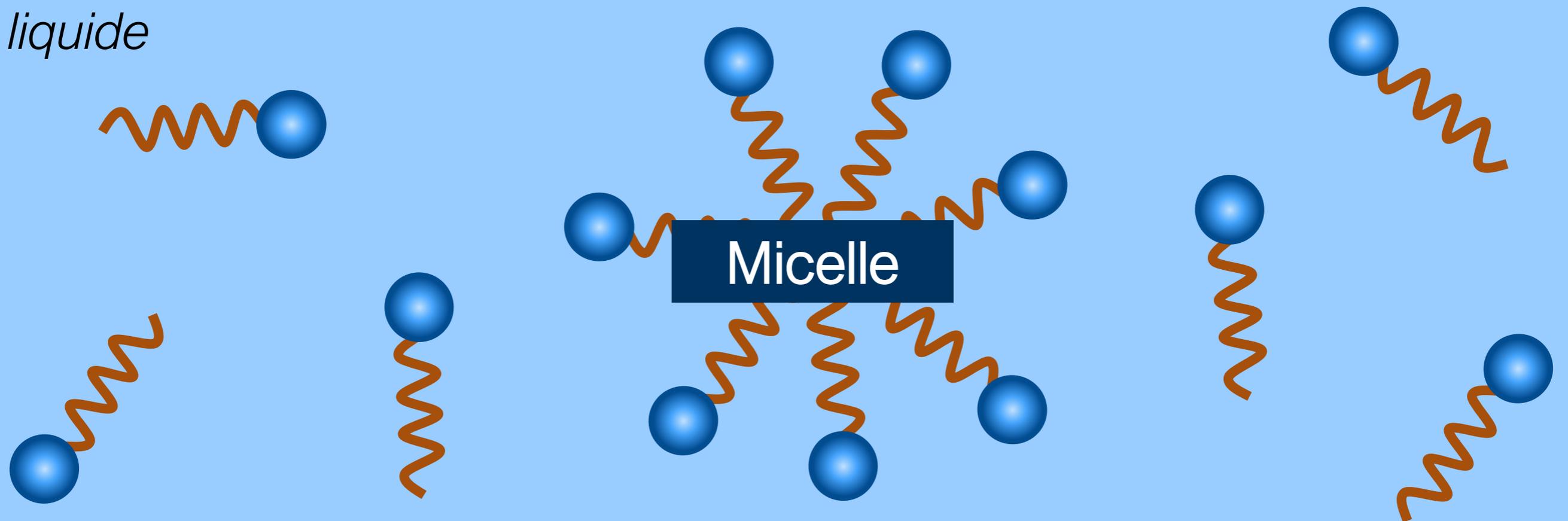
Les tensioactifs dans l'eau

gaz

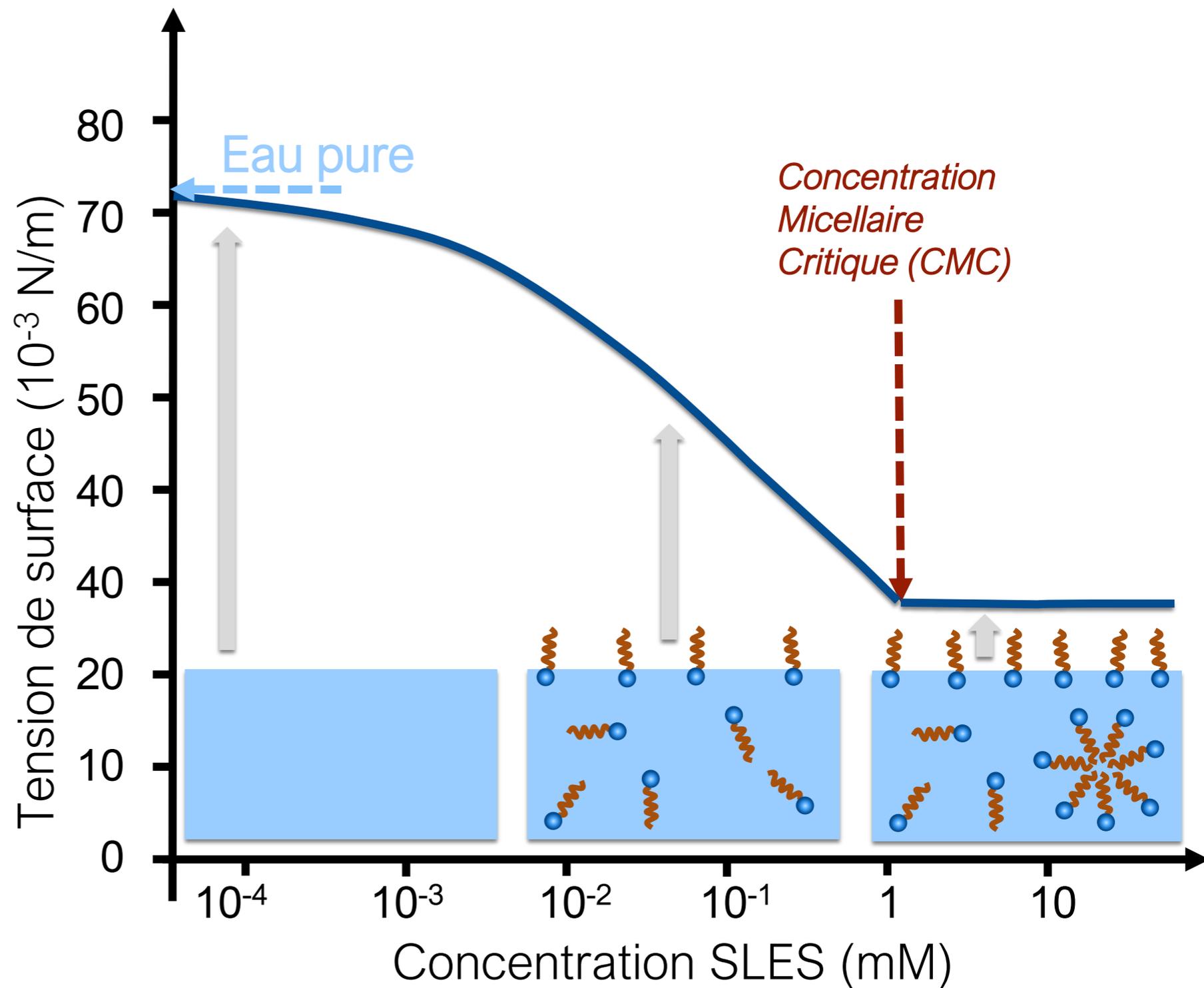
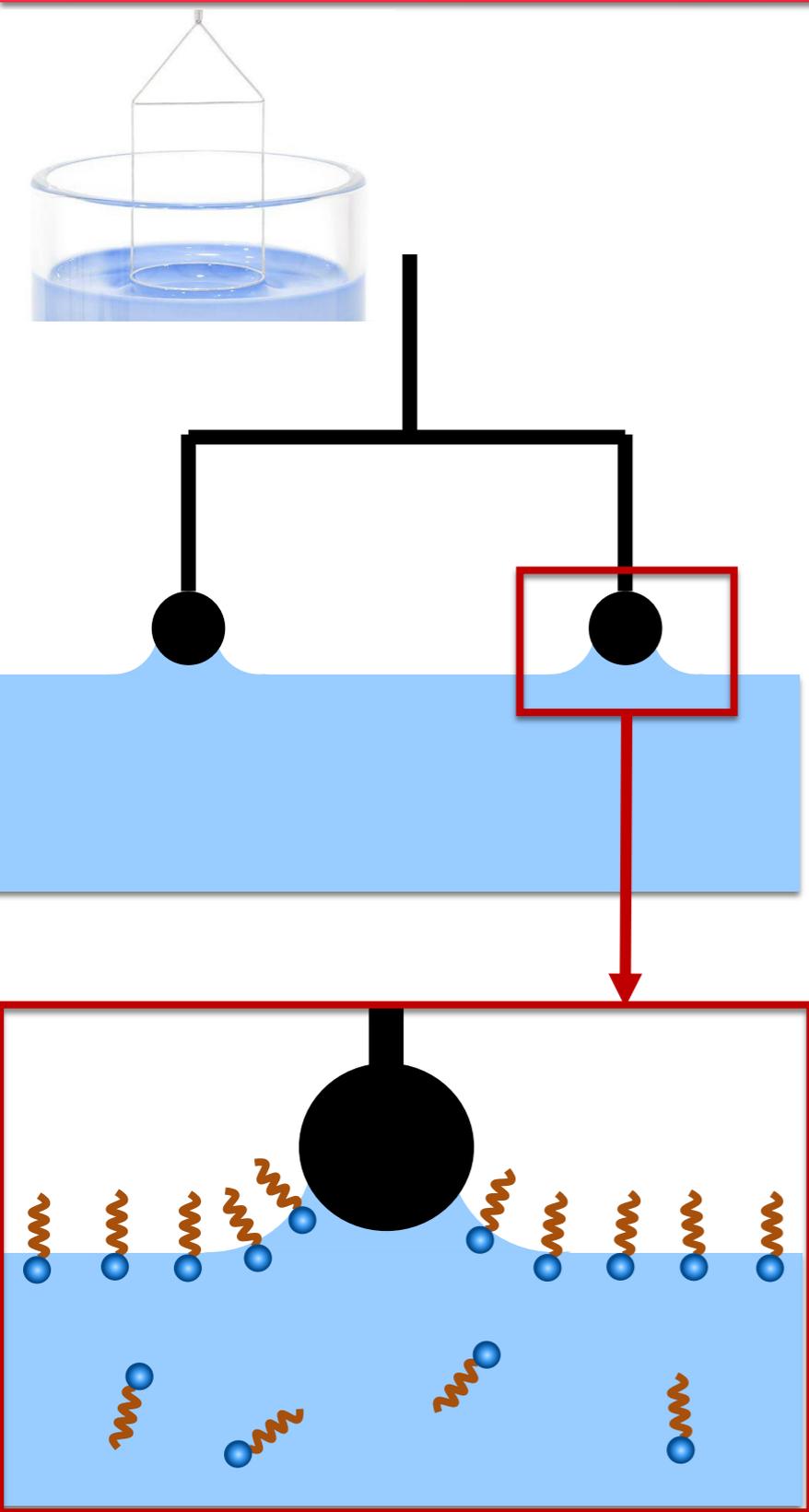
Monocouche de tensioactifs



liquide



Comment "voir" la monocouche ?



Les tensioactifs

Cuillère à soupe de PAIC

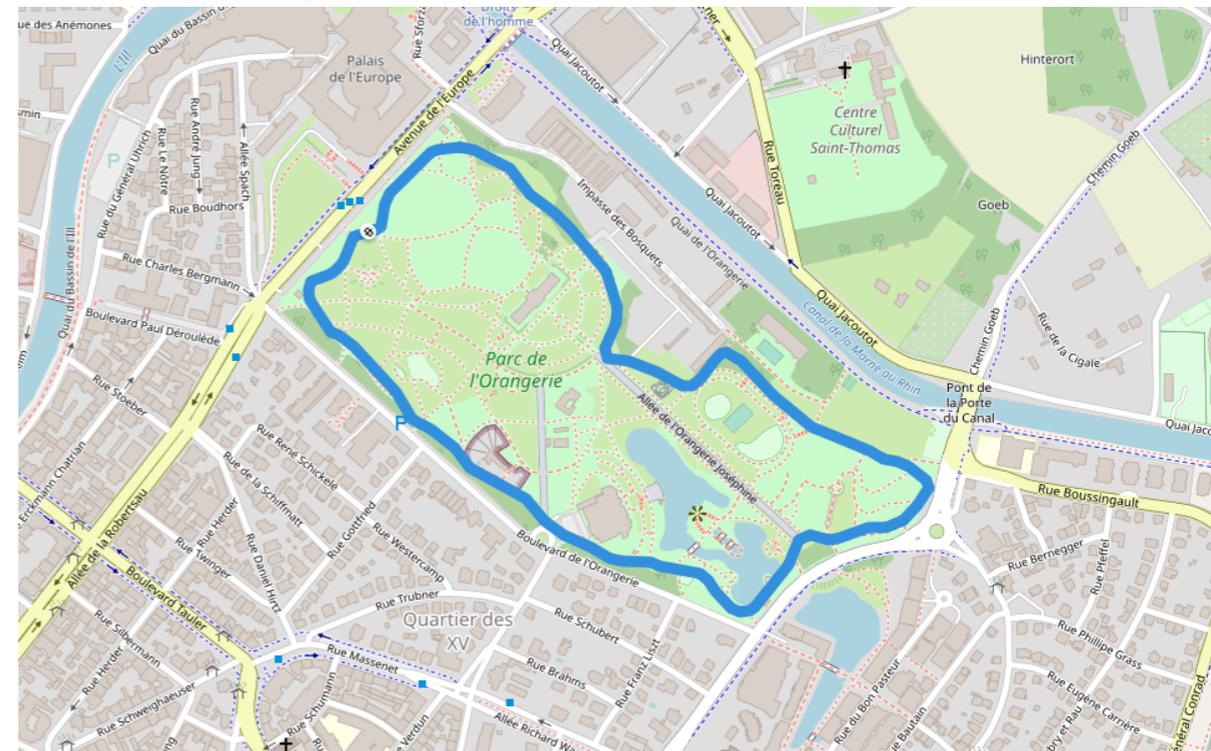
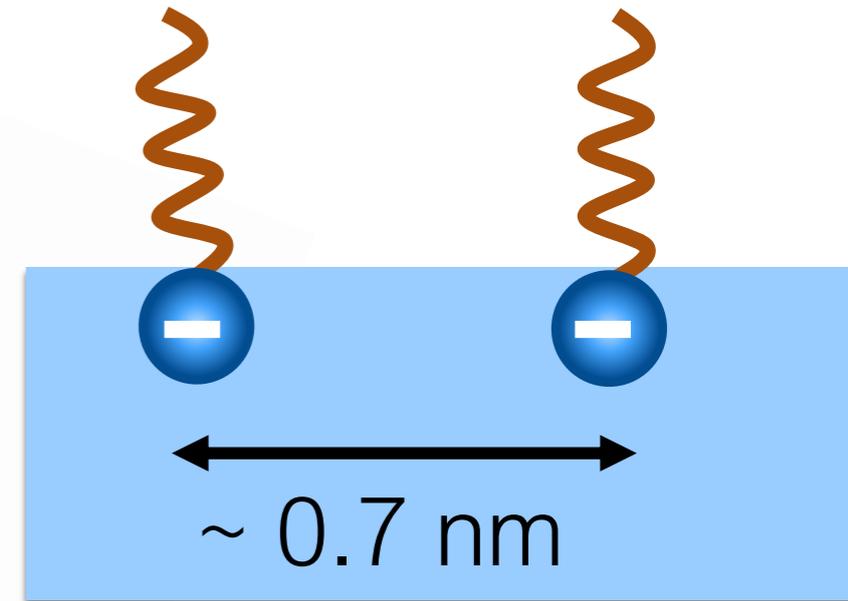
→ 1 g de SLES (15%)

