PSE - Wave resistance

Figures

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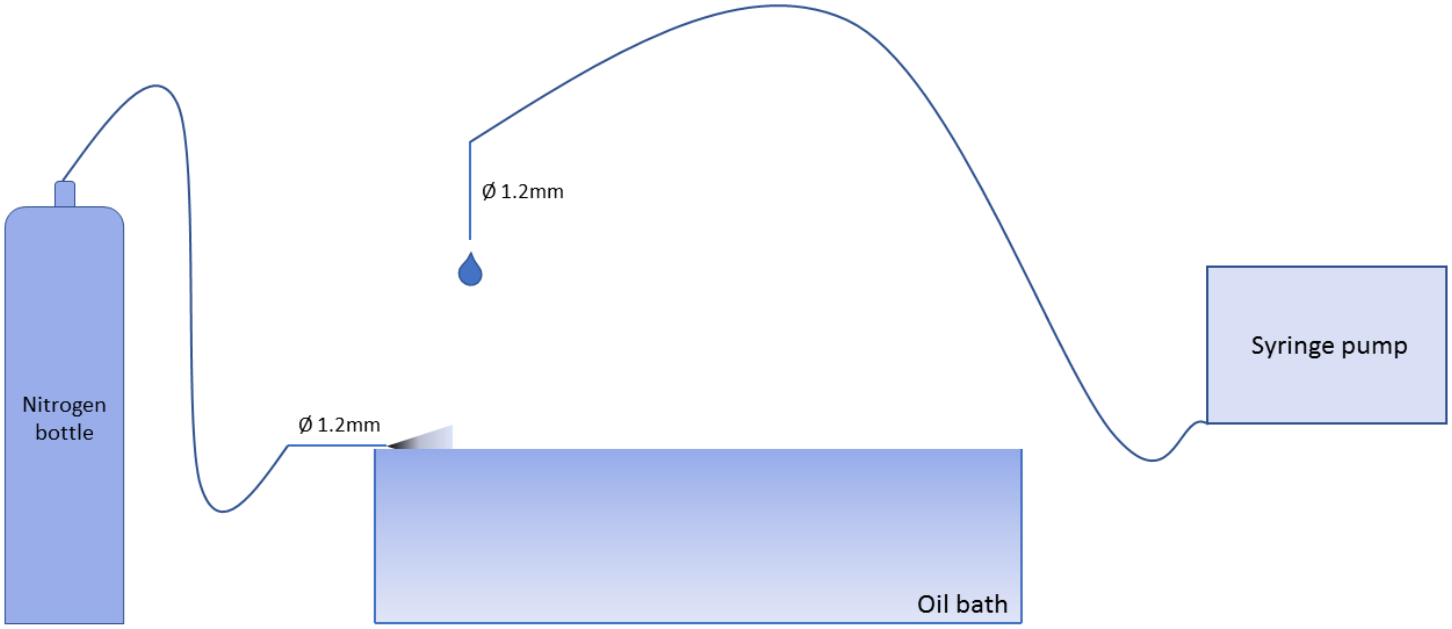

Figure 1: Experimental setup

The syringe pump allows to have a regular delivery of water drops. The air flow is generated by a nitrogen bottle connected to a needle (diameter: 1.2 mm), and pushes the drop with a flow velocity of about 3 m/s. The drop slides on the fluorinated oil bath until its fall into the bath.

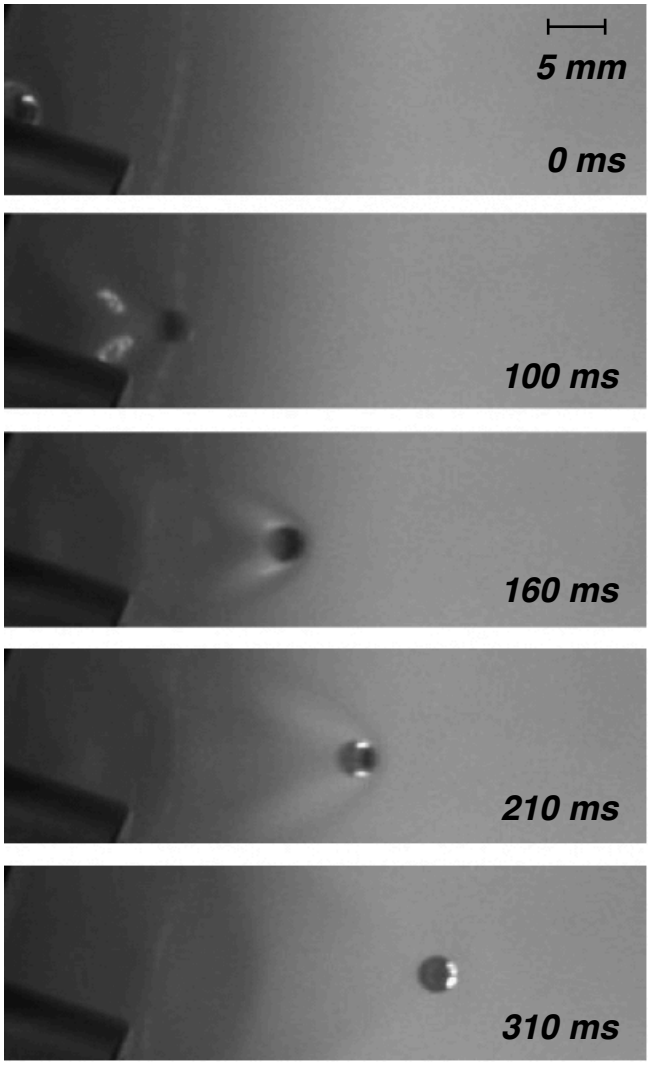

Figure 2 : Successive top views of a water drop sliding on fluorinated oil.

