

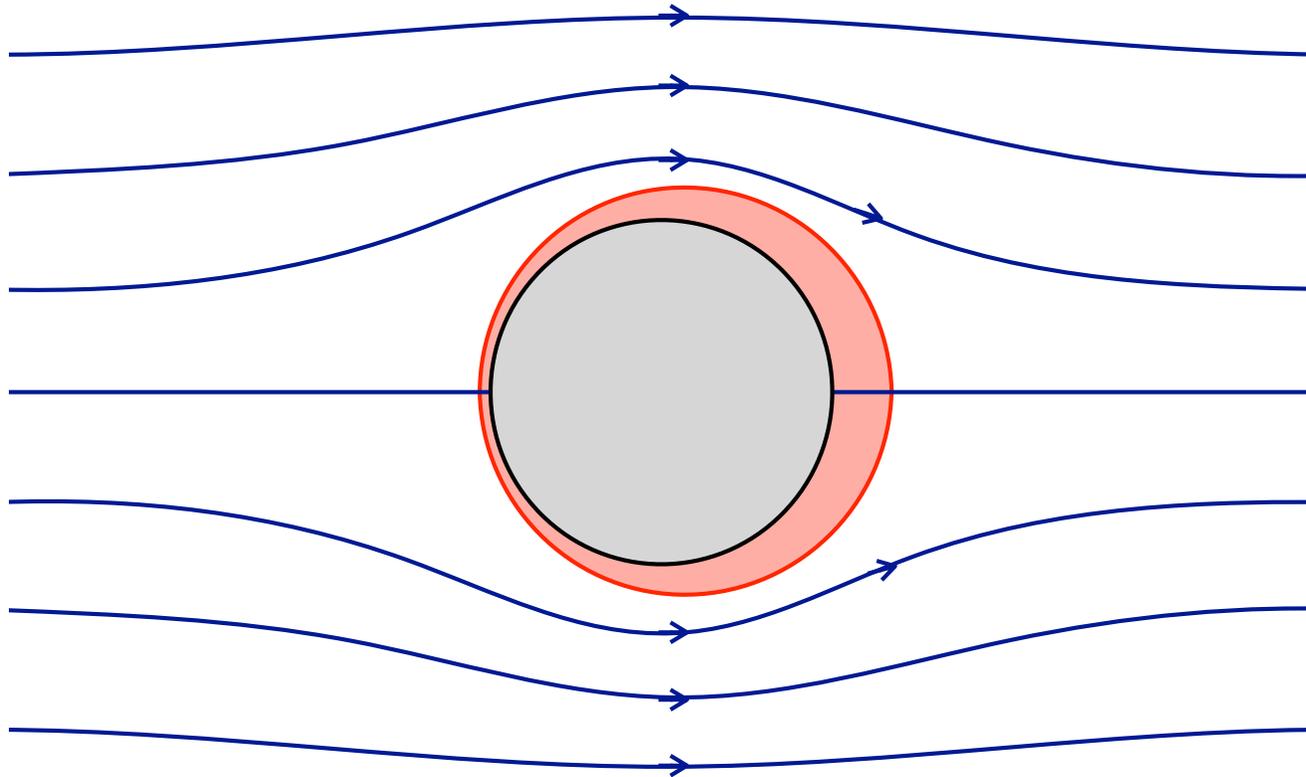
Trainée à haut Re

Traînée de forme

Une couche limite à contre-sens

$$Re \gg 1$$

hypothèse: écoulement laminaire



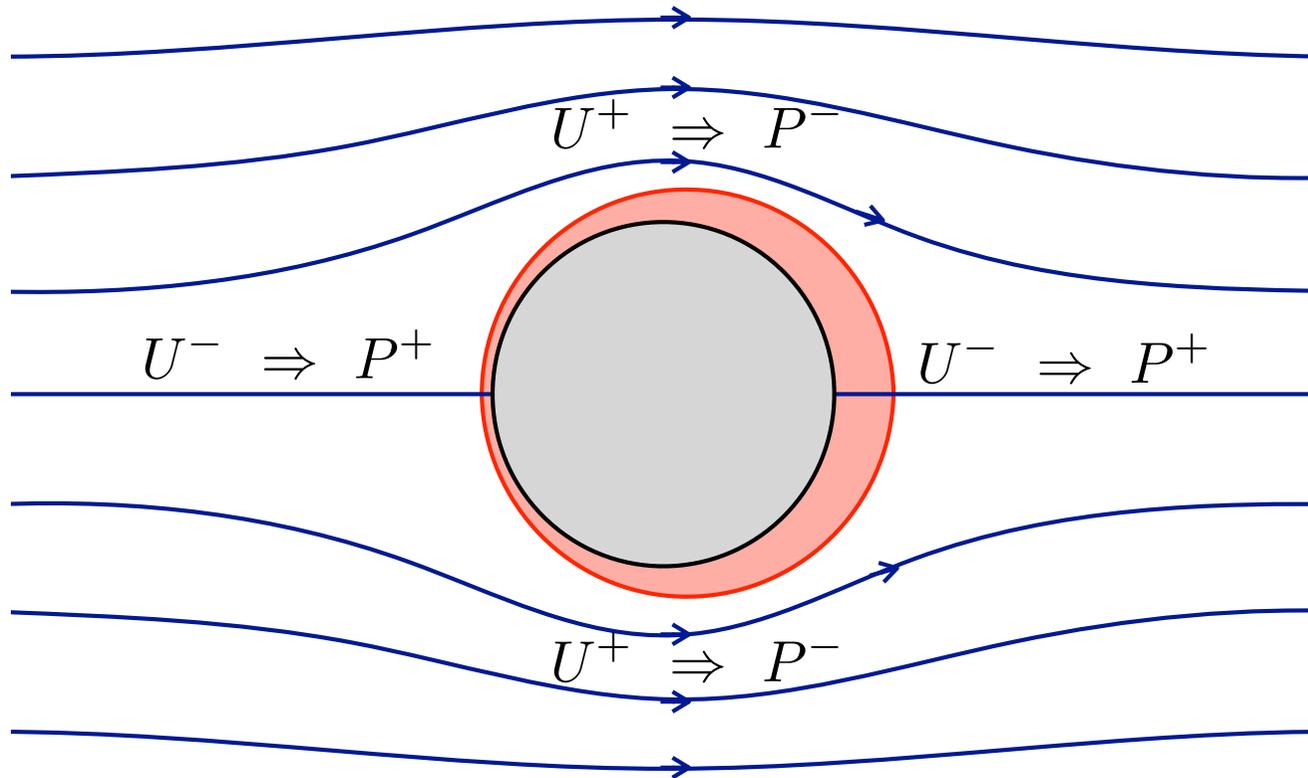
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⇒ hors couche limite: Bernoulli



Traînée de forme

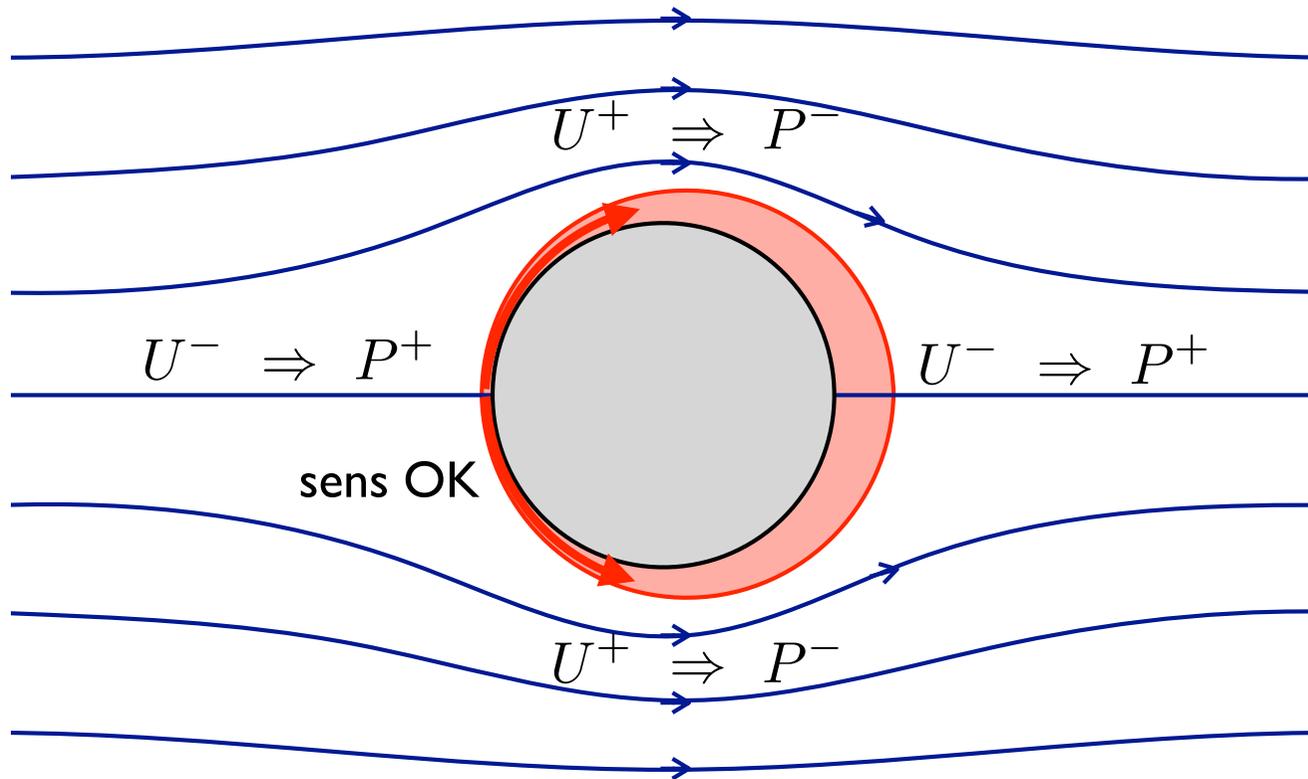
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couche limite, écoulement visqueux: $P^+ \rightarrow P^-$



