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Circular hydraulic jump

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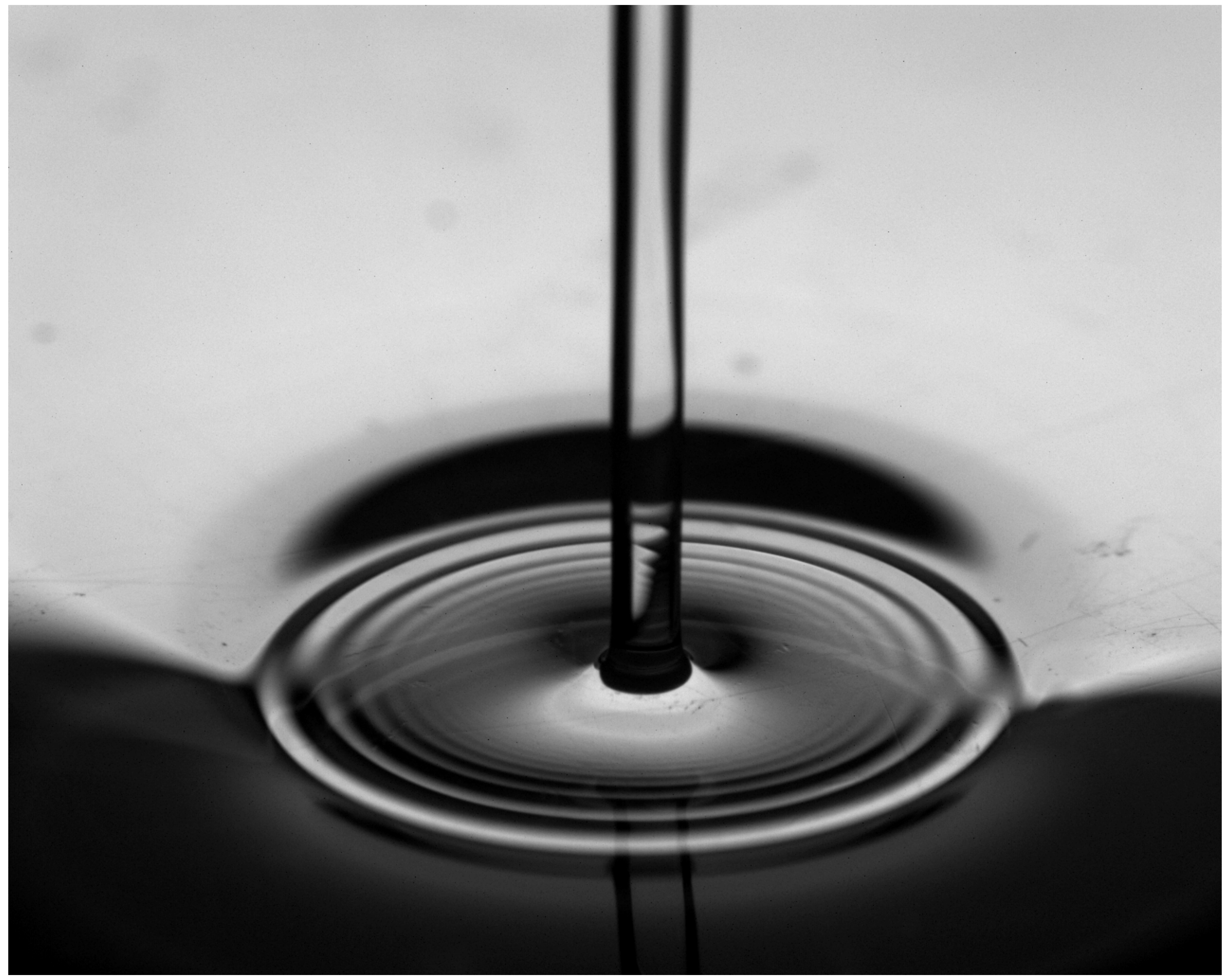
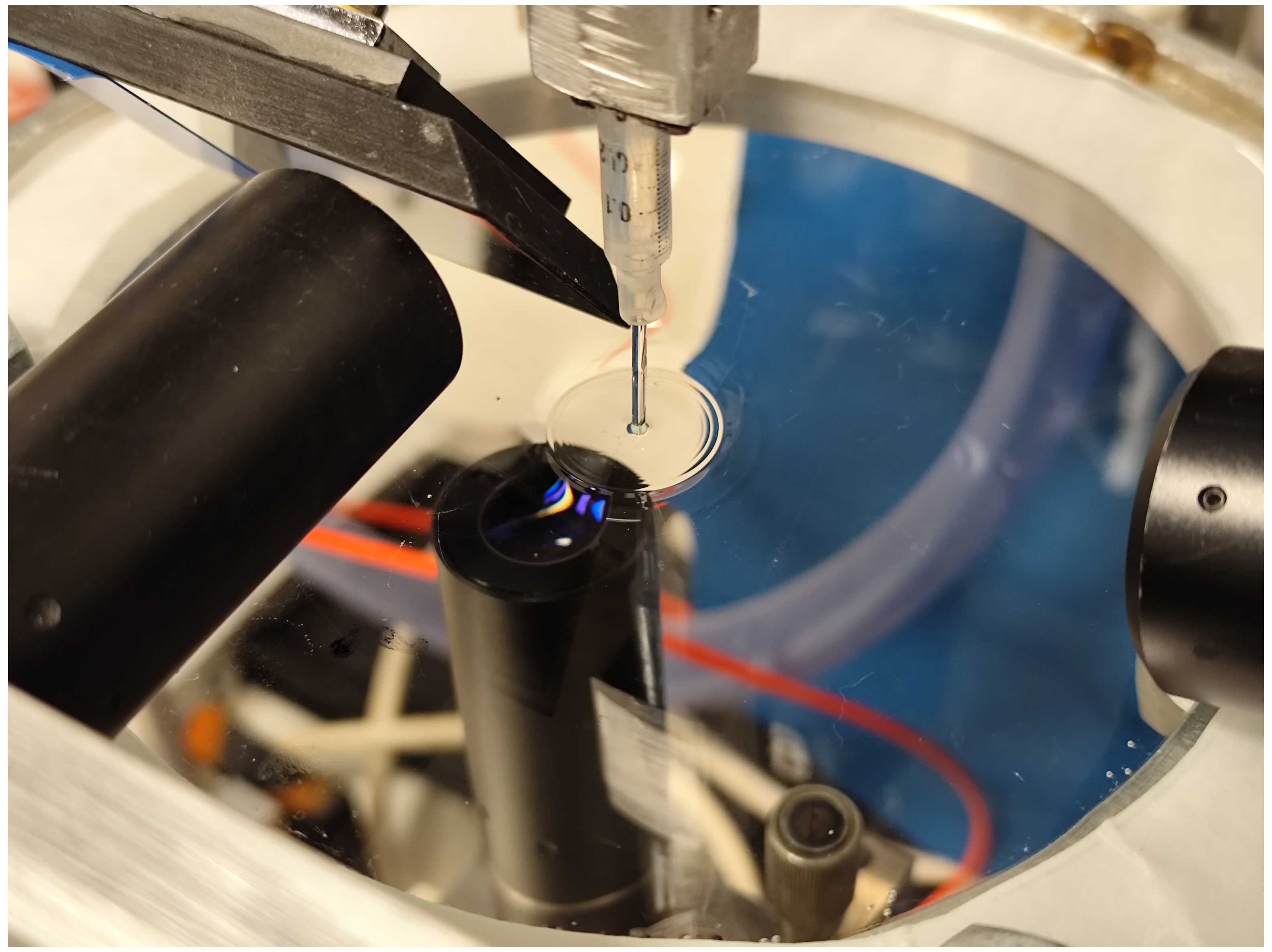