SLES: 288,38 g/mol

1 mol = $6,022\ 140\ 76 \times 10^{23}$

Aire par molécule à la surface:
 $(0.7\ \text{nm})^2 = 0.5 \times 10^{-18}\ \text{m}^2$

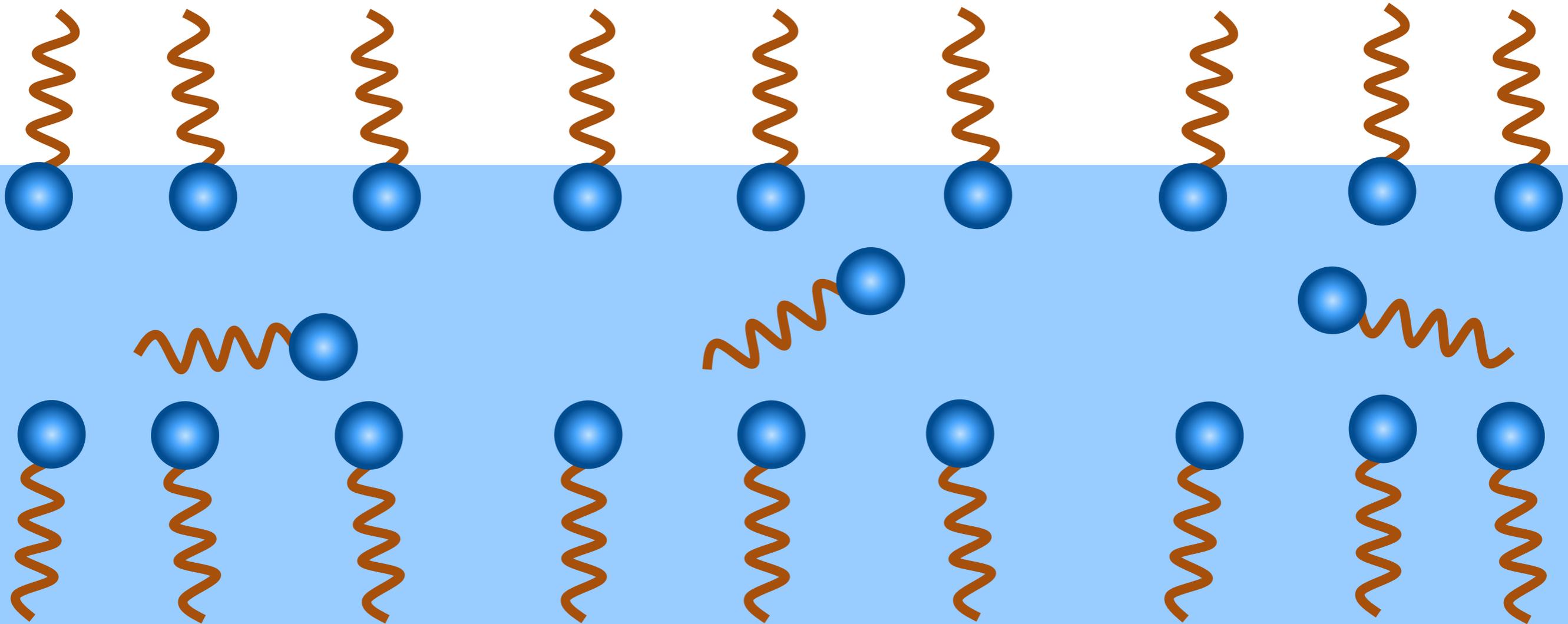
Surface totale :
 $300\ 000\ \text{m}^2 = 30\ \text{ha}$



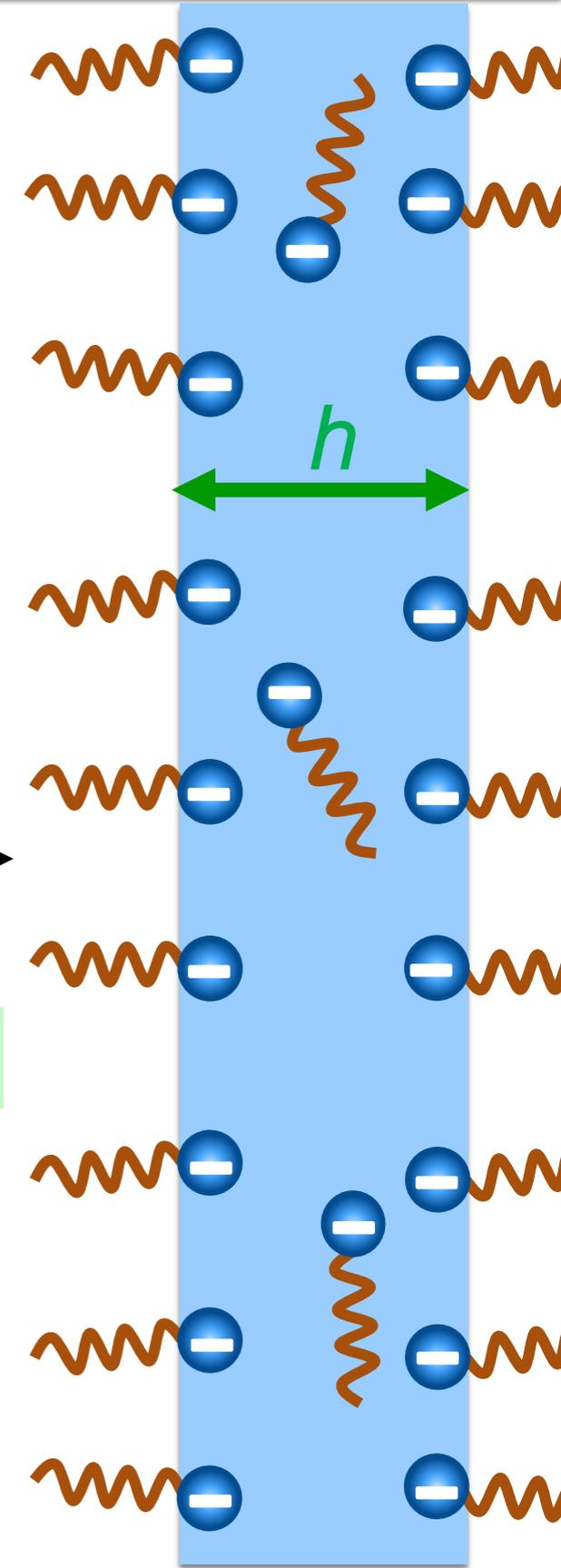
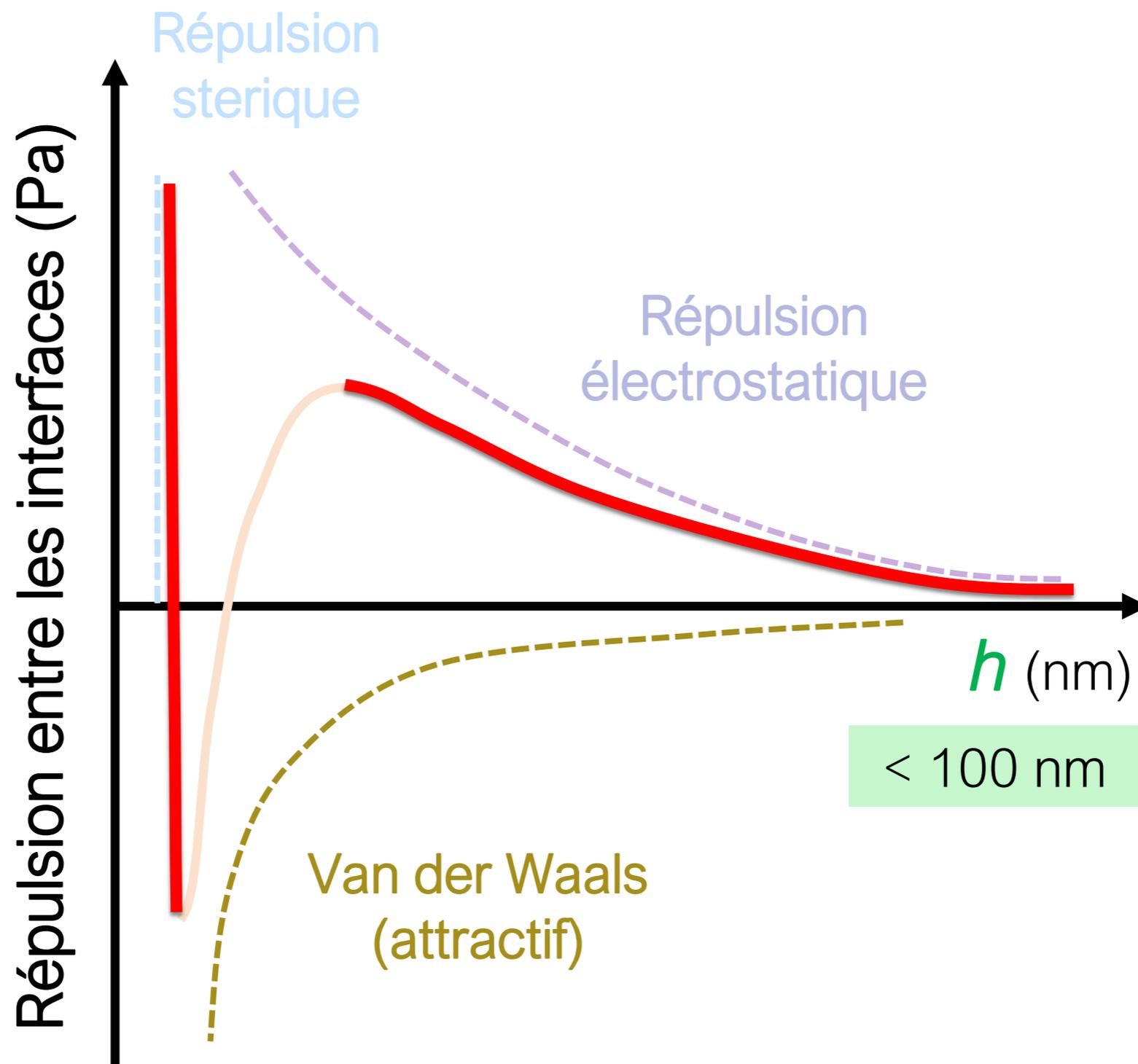
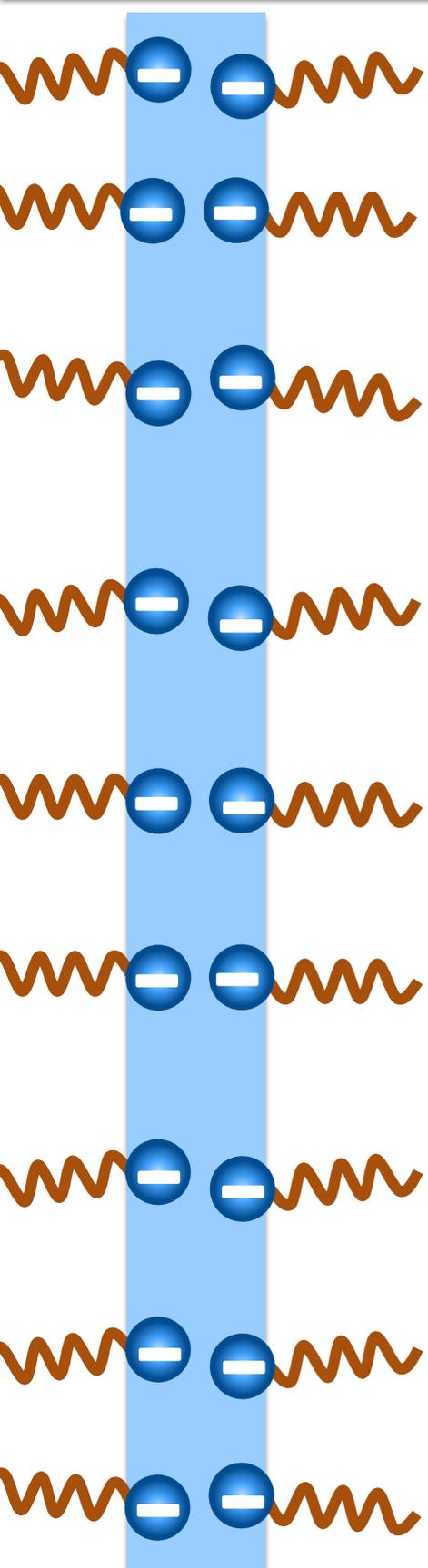
Surface de l'orangerie: 26 ha