Traînée de forme

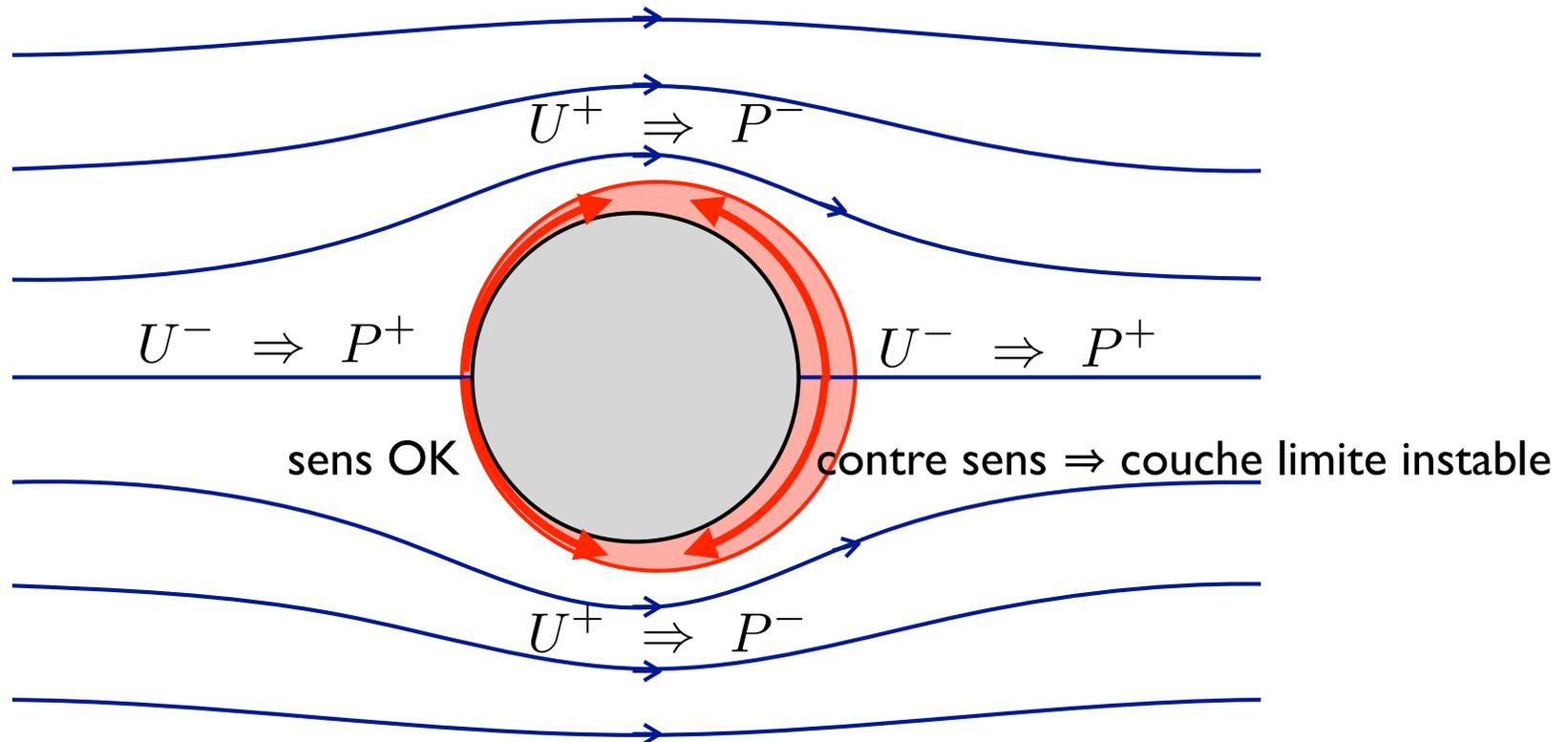
Une couche limite à contre-sens

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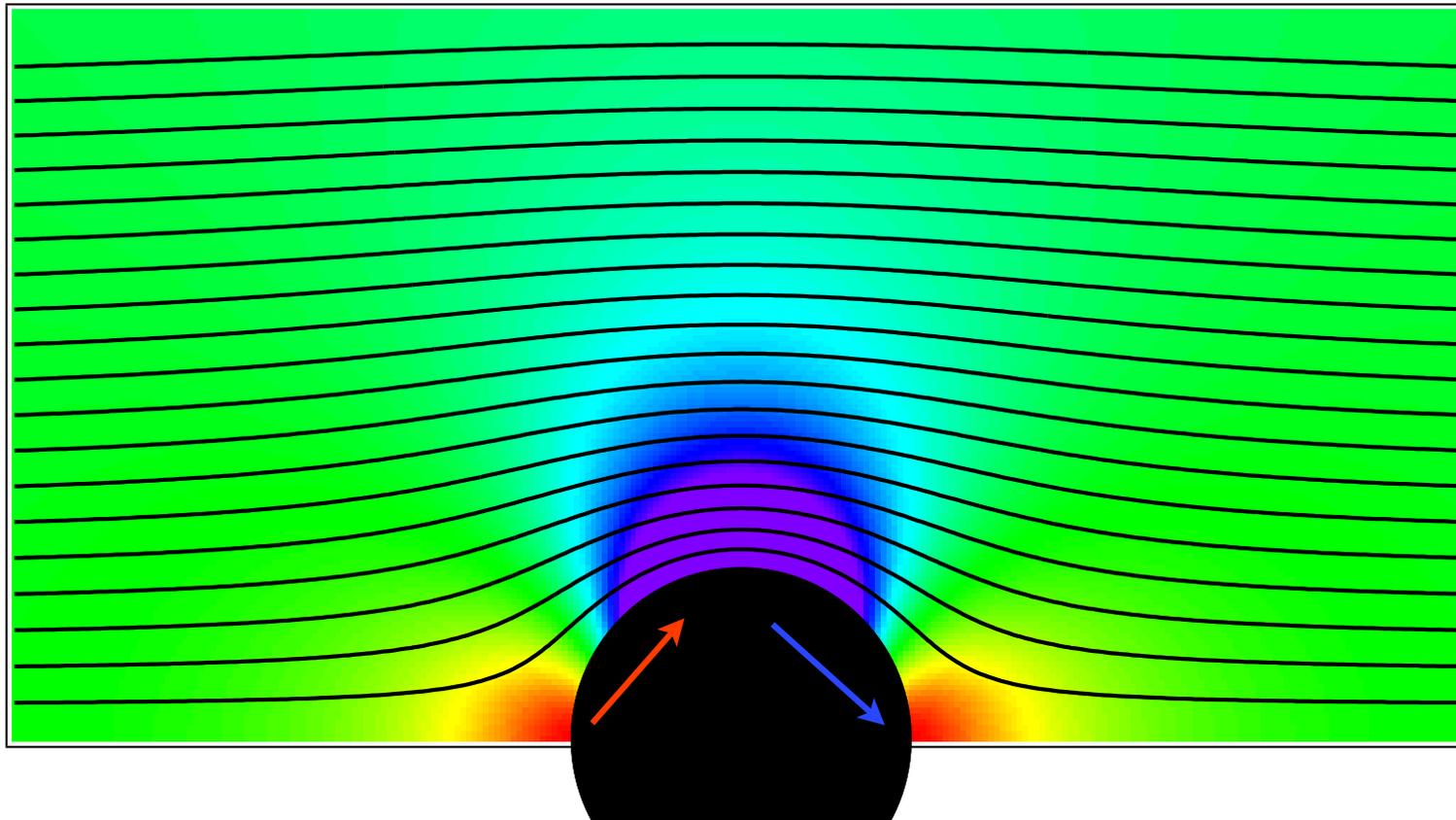
⇒ hors couche limite: Bernoulli