Hydraulic jump is an old free surface flows problem, where arise a sudden transition from high speed, supercritical flow to a subcritical one, with a sudden jump of the fluid depth.

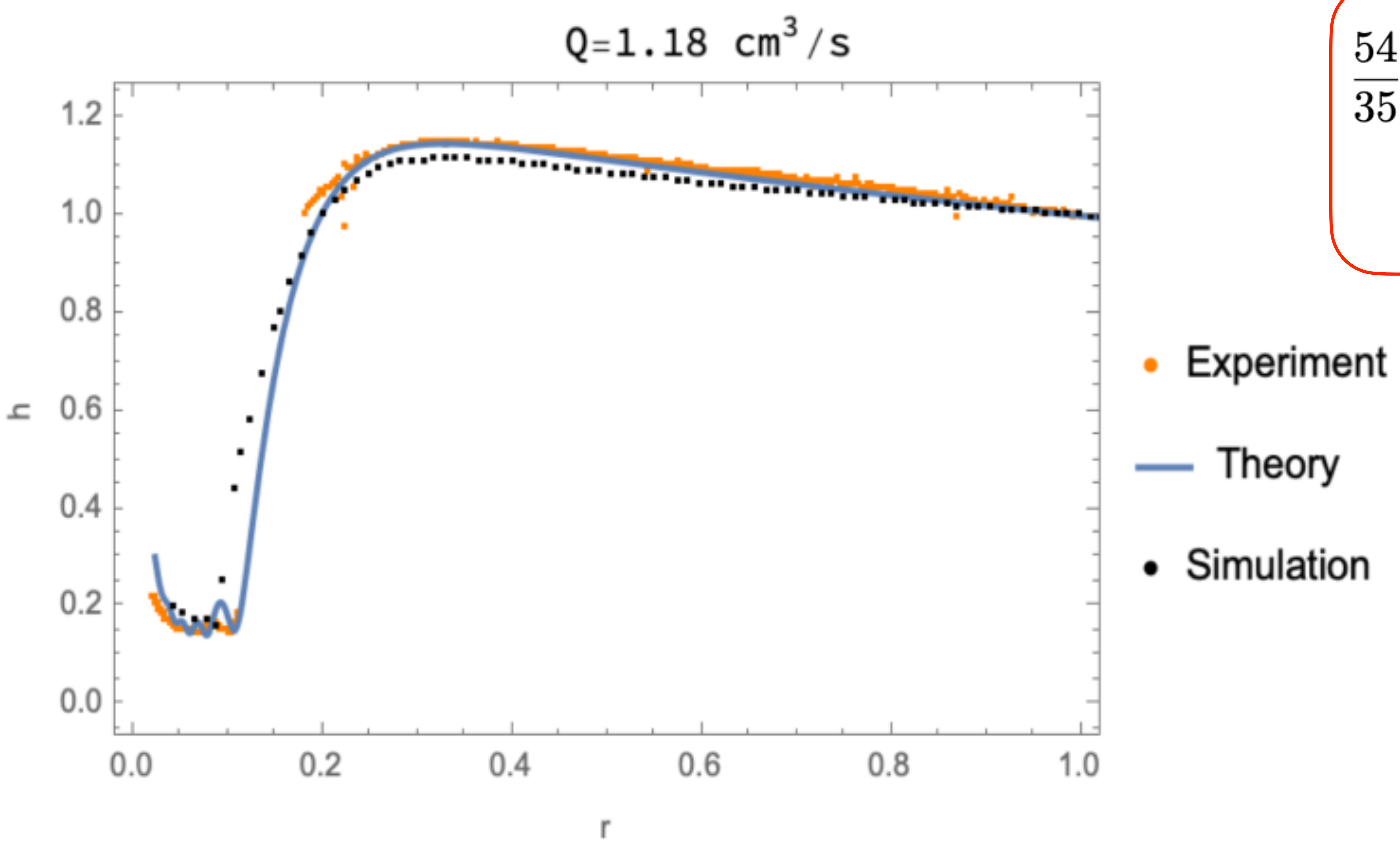
Many quantities are involved: viscosity, gravity, surface tension and the inertial term makes the problem non-linear.



Experiment

We managed to stabilize a jet of water for different fluxes, and we use Chromatic Confocal Pen to measure the profile thickness and to detect the ripples before the jump.