Une autre manière de sentir la monocouche

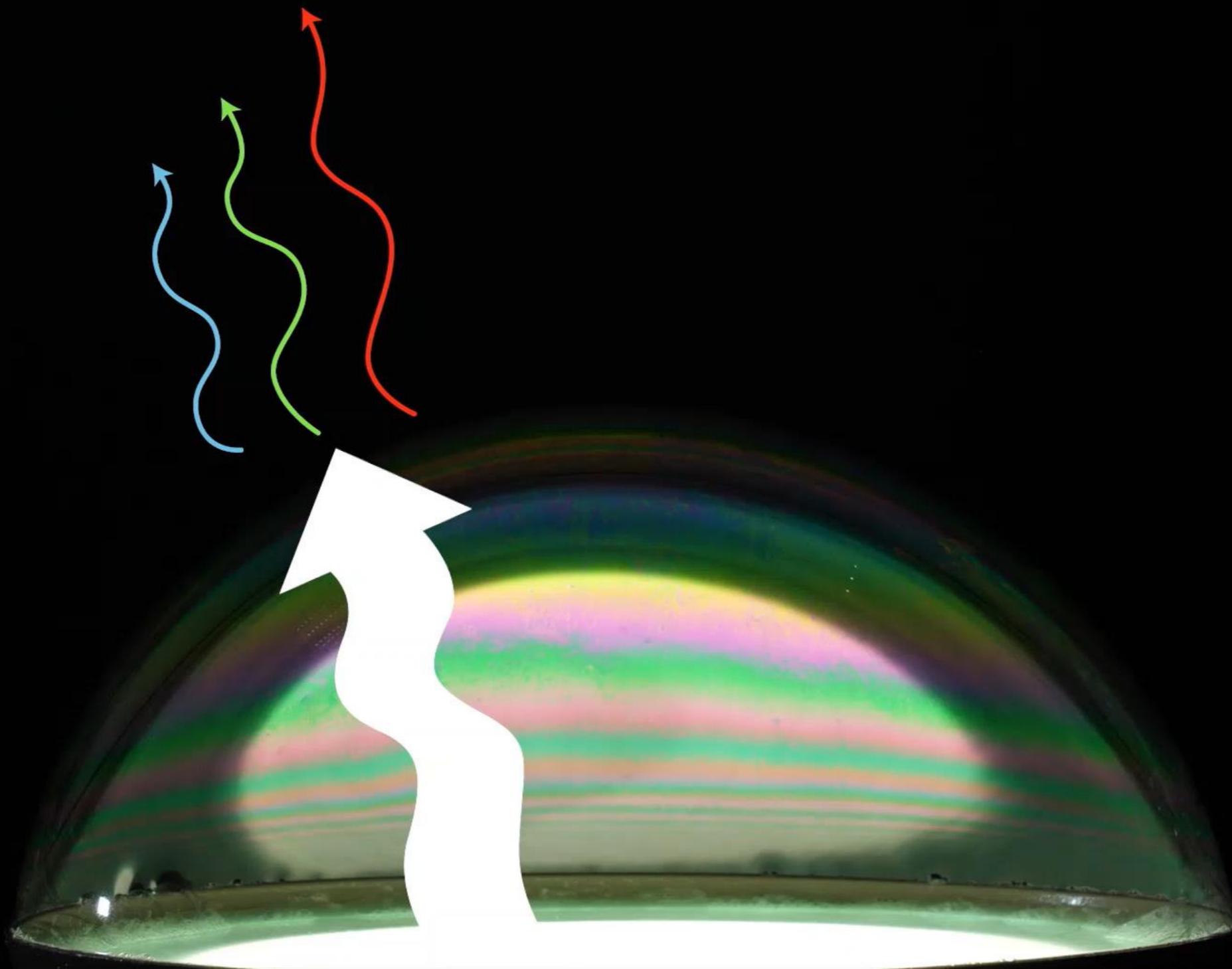
Film de savon

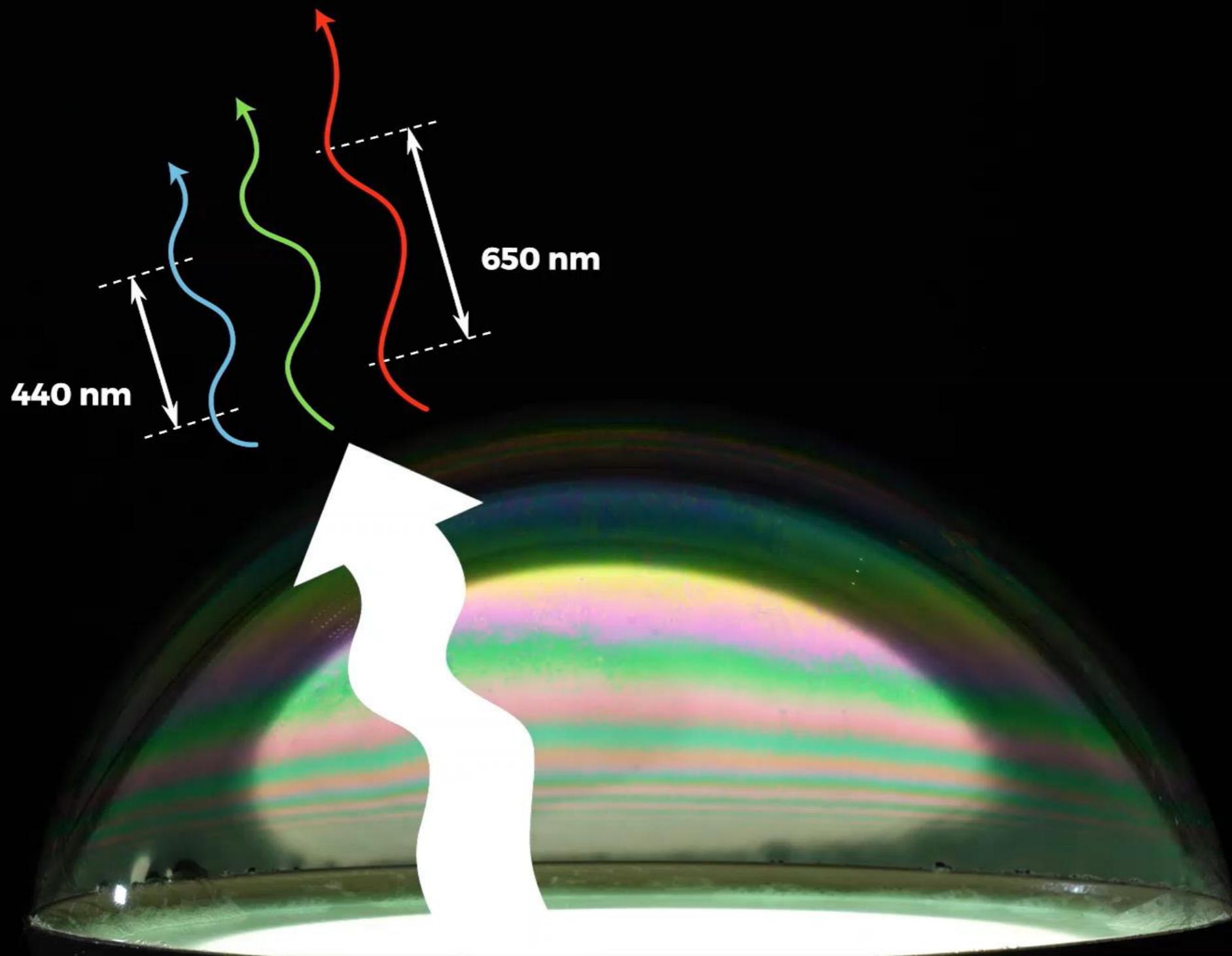


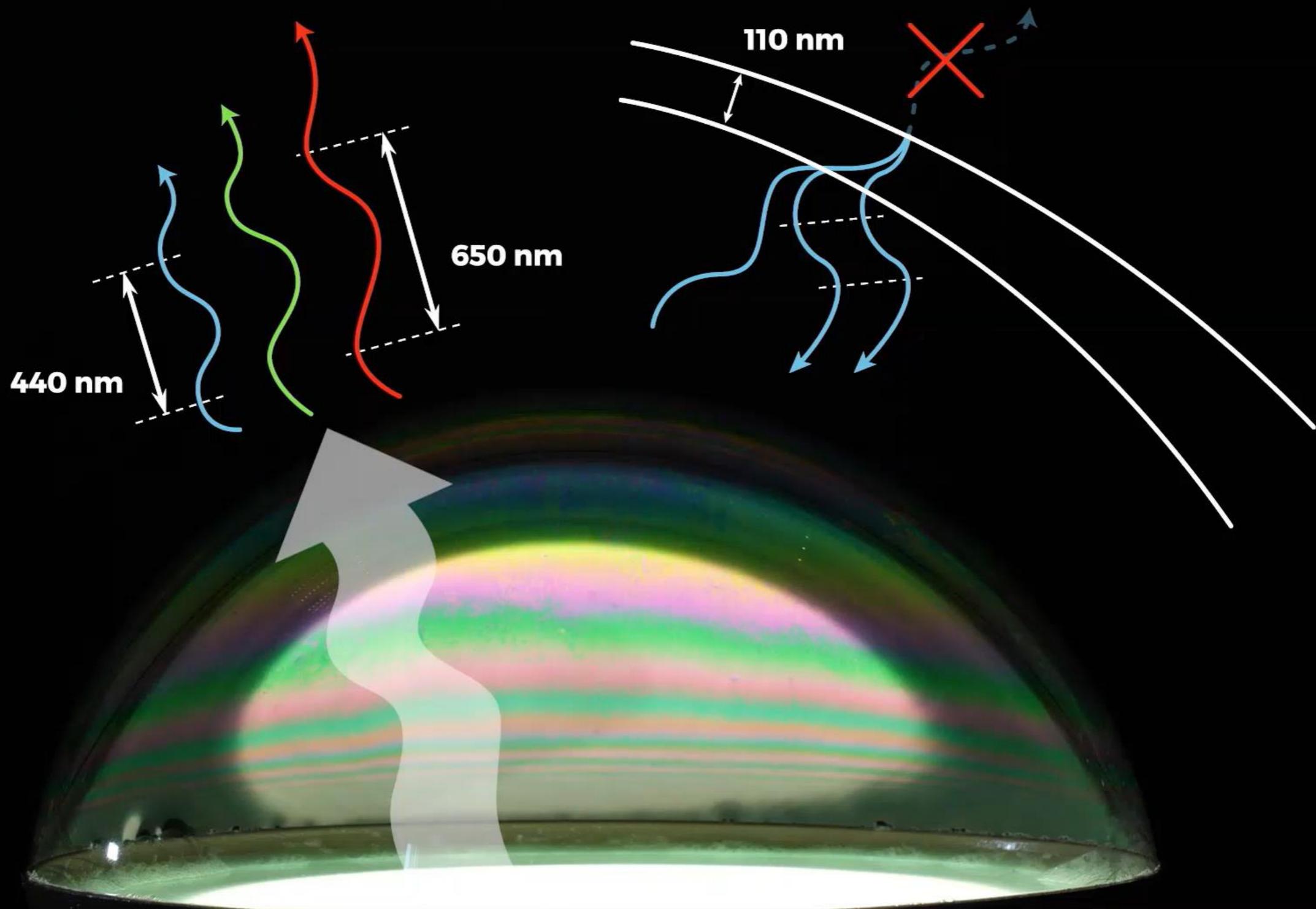
Les films de savon – la “pression de disjonction”











