Walking Droplets In Confined Geometries

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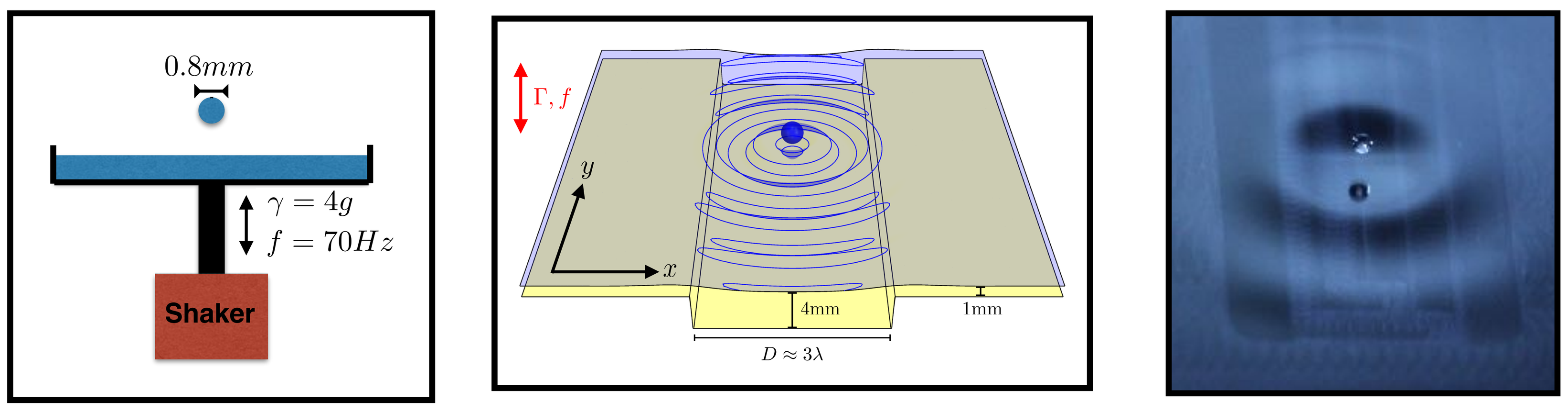
1) Abstract

Since the pioneering works of Couder and coworkers [1], a growing interest has emerged about bouncing and walking droplets. Various experimental works have been performed in 2d systems. Recent studies focused on droplet confinement. In particular, it was shown that by using a magnetic force it is possible to trap a drop in a harmonic potential [2,3]. For the very first time, we present the possibility to control droplet trajectories so that droplets are confined along 1d paths, thanks to linear submerged cavities used as waveguide for the drop. Thus, we work with an annular cavity and we evidence differences with 2d behaviors [4].

2.a) Walk the line

We study the motion of a droplet in **submerged linear cavities**, of different widths D, proportional to the **Faraday wavelength** λ_F. The cavity is **vertically vibrated**. The drop remains in the **deep water** region and can not walk in the **shallow water** region.

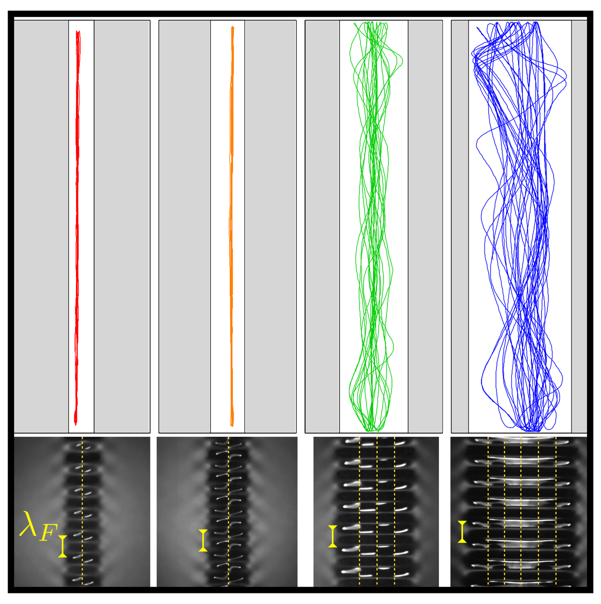


2.b) From 1d to 2d trajectories

Trajectories of a drop within four channels, of width $D/\lambda_F \simeq \{1.5, 2, 4, 6\}$.

Narrow channels: **linear** motion.
Large channels: **wobbling** motion.

Pictures of the **Faraday Instability**.
Faraday periodic pattern along the *y* axis.
Bump along the x axis.
We evidence a **substructure** of *m* **modes** along the *x* axis.