couche limite, écoulement visqueux: $P^+ \rightarrow P^-$



Ecoulement potentiel autour d'un cylindre

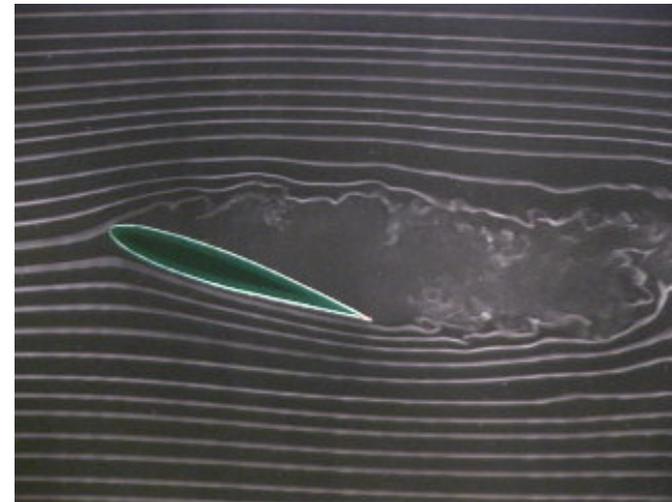
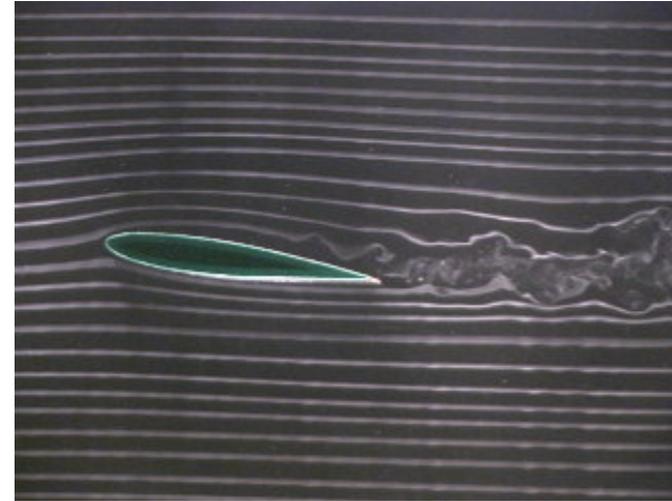
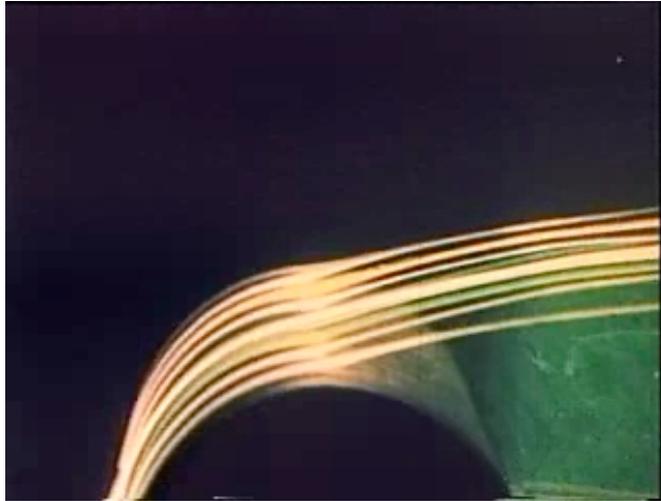
Lignes de courant et champ de pression



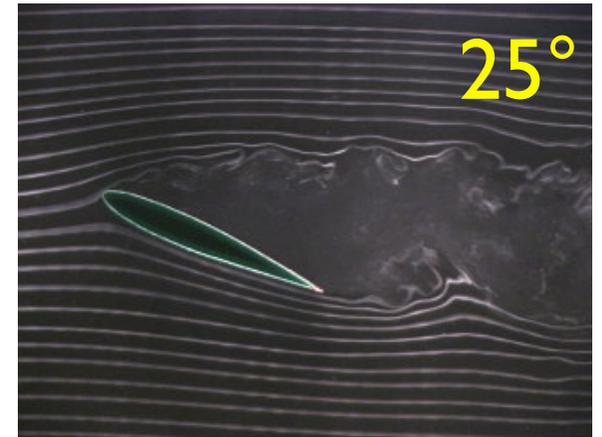
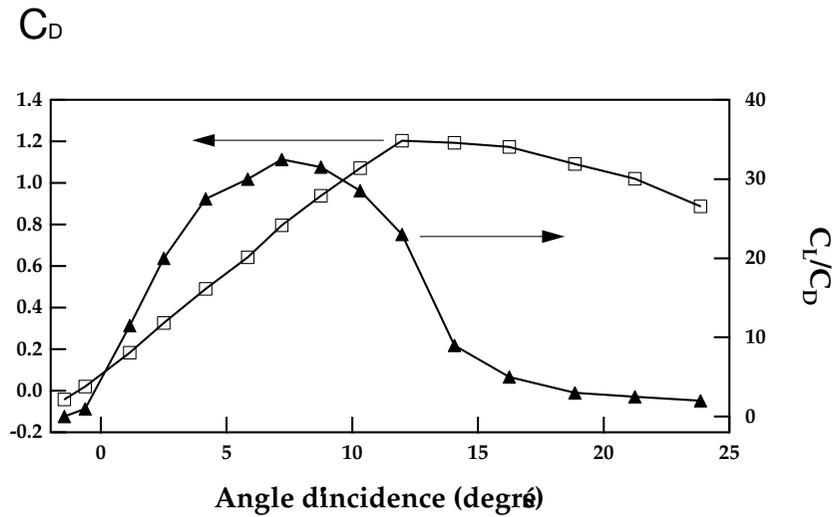
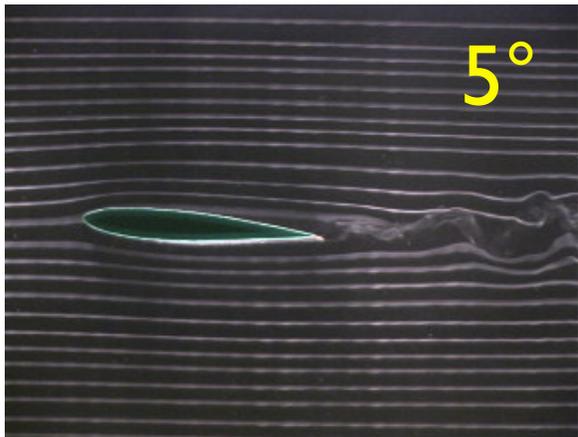
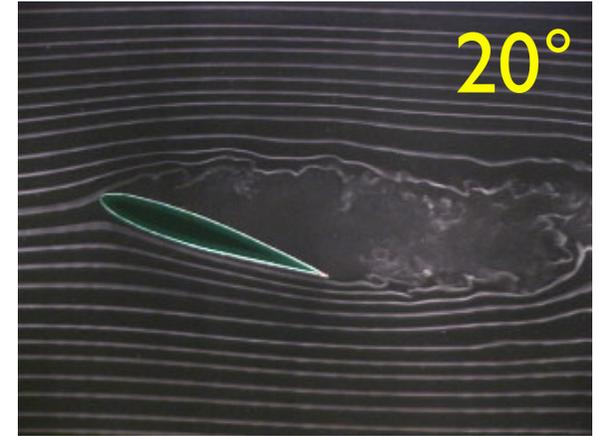
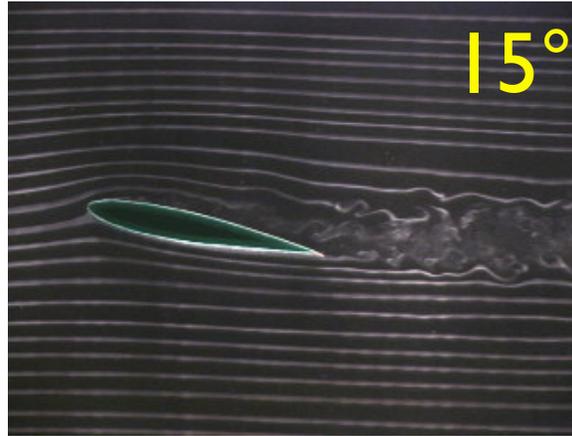
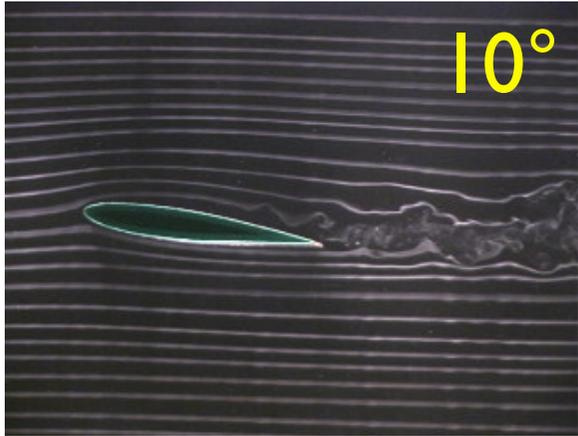
Grad. p
favorable