λ - longueur d'onde

h - épaisseur du film

440 nm

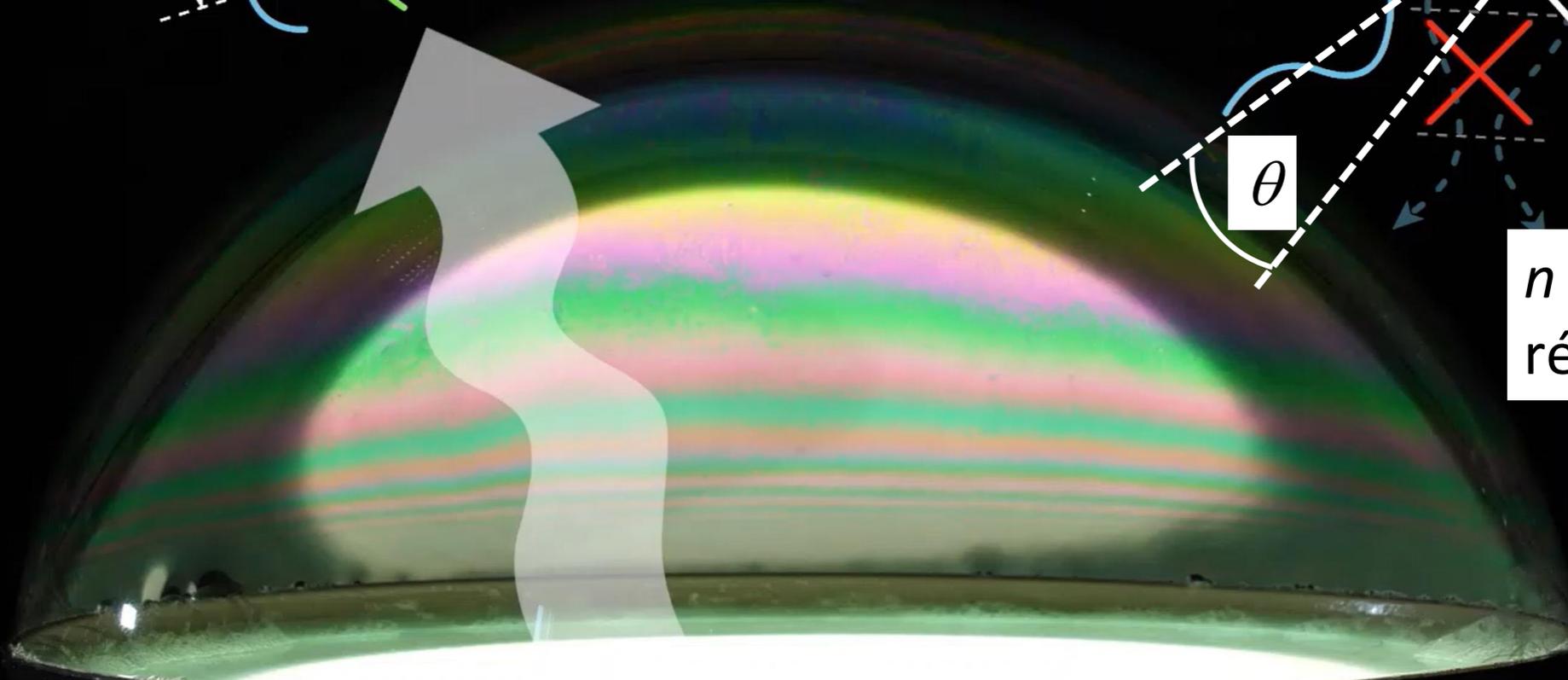
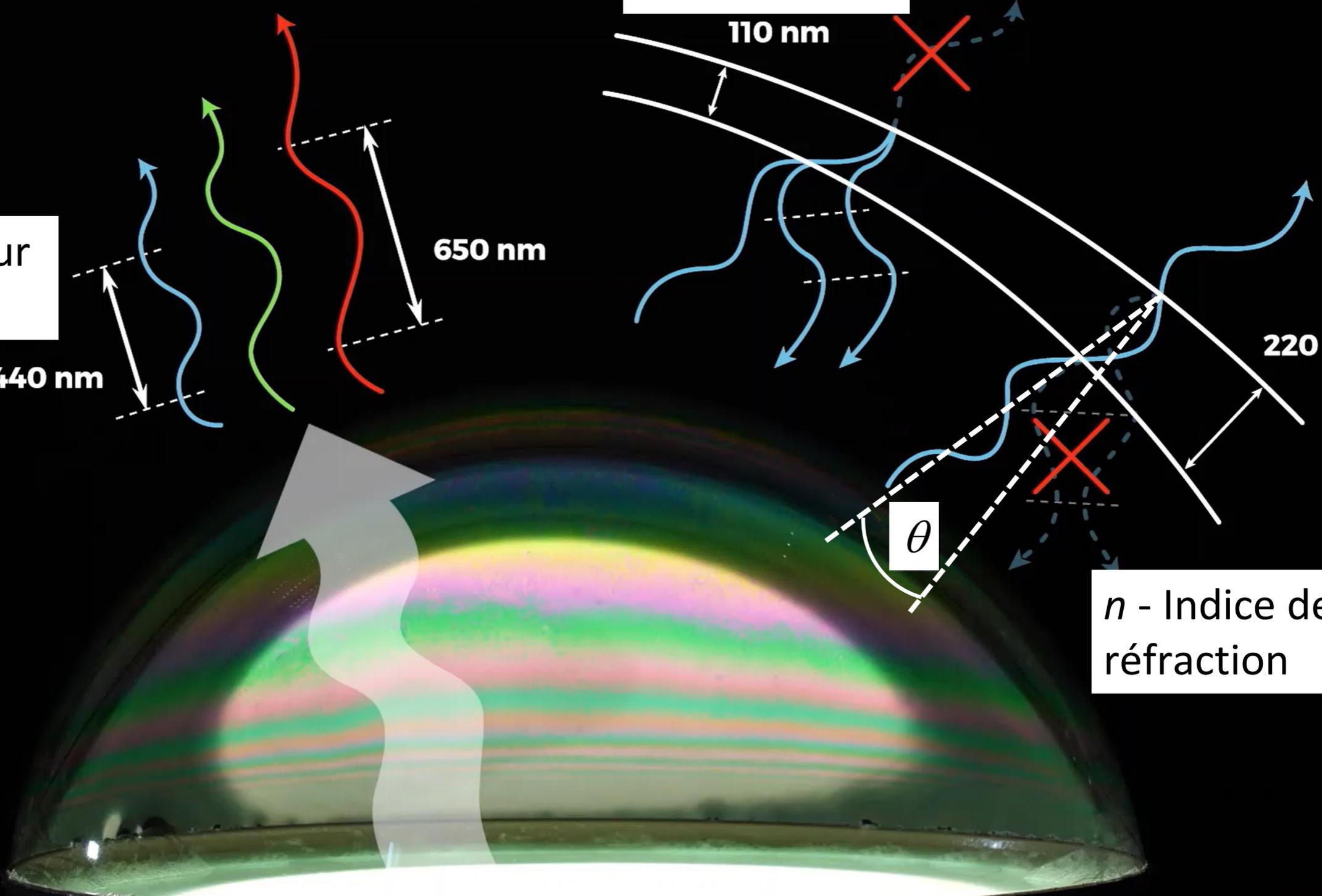
650 nm