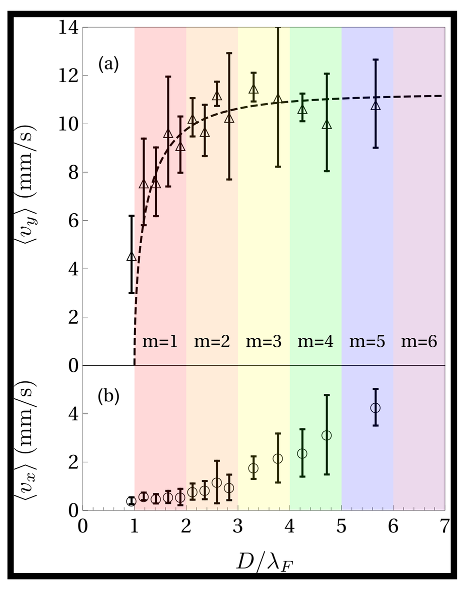
2.c) Faraday propagation, waveguide analogy

Analogy with the **light group velocity in TE1 waveguide**:

$$v_y = v_y^0 \sqrt{1 - \left(\frac{\lambda_F}{D}\right)^2},$$ v_y^0 is the 2d speed of a drop.

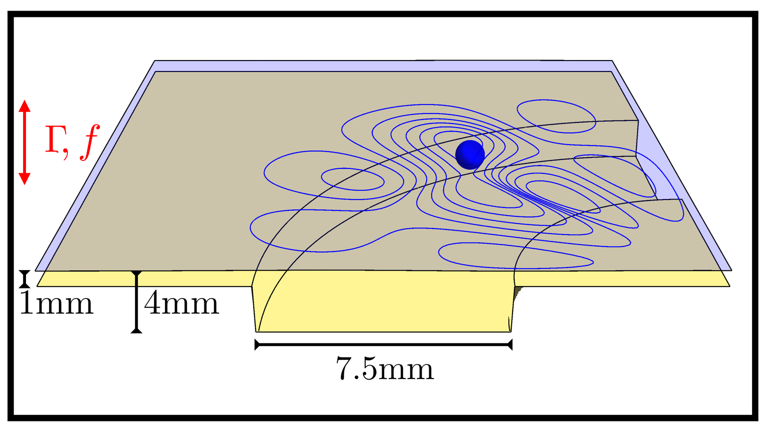
Some differences:

- the Faraday instability **auto-adapts** to the channel width.
- λ_F **varies** in the experiment while it is **constant** in the electromagnetic case.
- evanescent waves outside the channel [5].



m denotes the mode of vibration.

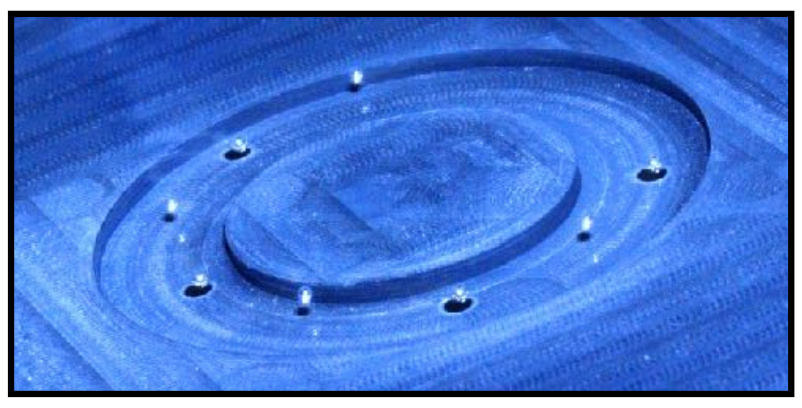
3.a) One ring to rule them all



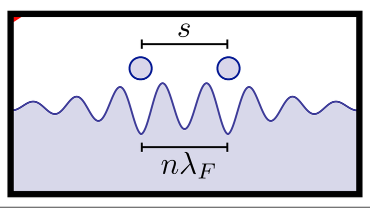
Case of droplets **confined** in a **submerged annular cavity**. The width is chosen to ensure a **1d motion** for the walkers.

A string of 8 identical droplets with:

- **antisynchronous** bounces
- **quantized interdistances**.



The space between drops is given by $s = (n - \varepsilon_0)\lambda_F$ where n is an integer.