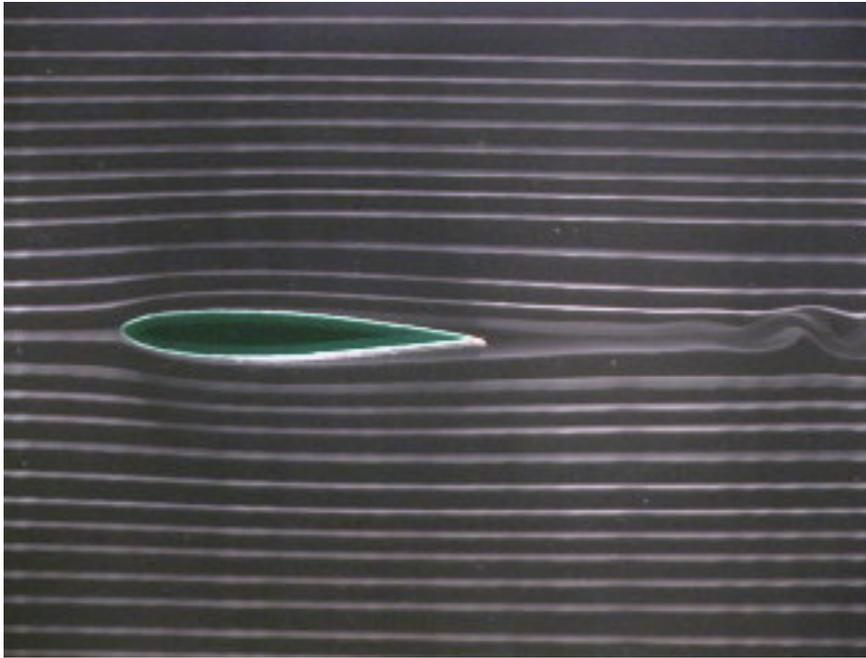
Grad. p
défavorable

Décollement des couches limites et traînée de forme

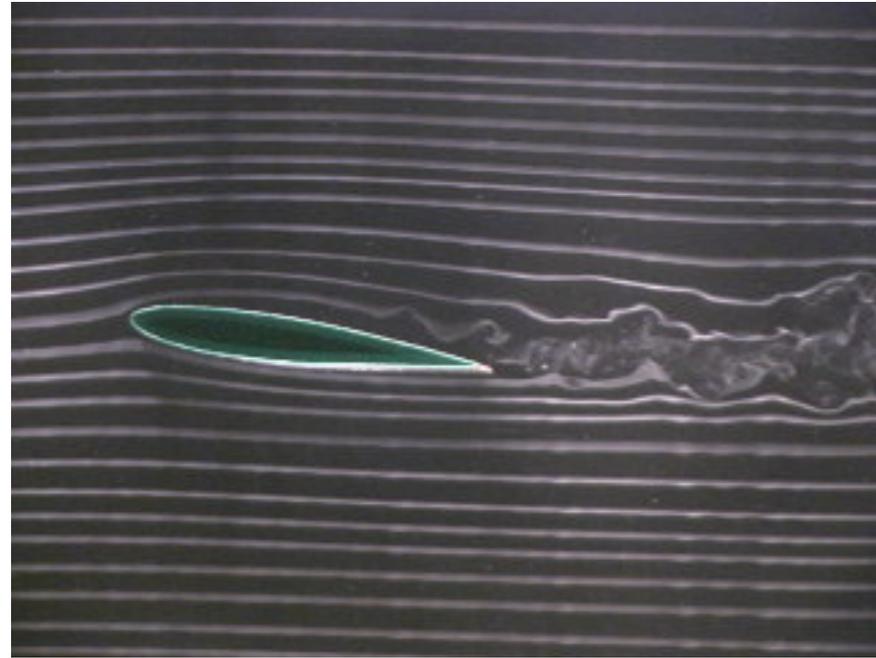


Décollement et portance

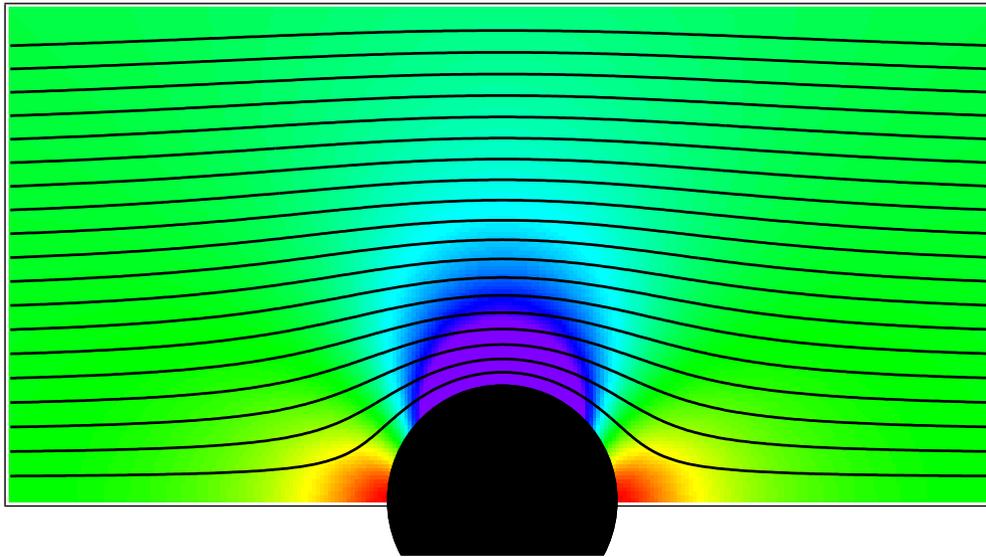




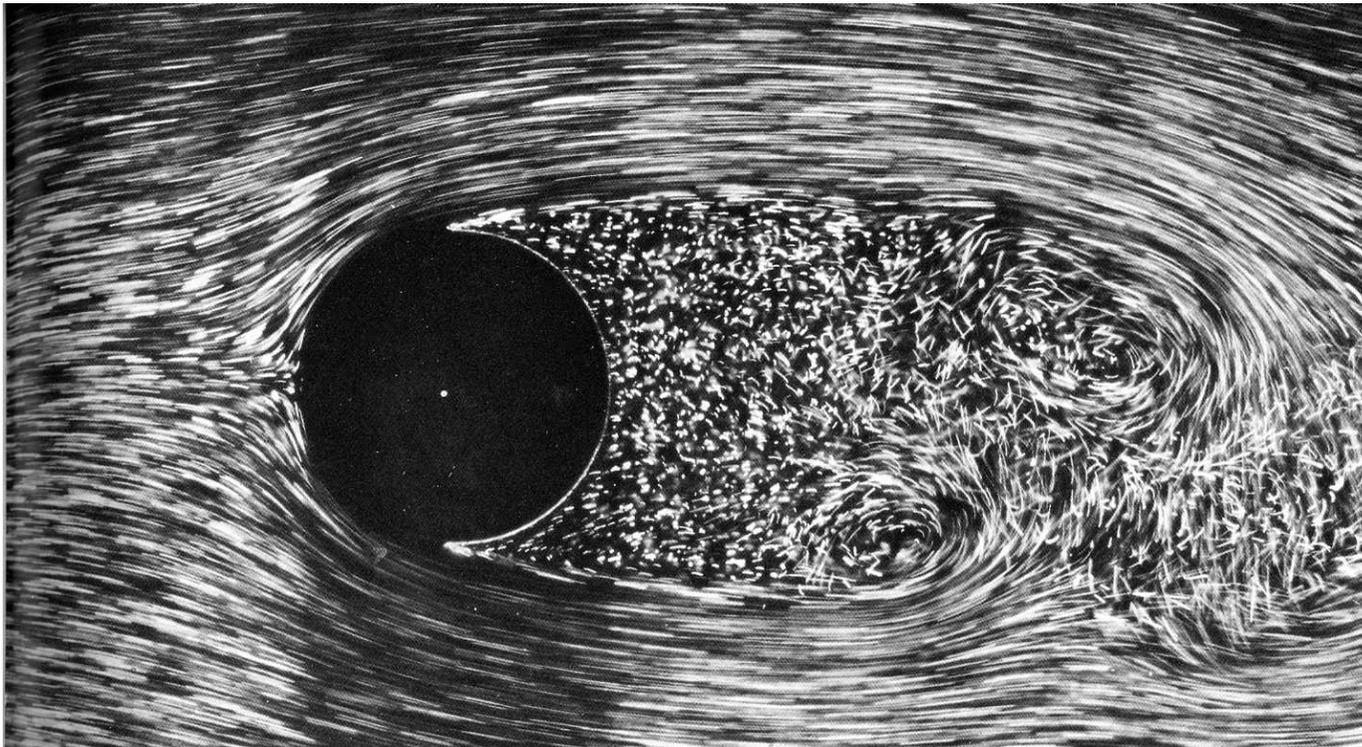
Incidence nulle



10° d'incidence