110 nm

220 nm

θ

n - Indice de réfraction



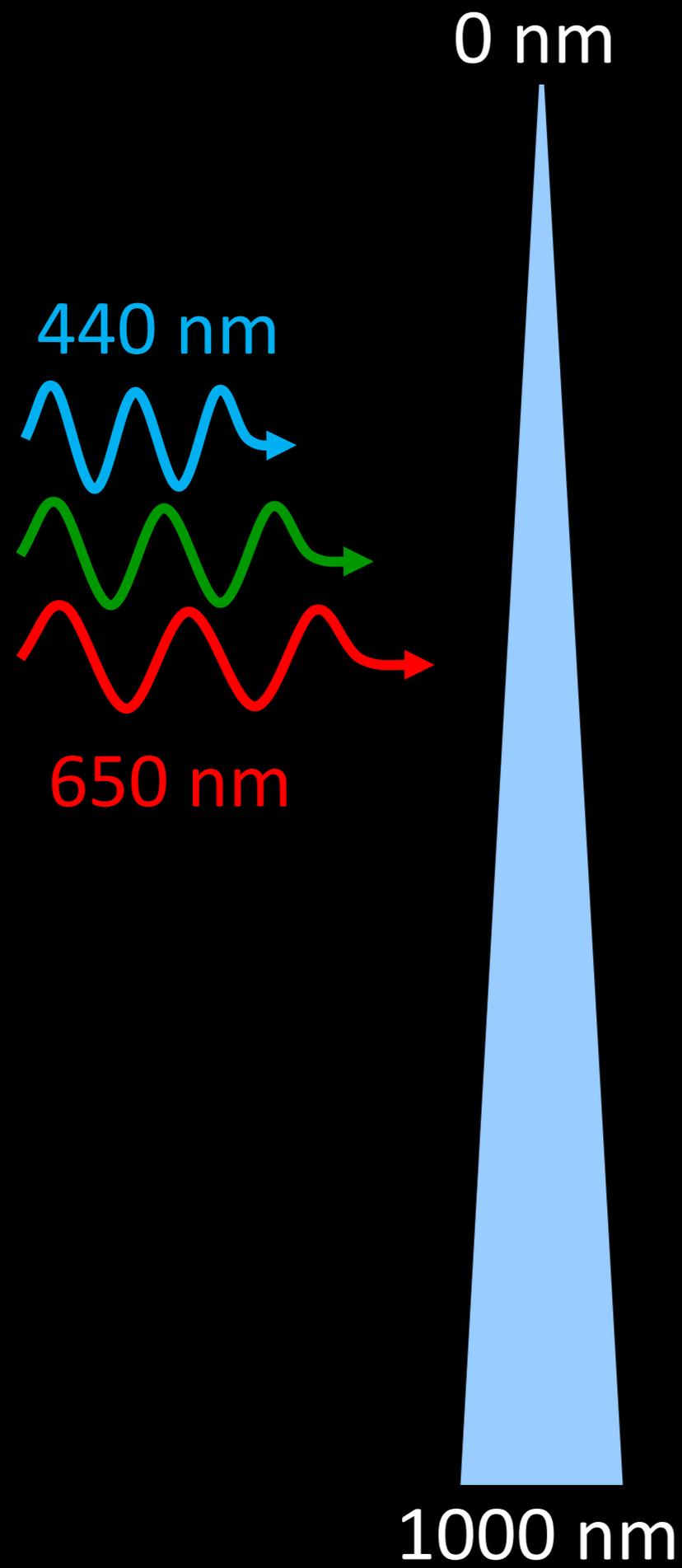
Interférence constructive

$$h = \frac{1}{2n \cos \theta} \left(m - \frac{1}{2} \right) \lambda$$

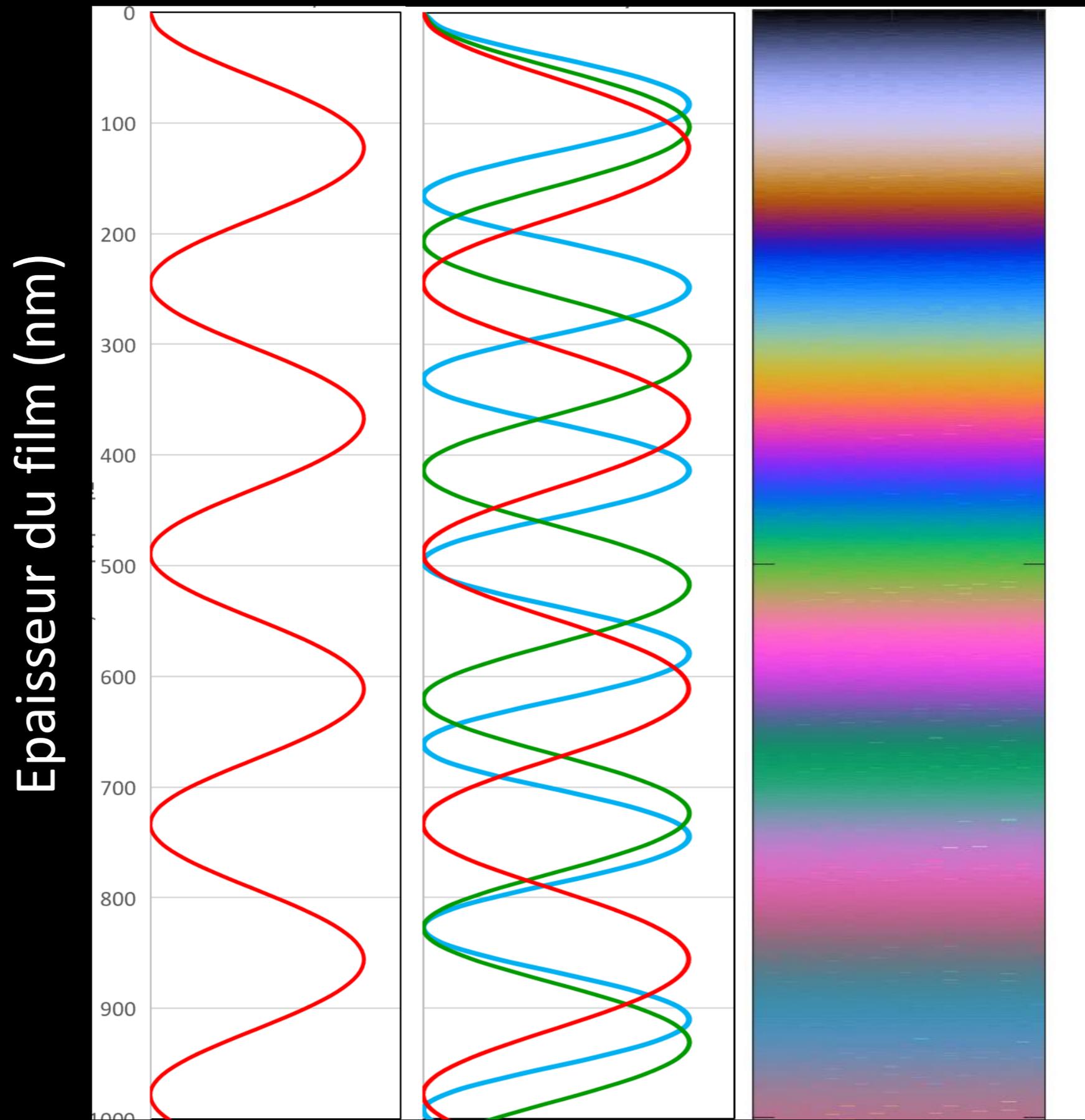
Interférence destructive

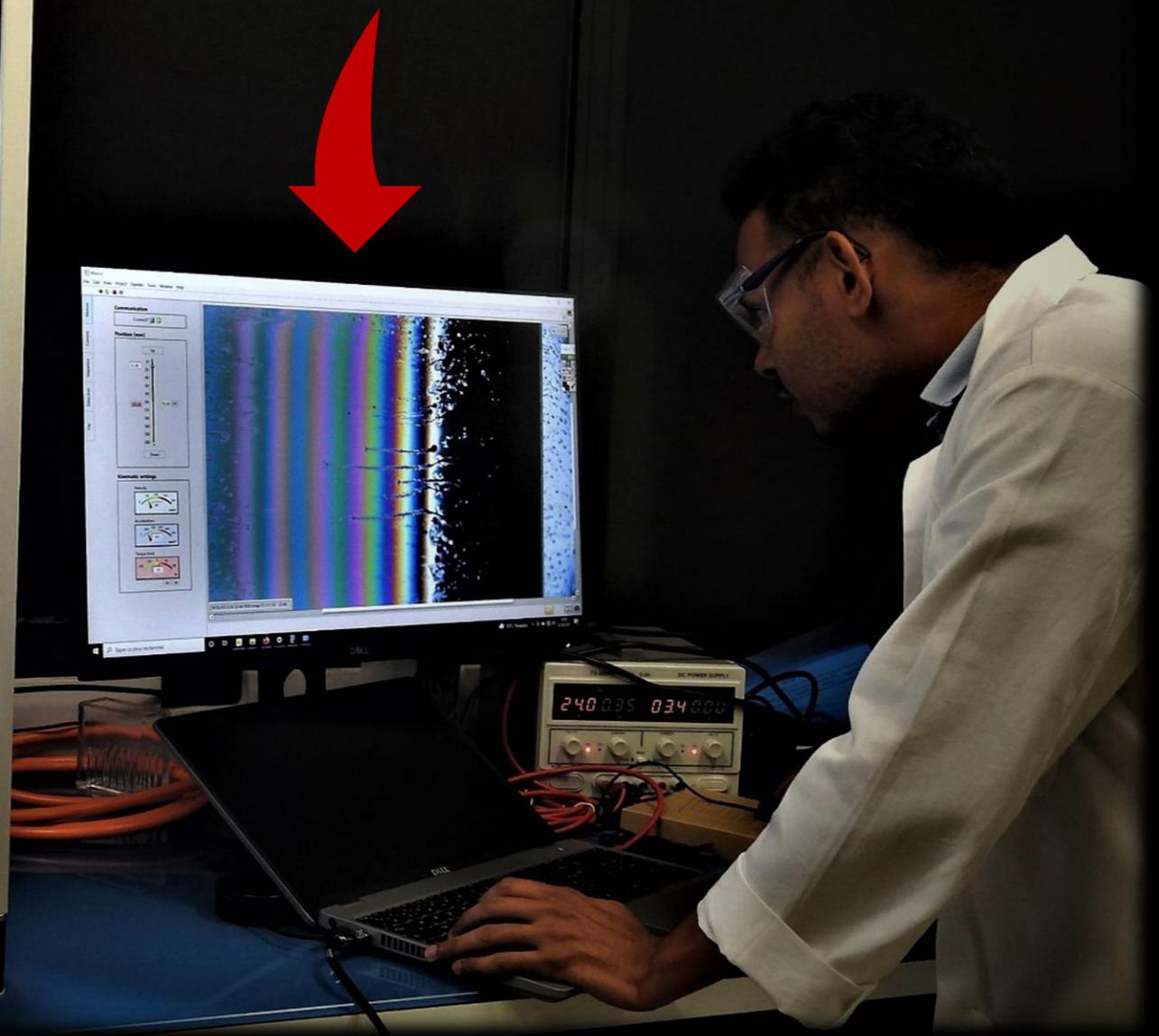
$$h = \frac{1}{2n \cos \theta} (m) \lambda$$