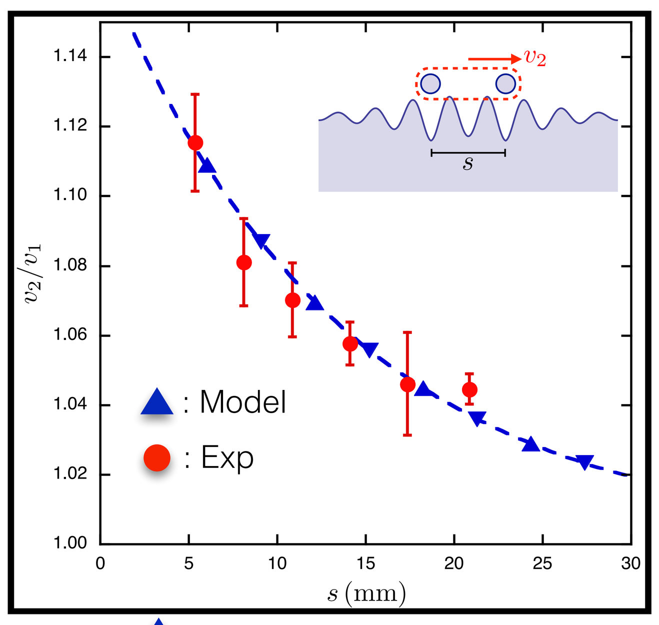


3.b) Influence of the distance between droplets

v_2/v_1 **decreases exponentially**.

Model in **good agreement** with the experiment [6].

The closer a pair of walkers are, the faster they move.

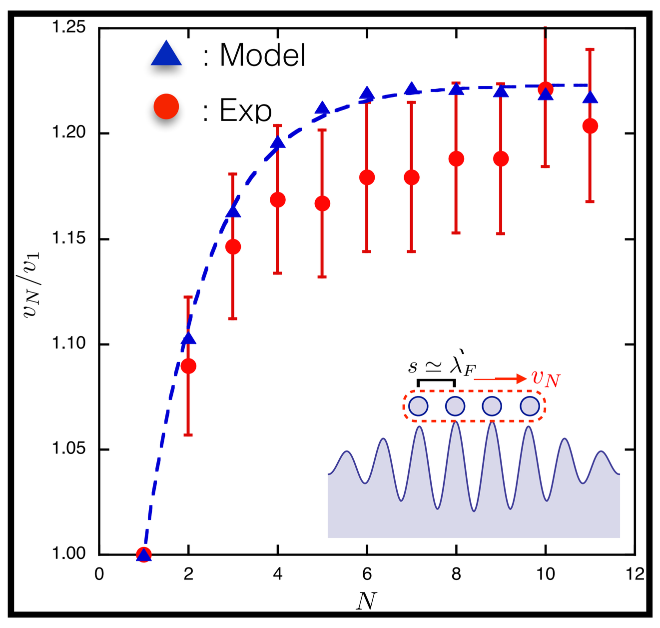


▲ : synchronous bounce
▼ : anti-synchronous bounce

3.c) Influence of the number of droplets

Speed of a string of droplets **regularly spaced**.
The speed **rises exponentially** with ***N*** until saturation.
Model in **good agreement** with the experiment [6].

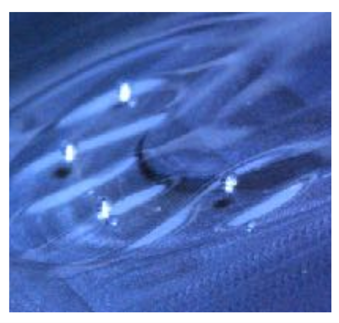
All the drops interact and share a **coherent wave**.



4) Conclusion

- We **confine** a drop in a 1d geometry.
- The channels are **waveguides** for Faraday waves.
- A **fine structure** of *m* modes is observed in the **transversal direction**.
- We **model** the **longitudinal speed** of a walker within a linear channel.
- Analogies and differences with waveguides.

- **Quantization** and **influence** of the **distance** between droplets.
- **Influence** of the **number of drops** on the speed of a string.
- A **model** developed in **good agreement** with the experiment.
- A chain of drops share the same **coherent wave**.
- **Constructive interferences** cause an increase of the speed.



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[2] Perrard *et al.*, Nat. Commun. **5**, 3219 (2014).
[3] Labousse *et al.*, Phys. Rev. E **90**, 022913 (2014).
[4] Borghesi *et al.*, Phys. Rev. E **90**, 063017 (2014).
[5] Filoux *et al.*, arXiv:1507.08228 (2016).
[6] Filoux *et al.*, Phys. Rev. E **92**, 041004(R) (2015).

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Quandrops

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