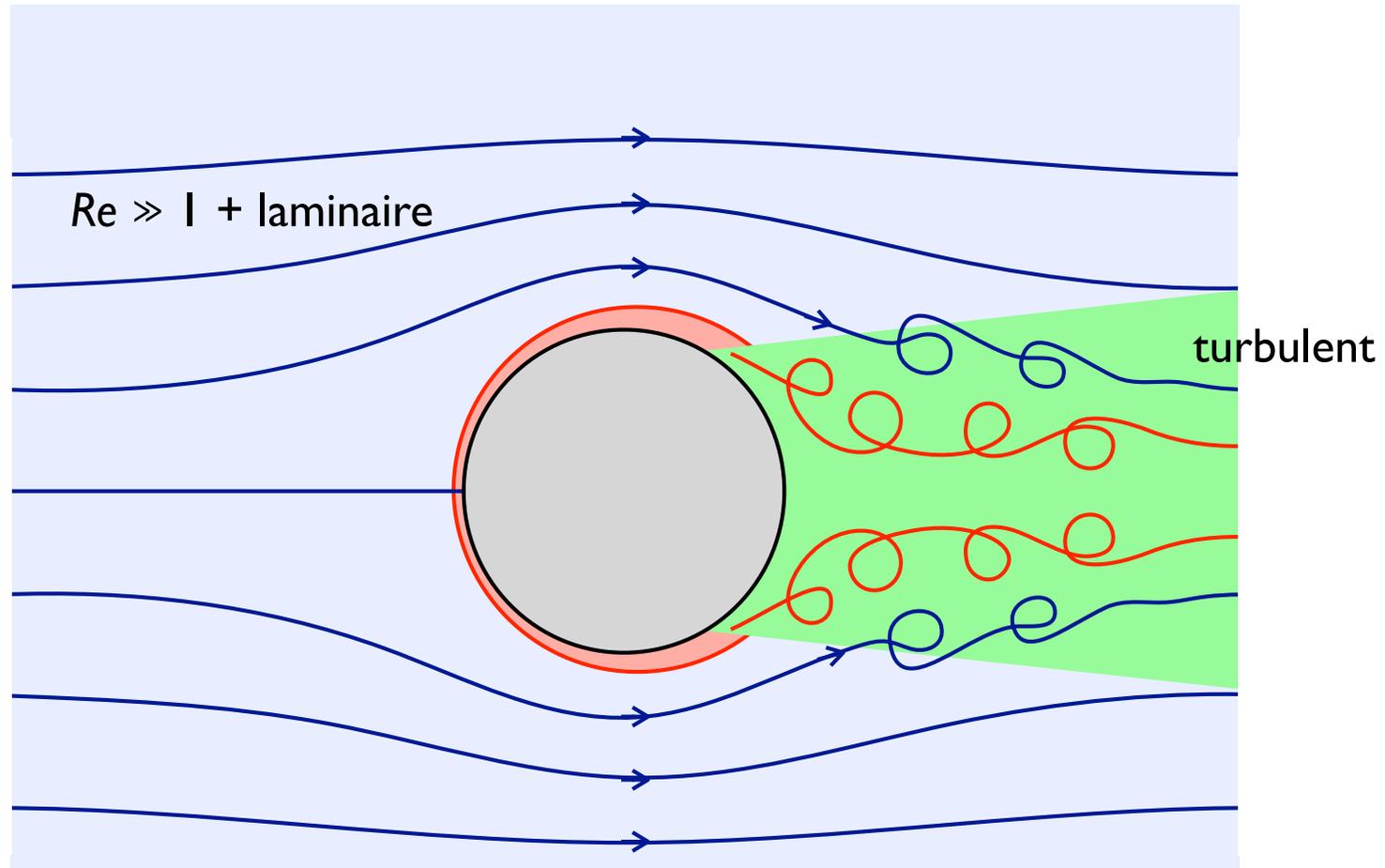
Écoulement potentiel



Écoulement réel

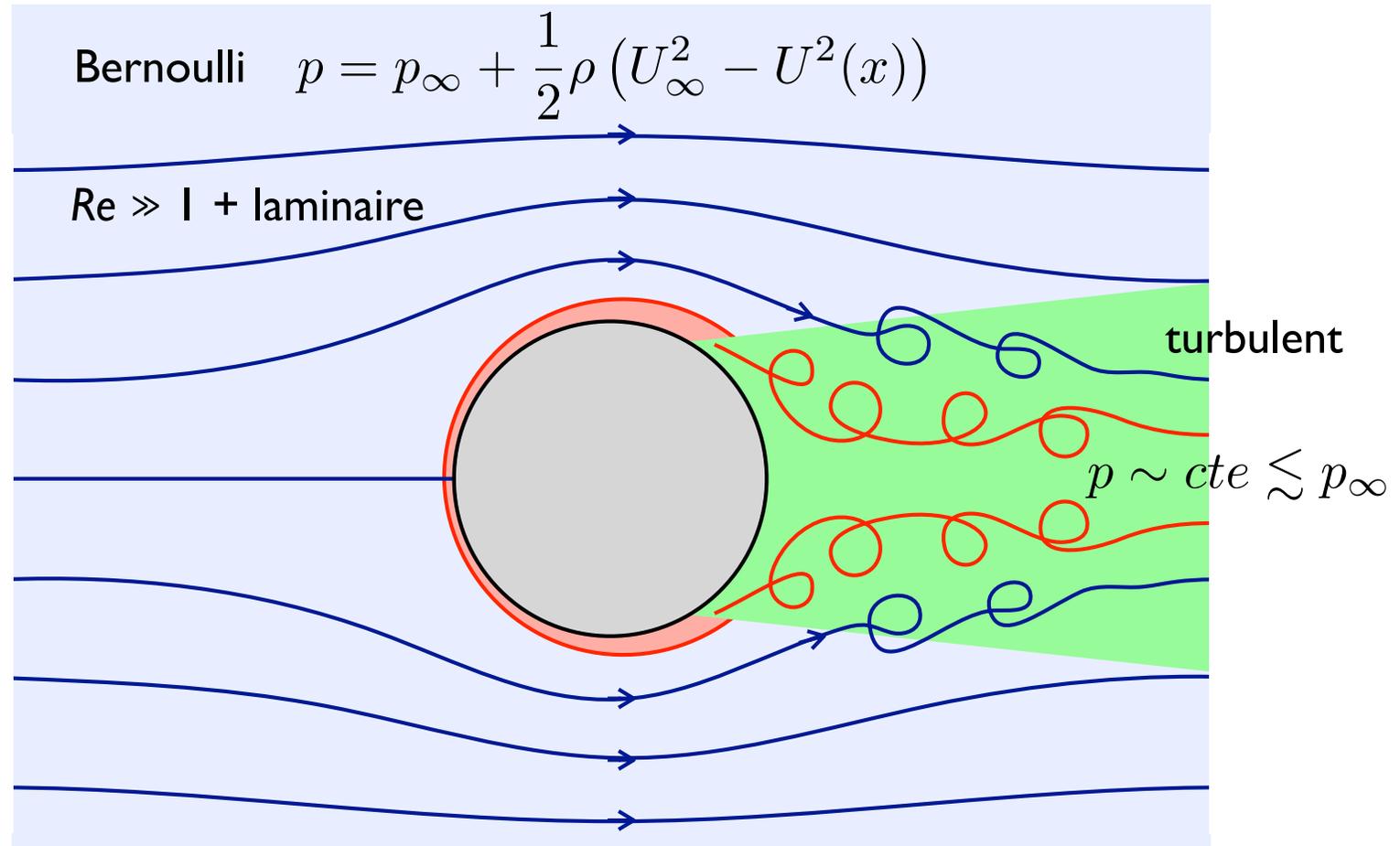
Traînée de forme

Au-delà du décrochement de la couche limite ?



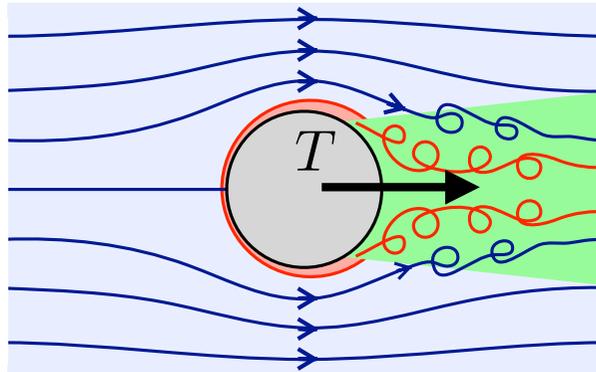
Traînée de forme

Au-delà du décrochement de la couche limite ?