$m = 1, 2, \dots$

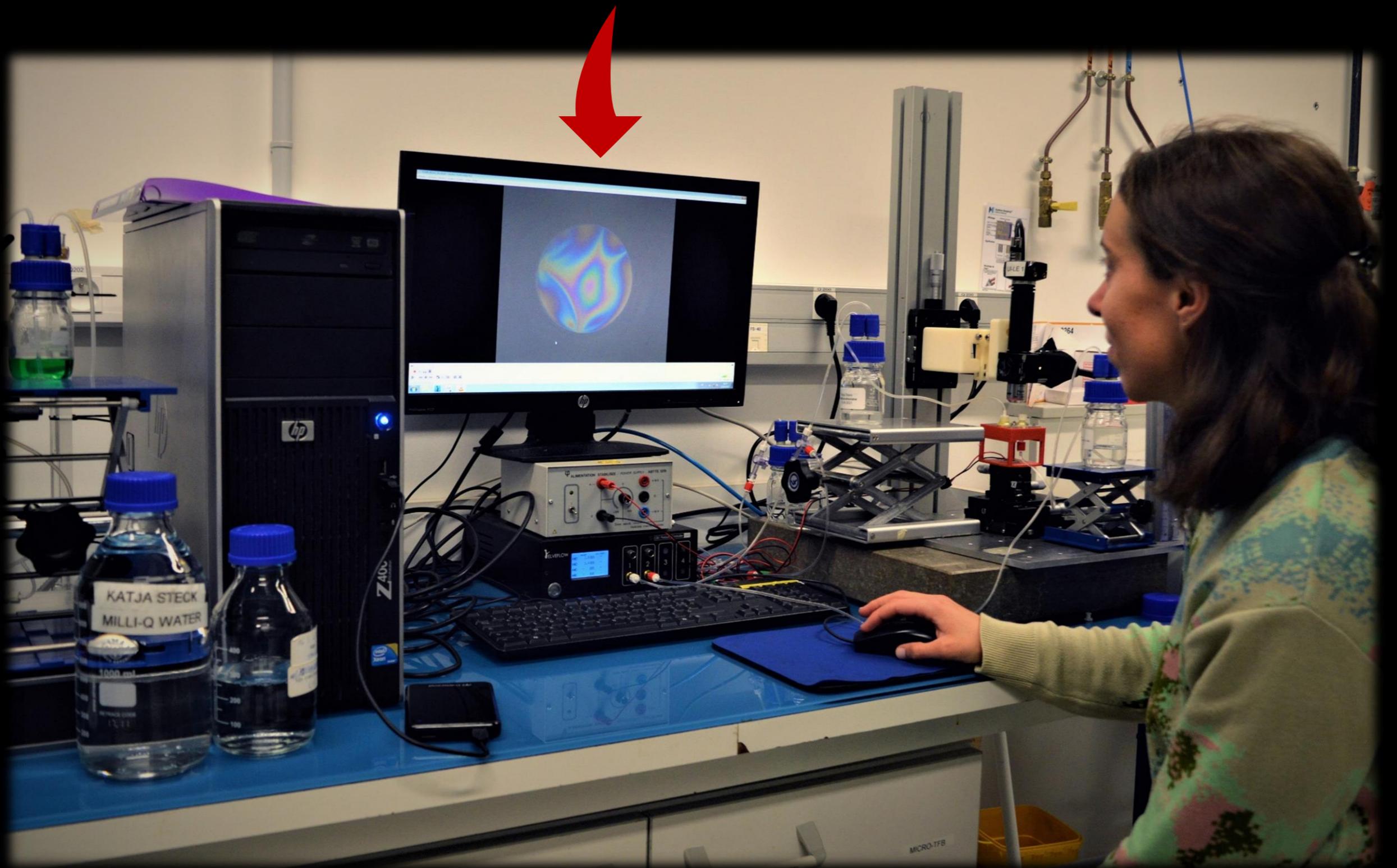


Intensité réfléchie

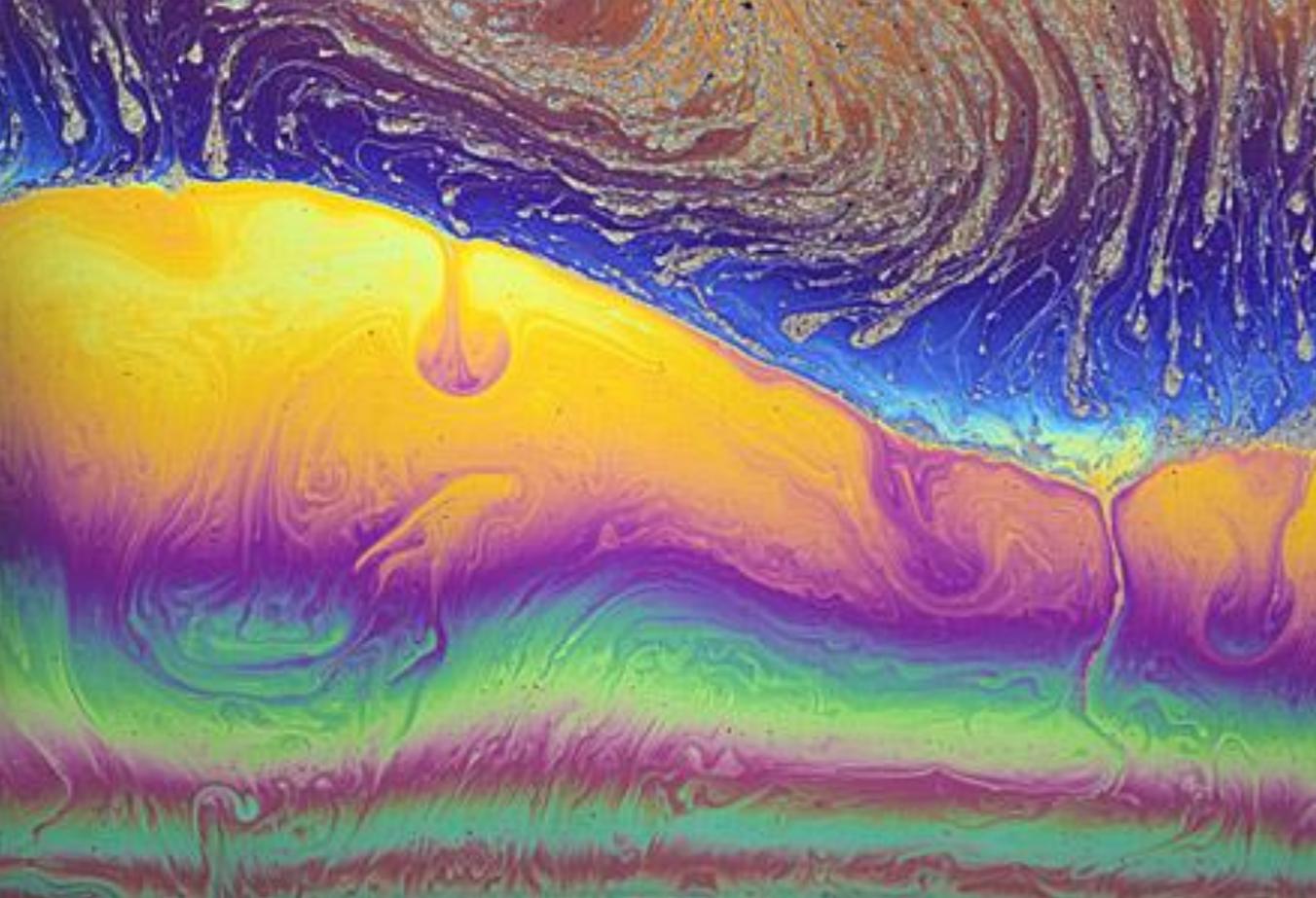




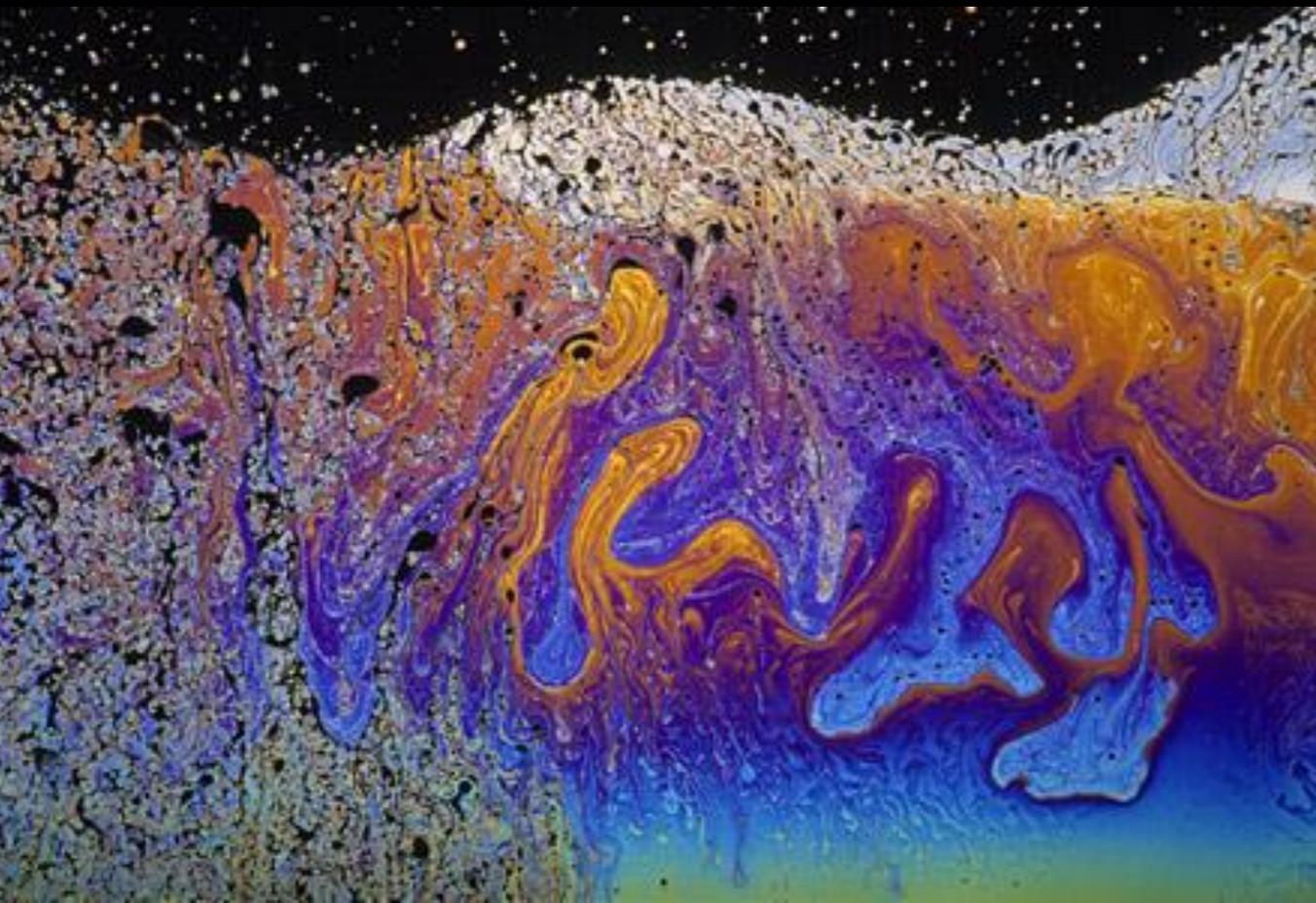
Jonathan Dijoux



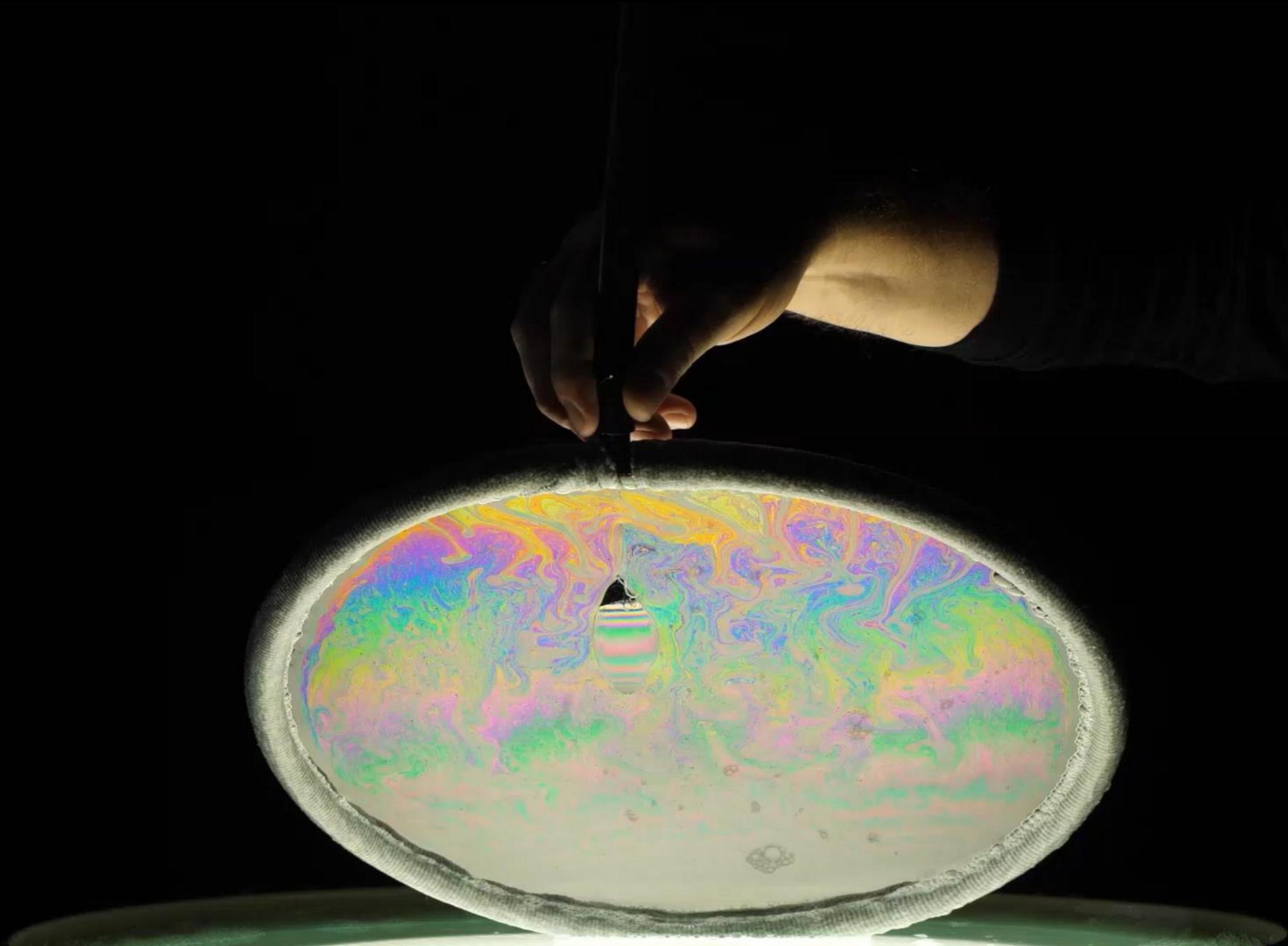
Sébastien Kauffmann



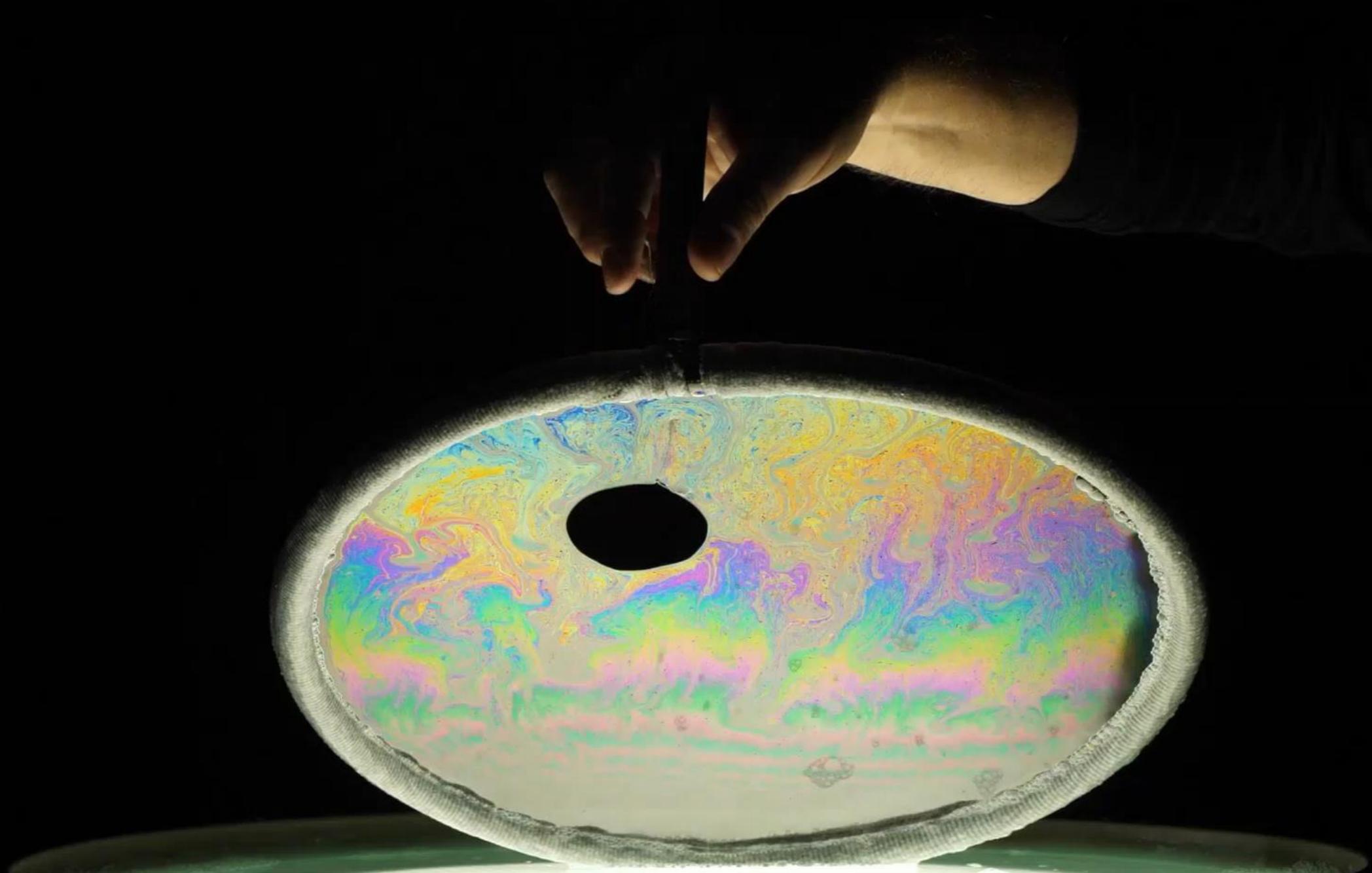
by Dublin Photographer Tim Durham



Comment voir la tension de surface dans des films?



Comment voir la tension de surface dans des films?

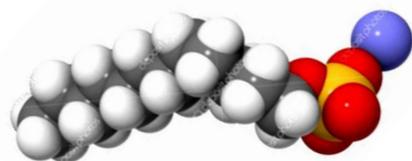


Les tensioactifs

Anioniques

Sodium dodecylsulphate

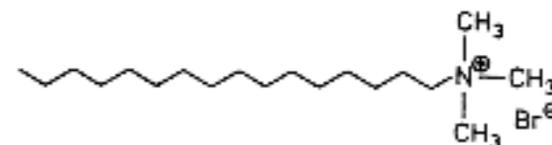
SDS



Cationiques

Cetyltrimethylammoniumbromide

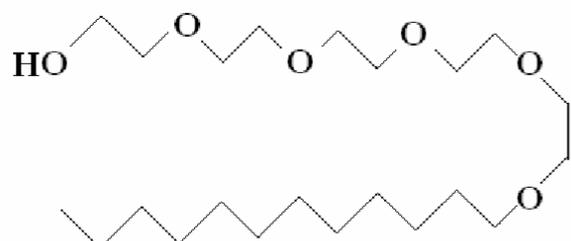
CTAB



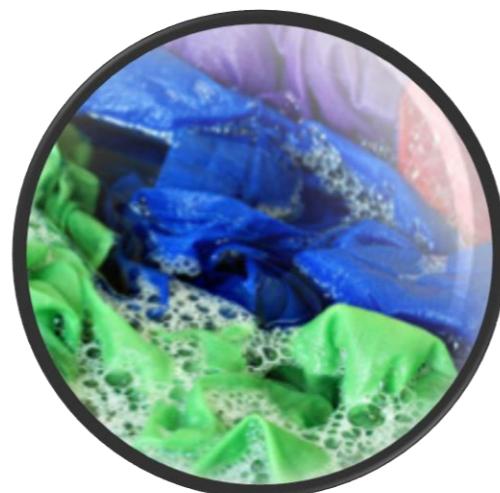
Non-ioniques

Polyoxyethylene (5) lauryl ether

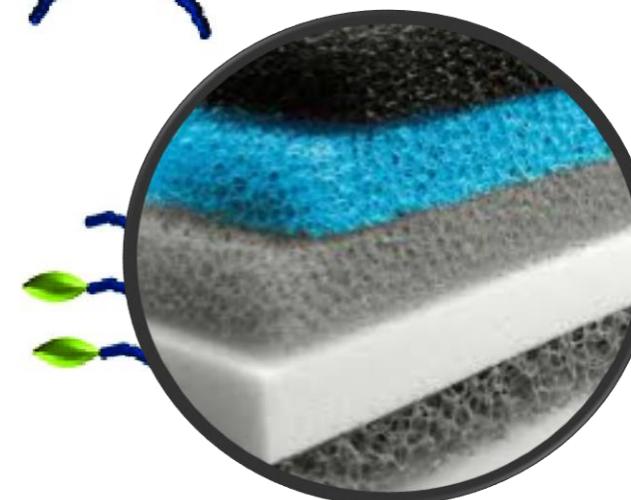
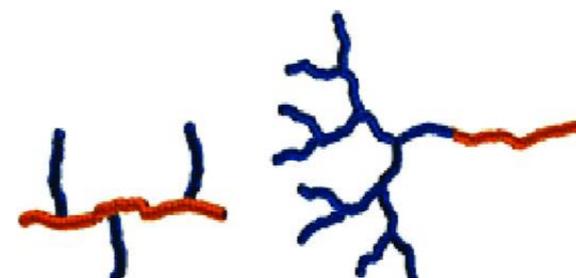
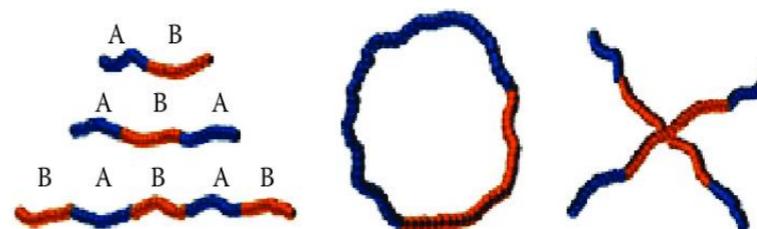
C₁₂E₅