Theory



$$\frac{54}{35} Re U U' = -\partial_s \tilde{P} - 3\frac{U}{h^2} + \frac{3\epsilon^2}{h}\left(\frac{12}{5}h''U + \frac{8}{5}h'U' + \frac{7}{10}\frac{h'U}{s}\right)$$

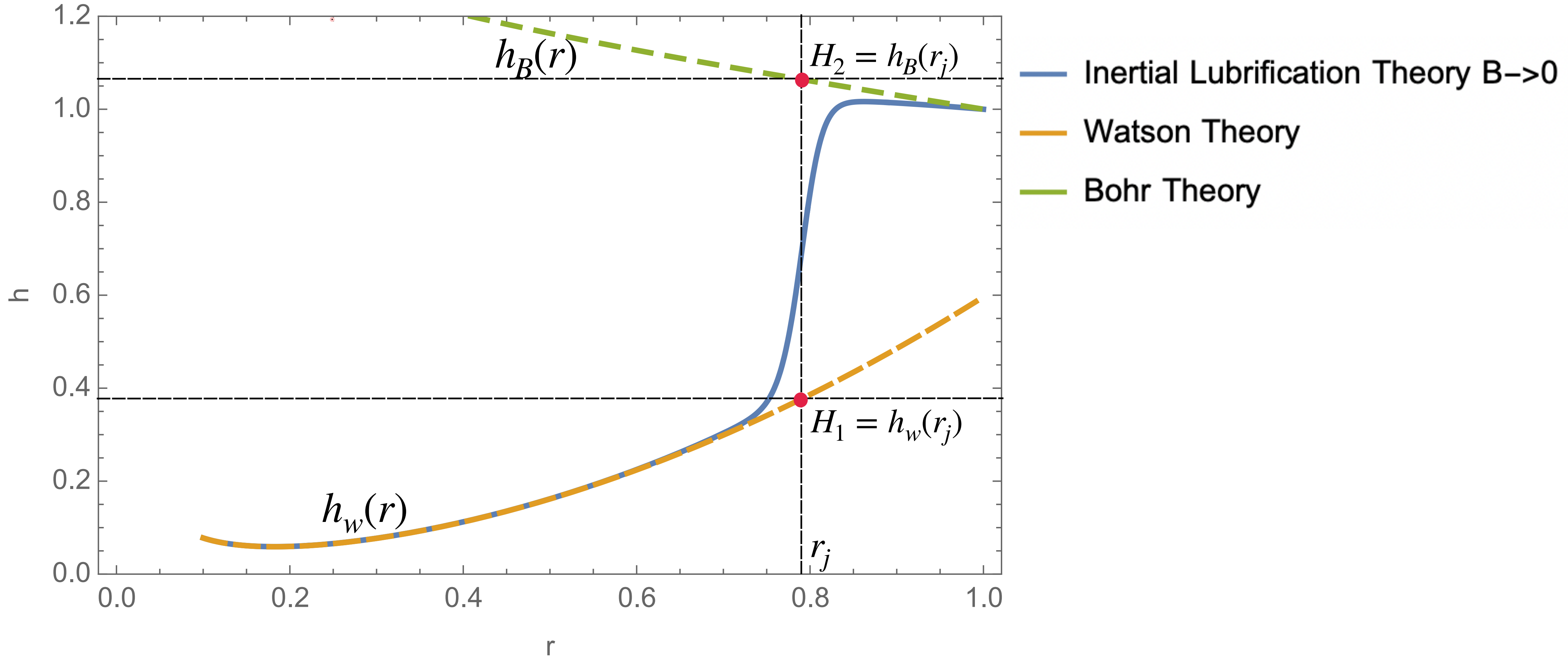
$$\tilde{P} = Gh - B\frac{1}{s}\partial_s\left(sh'\right),$$

Mean velocity:

$$U = 1/sh$$

From Rojas et al, PRL, 2010.

For $B \to 0$: Boundary layer approximation



Implicit relation for the position r_j of the jump

$$H_1^{1/3}\left(\frac{5}{27Fr^2}H_1^2 + \frac{1}{H_1^2 r_j^2}\right) = H_2^{1/3}\left(\frac{5}{27Fr^2}H_2^2 + \frac{1}{H_2 r_j^2}\right) \qquad Fr^2 = \frac{Re}{G} = \frac{U_0^2}{gH_0}$$

In the limit: $H_1 \ll H_2 \longrightarrow r_J \propto \left(\frac{Q^5}{g\nu^3}\right)^{\frac{1}{8}}$ Bohr scaling law

Objectives

-Find an expression for the radius of the jump including the effect of the surface tension

-Investigate better the nature of the ripple before the jump

- Find an analytical solution for the profile thickness

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