Traînée de forme

Au-delà du décrochement de la couche limite ?



Traînée de forme

$$T = \frac{1}{2} \rho U^2 C_x S$$

C_x, C_d coefficient de traînée

S usuellement section frontale (aviation surface des ailes)

Traînée de forme

Quelques exemples

$$C_x \sim 0.58$$



$$C_x \sim 0.48$$



$$C_x \sim 0.23$$



$$C_x \sim 0.1$$



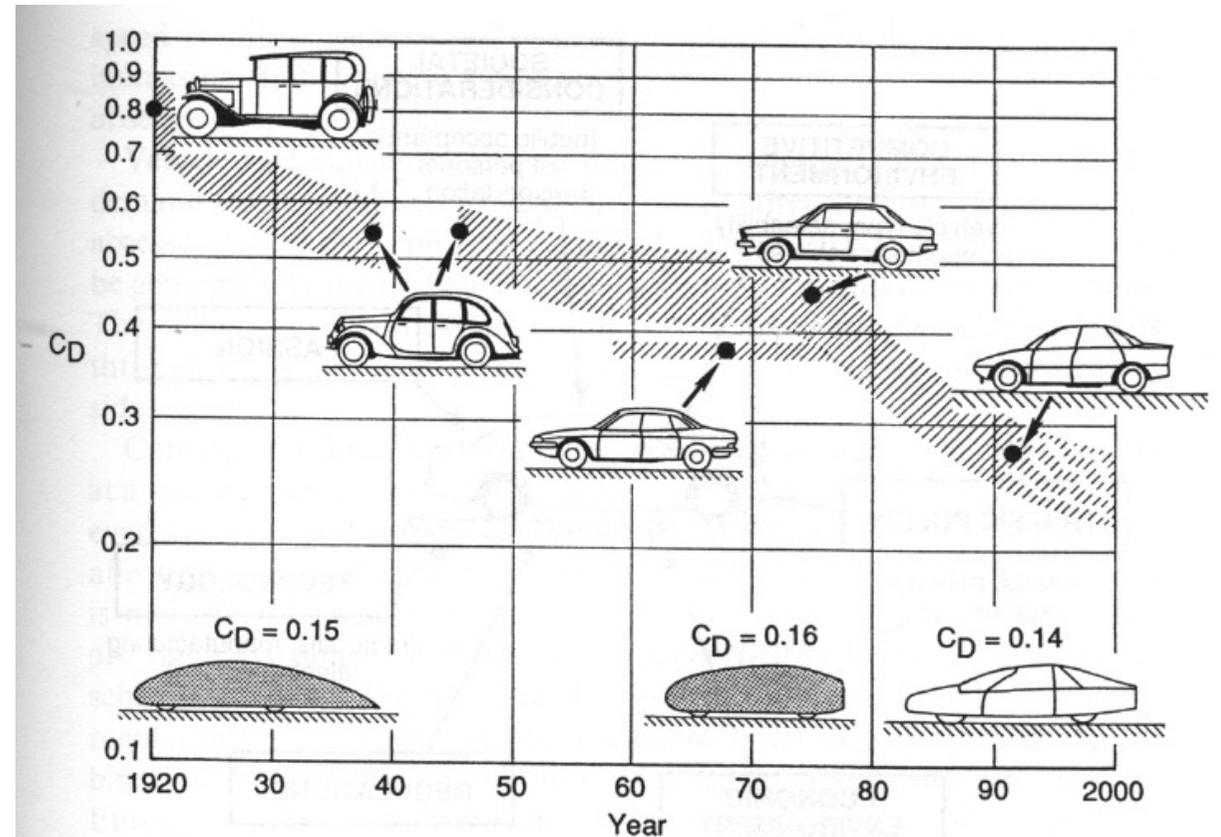
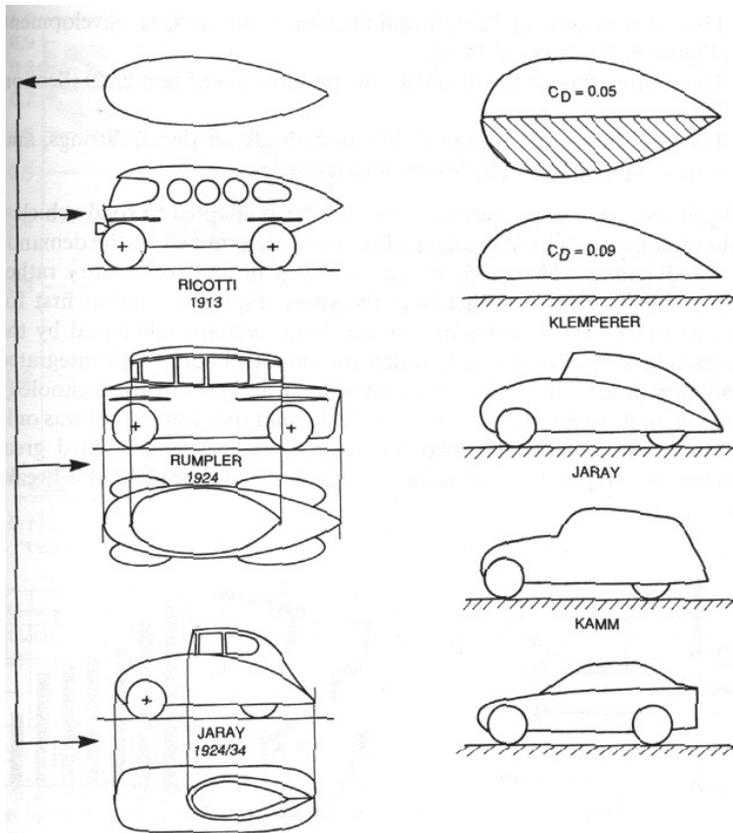
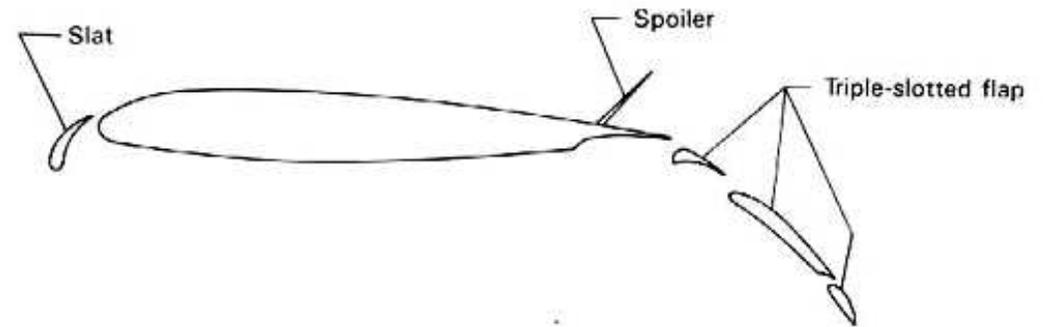
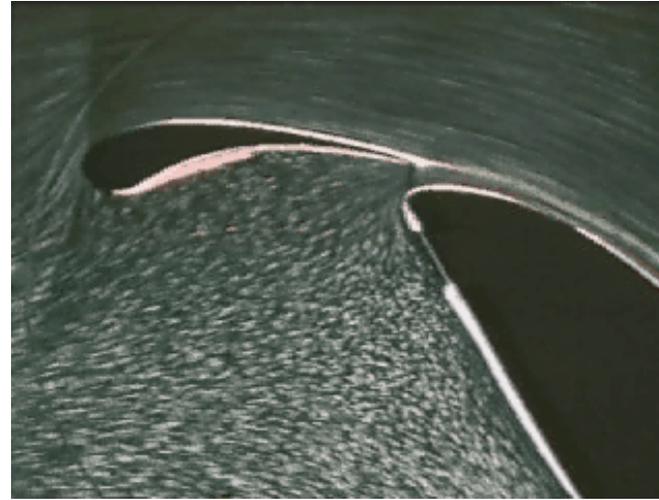


Figure 6 The drag history of cars. Using a logarithmic scale for drag emphasizes how difficult it is to achieve very low drag values. Research has been far ahead of what has been realized in production.