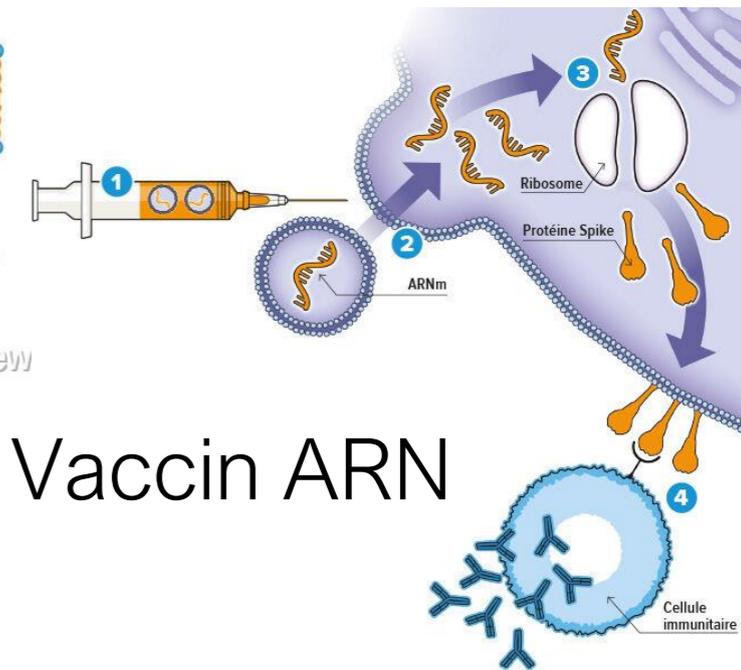
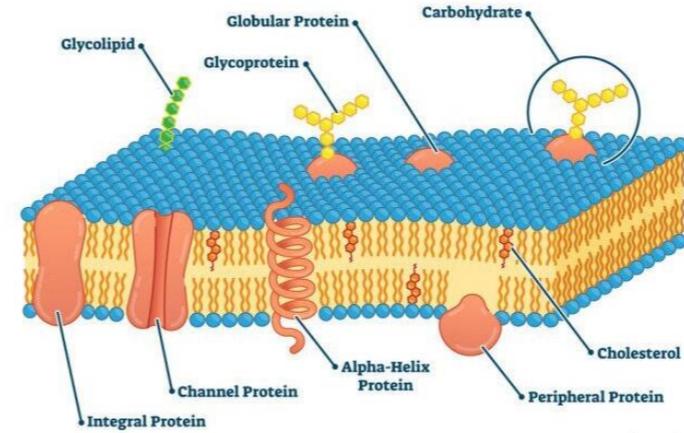
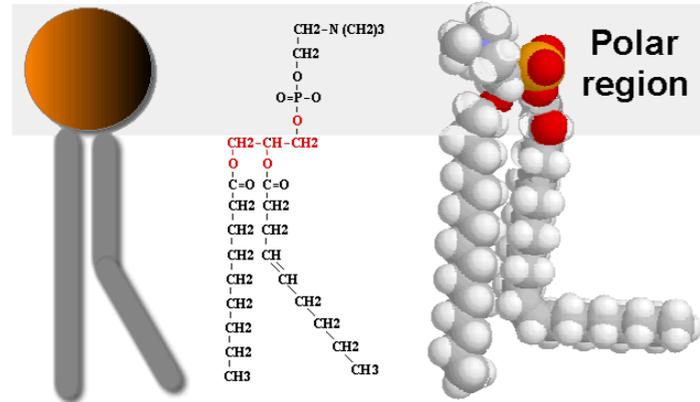
C_nE_m



Polymères amphiphiles

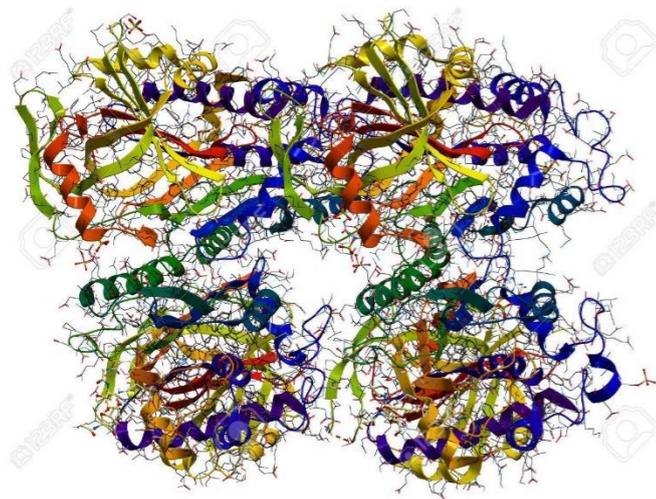


Phospholipides



Vaccin ARN

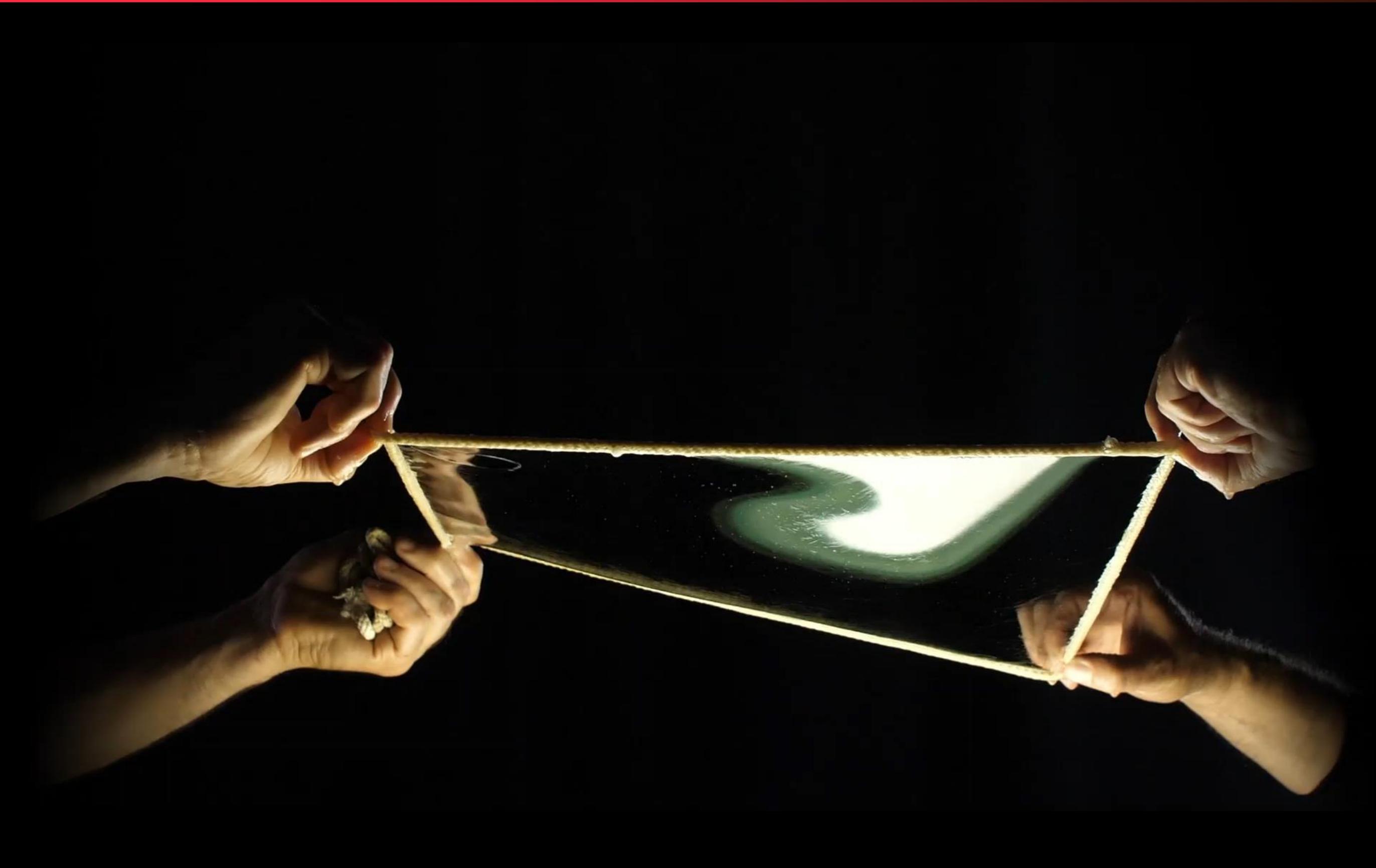
Protéines



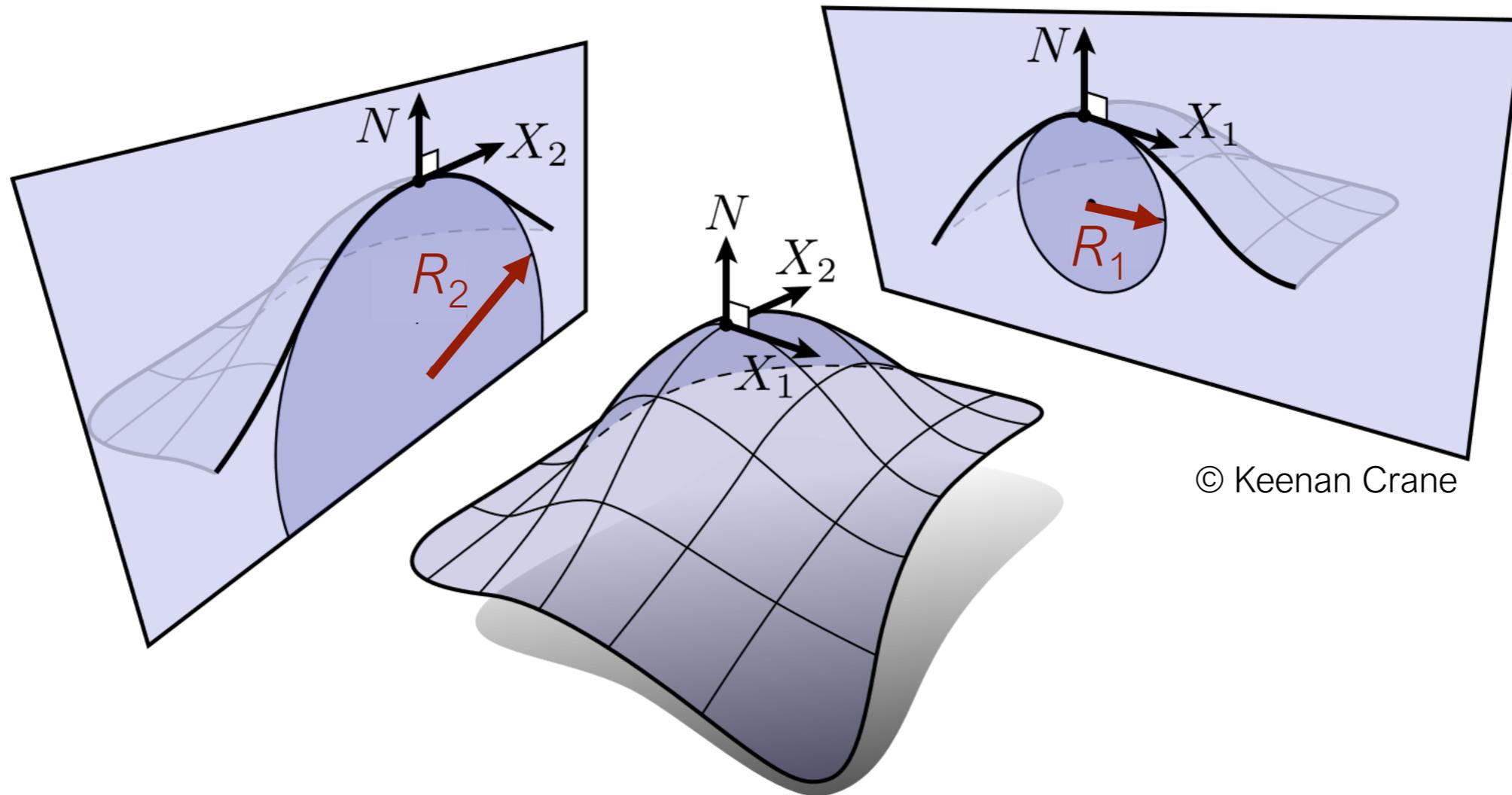
Blanc d'œuf, lait, ...



Les films courbés

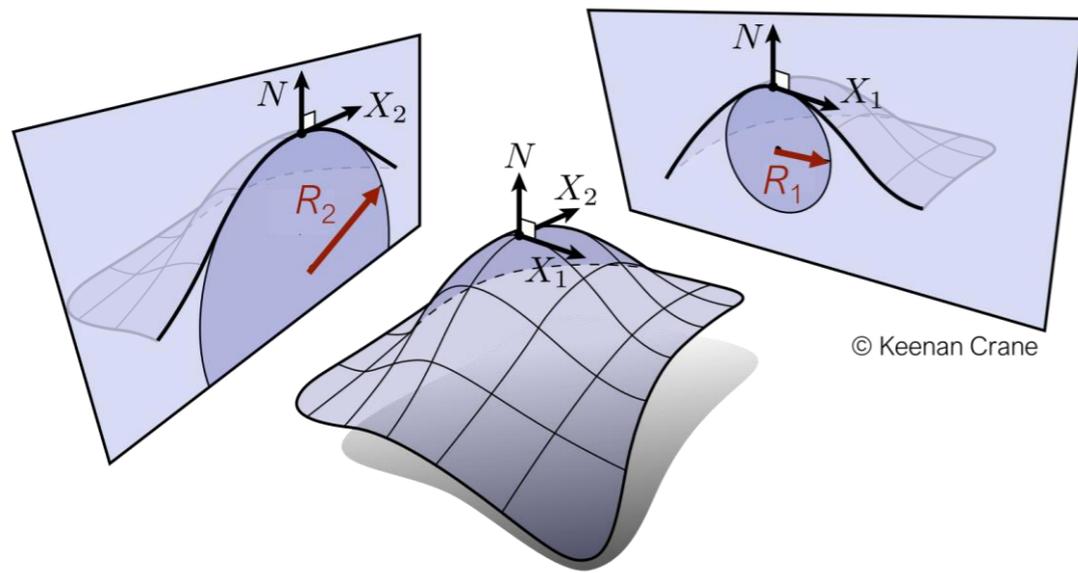


Comment d'écrire une surface courbée ?



A chaque point de la surface peuvent être associés deux rayons de courbure principaux R_1 et R_2

Comment d'écrire une surface courbée ?



I. La courbure moyenne

$$H = \frac{1}{2} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

II. La courbure Gaussienne

$$K = \frac{1}{R_1 R_2}$$

	$K < 0$	$K = 0$	$K > 0$
$H < 0$	Selle 	crête 	pic
$H = 0$	Surface minimale 	plan 	Pas possible
$H > 0$	Selle inv. 	vallée 	puit

La courbure des films de savon

Energie du film

$$E = 2\gamma A$$

γ – tension de surface
 A – aire de la surface



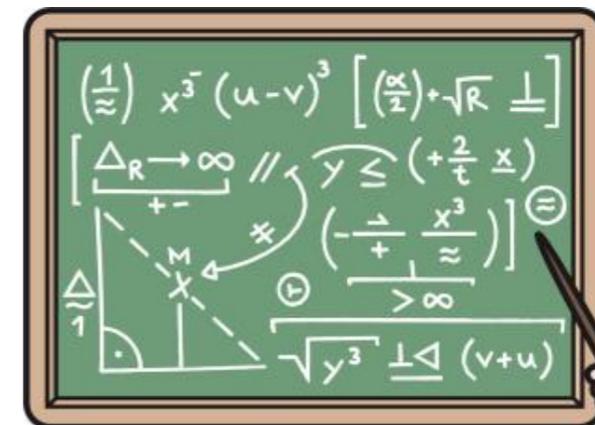
Minimiser l'énergie = minimiser surface A



“Surface minimale”

Courbure
moyenne

$$H = \frac{1}{2} \left(\frac{1}{R_1} + \frac{1}{R_2} \right) = 0$$



Un film de savon est une surface minimale
avec une **courbure moyenne de zéro**

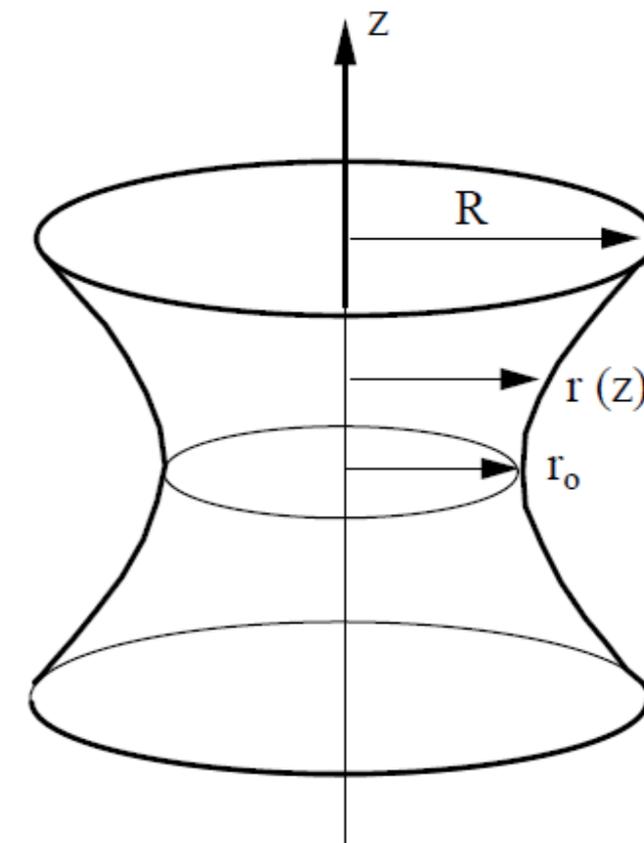
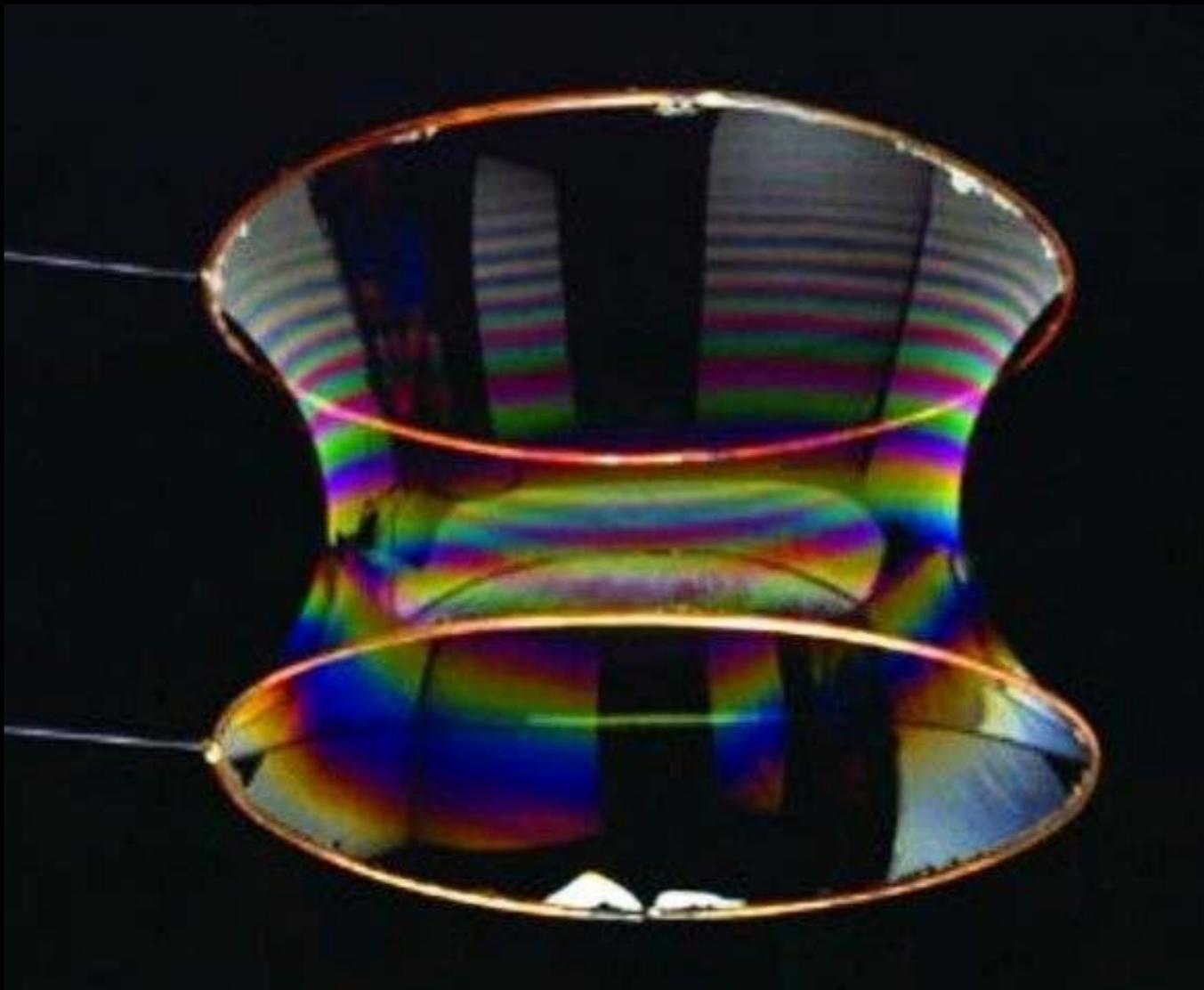
Surfaces minimales en architecture



Stade Olympique Monacco (Otto Frei)

Example: la catenoïde

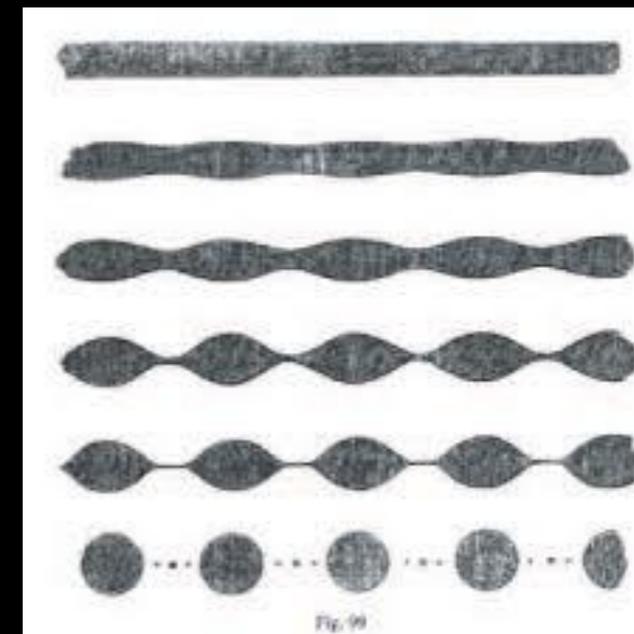
Seule surface minimale ou expression analytique est connue



$$r(z) = r_0 \cosh\left(\frac{z}{r_0}\right)$$

Est-ce qu'il y a toujours une solution ?

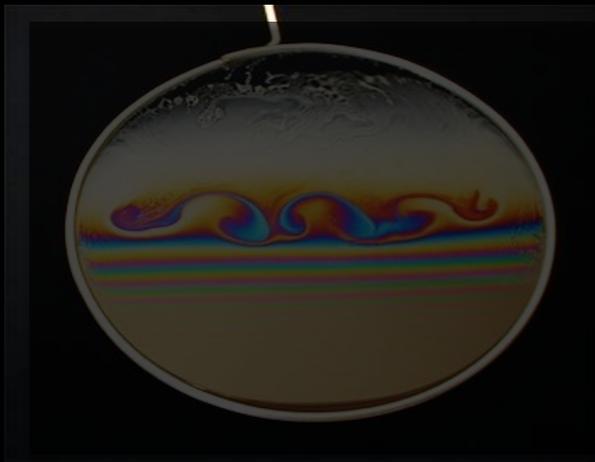
Les instabilités en oeuvre dans notre vie quotidienne



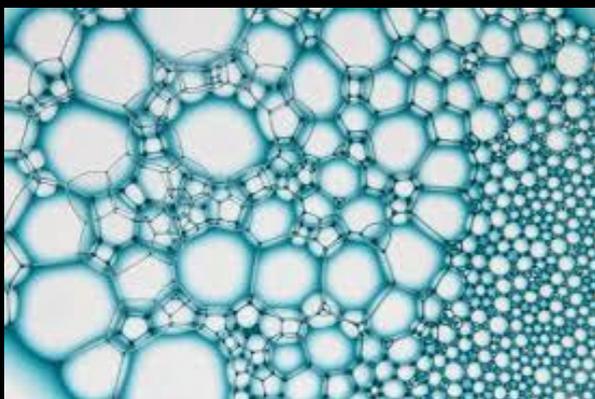
Et pour créer
des bulles !



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