Contrôle du décollement

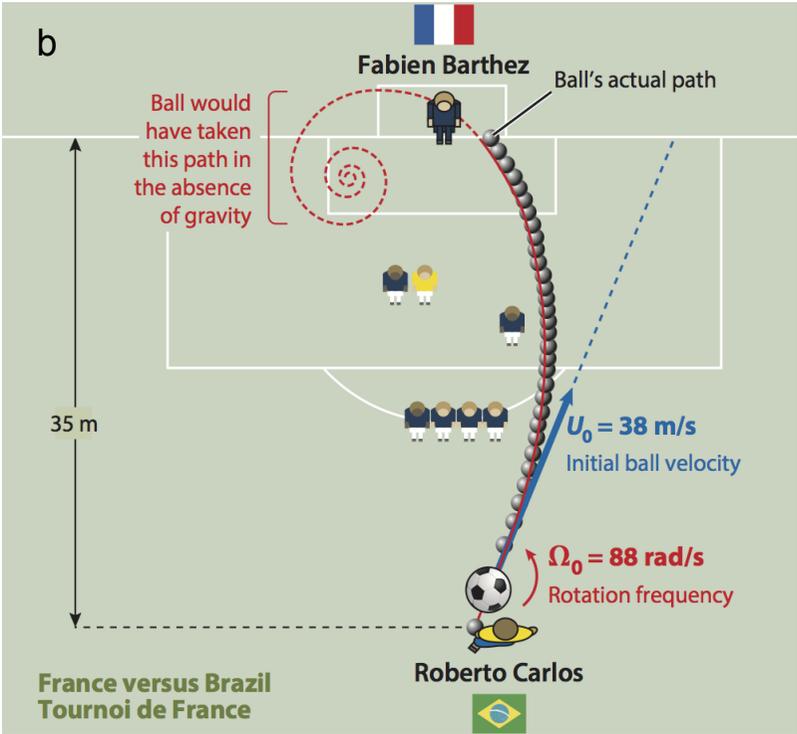
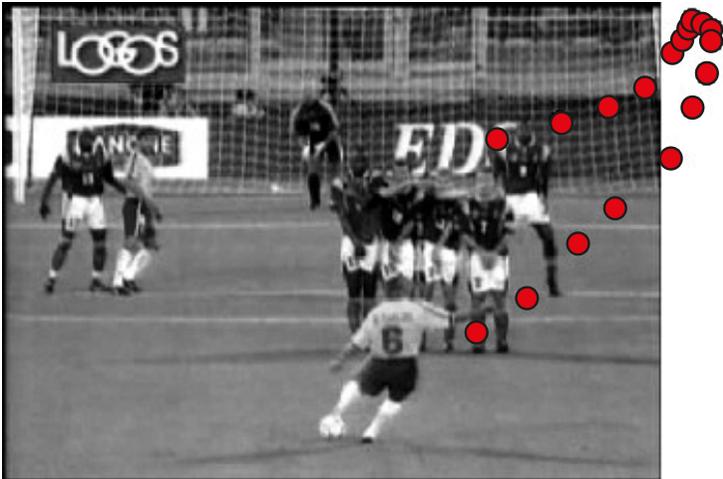


Portance

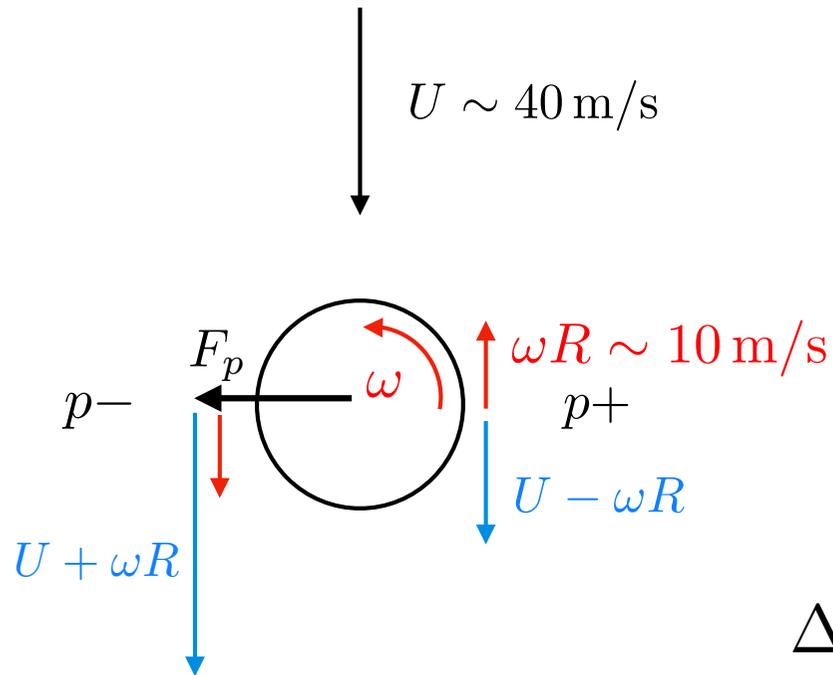
Le but de Roberto Carlos



a



Le but de Roberto Carlos : force latérale sur le ballon

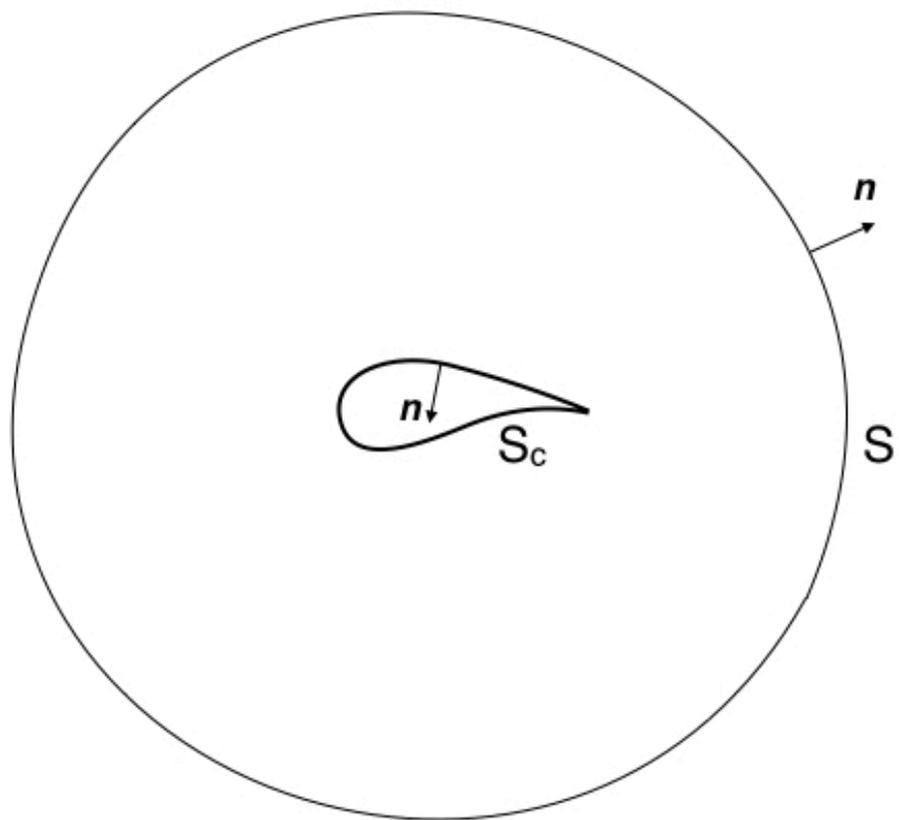


$$\Delta p = \frac{1}{2} \rho [(U + \omega R)^2 - (U - \omega R)^2]$$

$$\Delta p = 2\rho U \omega R$$

$$F_p \sim \Delta p \pi R^2 = 2\pi \rho U \omega R^3$$

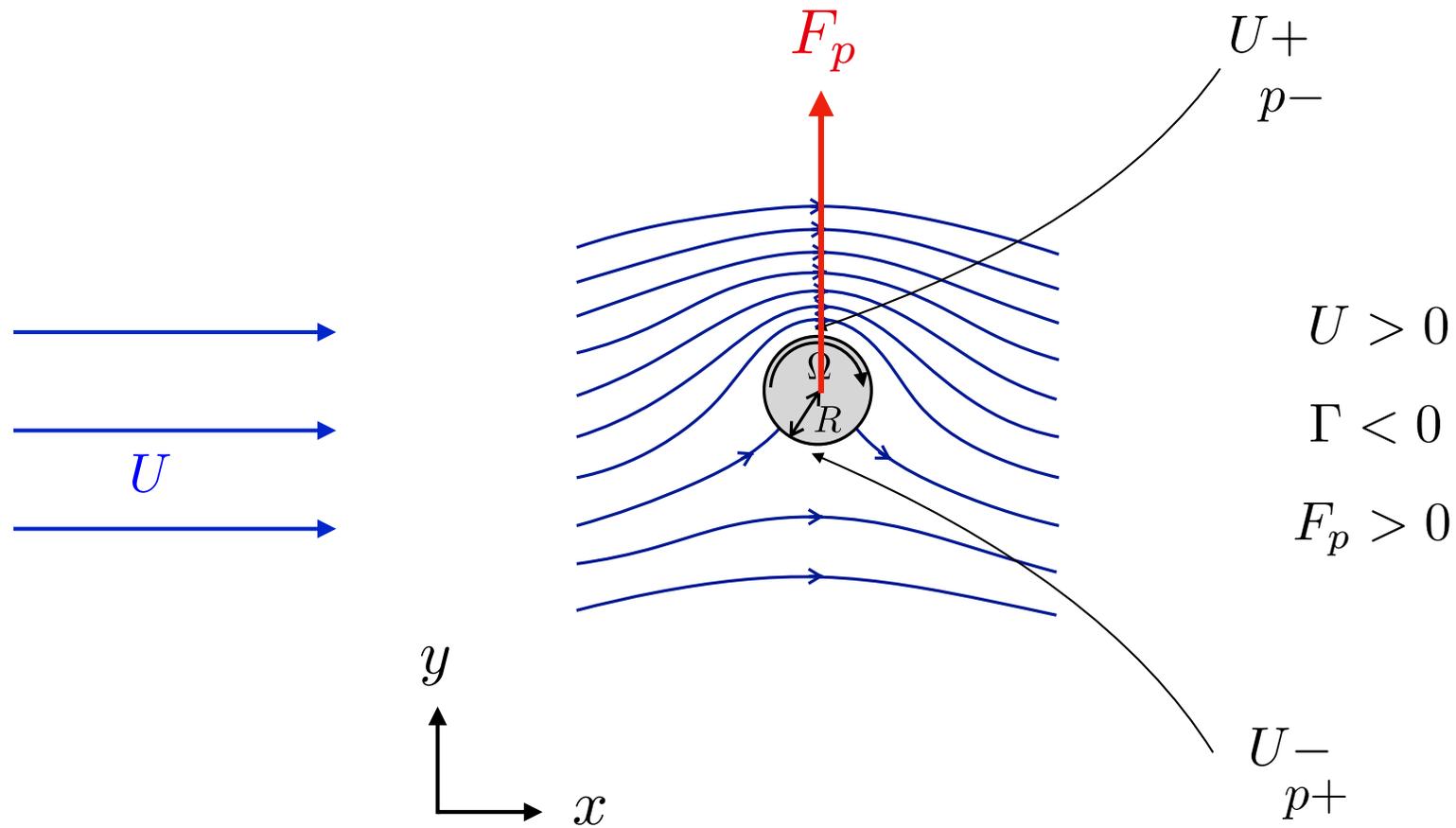
$$\text{A.N. : } F_p \simeq 6.1.40.100.10^{-3} \simeq 24 \text{ N}$$

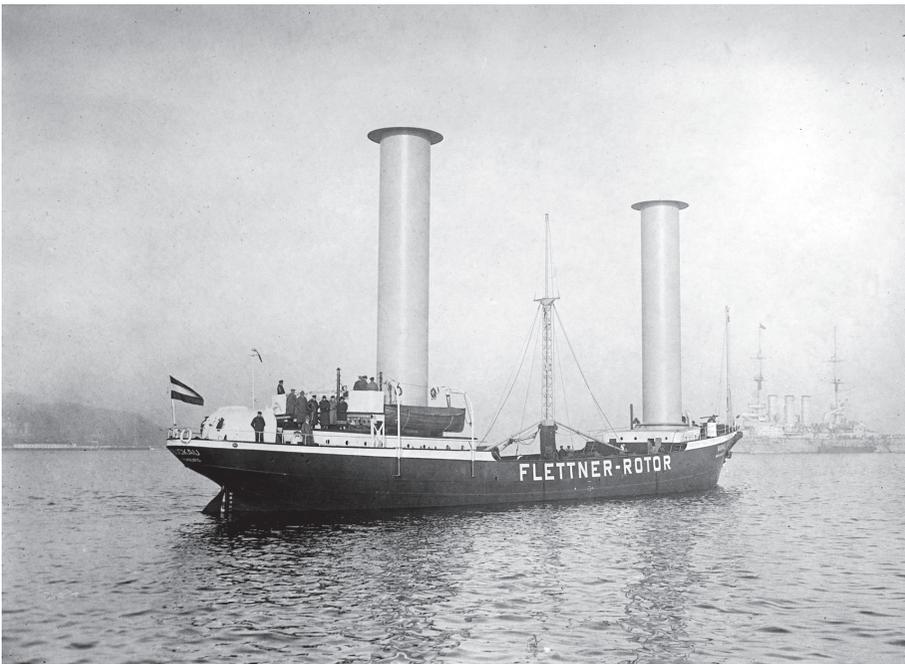


$$F = -\rho \mathbf{U} \wedge \int_S \mathbf{v} \wedge \mathbf{n} dS$$

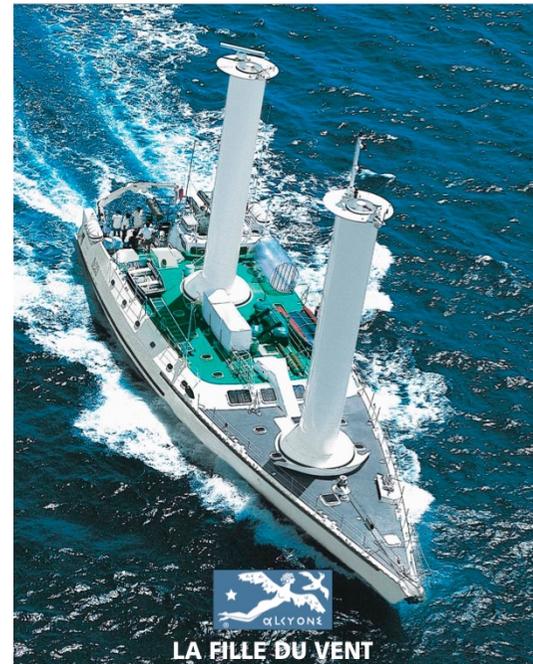
Formule générale de **Joukovski** qui lie la portance à la circulation

$$F_p = -\rho U \Gamma$$





Rotorship Flettner *ca* 1930

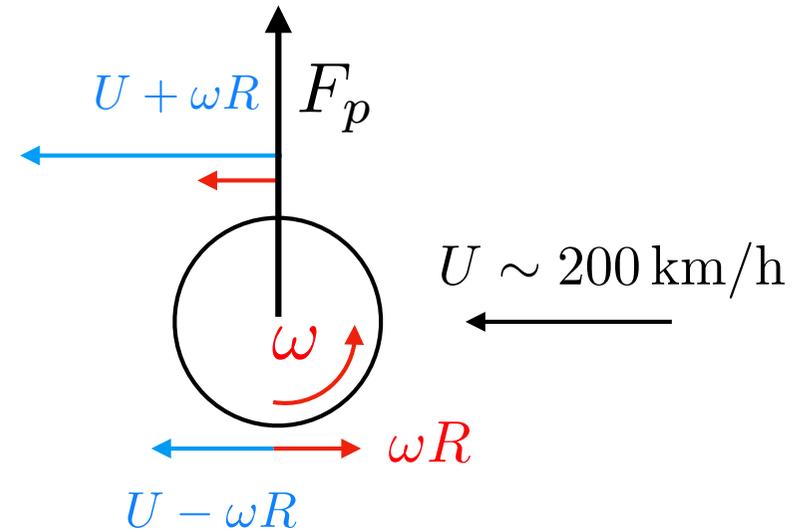
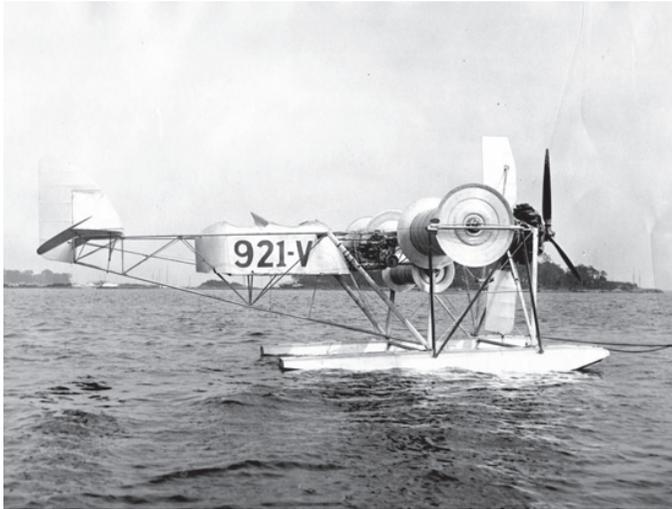


Turbovoile Malavard-Cousteau



E Ship I 2010

Un avion à ailes tournantes ?



$$F_p \sim \rho U \Gamma W \quad \text{et} \quad \Gamma = 2\pi R(R\omega)$$

$$F_p \sim \rho U (2\pi R^2 \omega) W$$

$$\omega \sim \frac{Mg}{2\pi \rho R^2 U W}$$

$$M \simeq 500\text{kg}, U \simeq 50\text{ m/s}, W = 4\text{ m}, R = 0.3\text{ m}$$

$$\omega \simeq 40\text{ rad/s} \simeq 6,5\text{ tours/s}$$

incidences modérées

$$\Gamma = \frac{1}{2} C_p U \ell$$

$$F_p = C_p \frac{1}{2} \rho U^2 \ell L$$

$$T = C_x \frac{1}{2} \rho U^2 \ell L$$

Polaires