The drop diameter is 3.5 ± 0.3 mm. Images were taken by a camera with an acquisition rate of 100 images per second. The air flow accelerates the drop until a critic velocity beyond which a wave is generated. The wave slows the drop down and then disappears. The moment the wave disappears seems to be better determined than the moment it is formed.

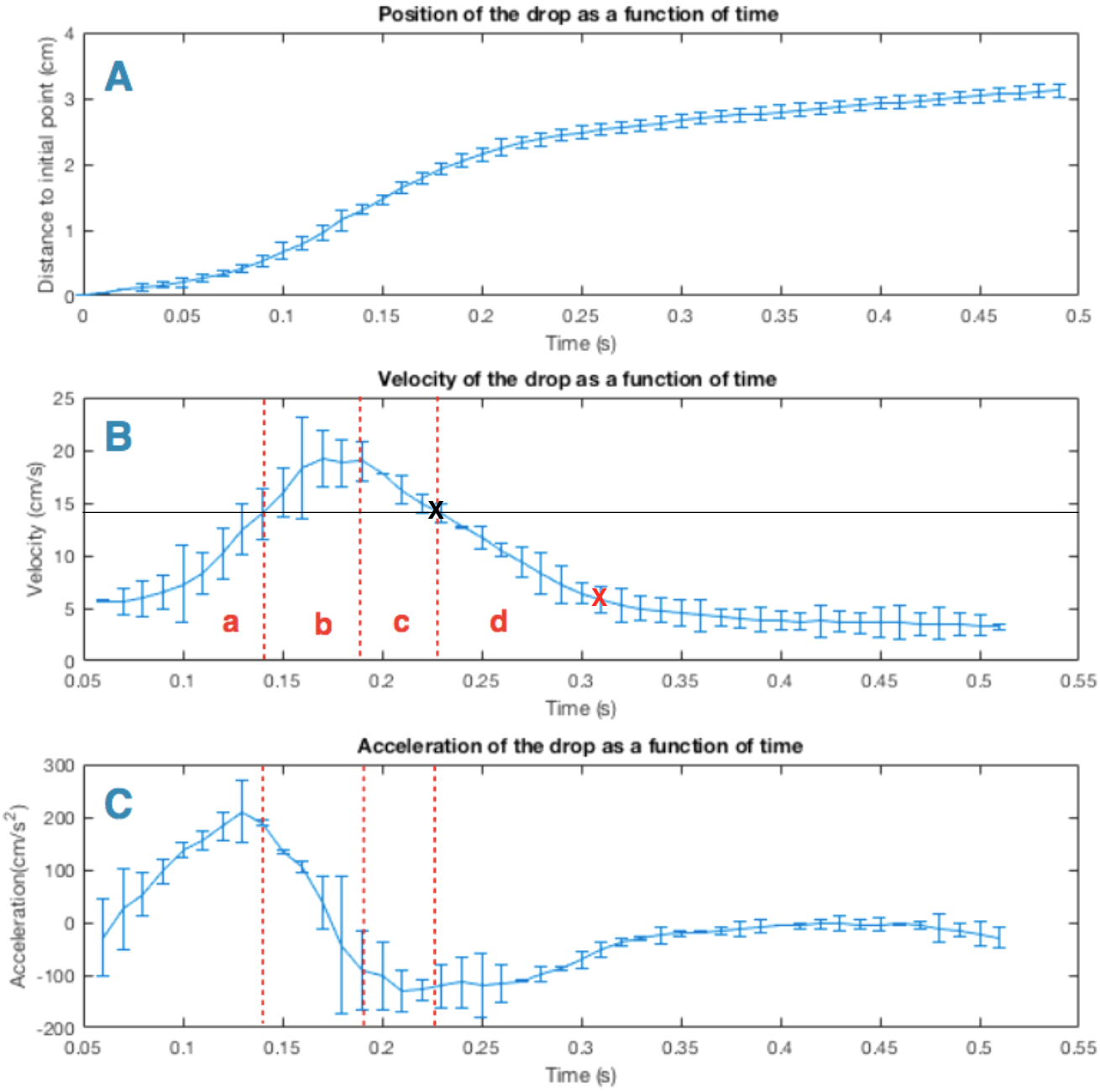

Figure 3 : Position, velocity and acceleration of the drop as functions of time.

(A) All images of the drop sliding on oil are processed under Image J, an image processing software. The same part of each image, along the trajectory of the drop, are juxtaposed vertically, using the Reslicing function. In this way we have the position of the entire droplet, depending on time. An algorithm has been developed to find the position of the center of the drop as a function of time.

(B)/(C) From the position of similar drops, the average velocity is calculated. We notice four different parts of the movement: (a) At first, the drop is pushed by the air flow, and accelerates. (b) A wave appears beyond a critical velocity, but does not stop the drop. The acceleration decreases but the drop is still accelerating. (c) Then, when wave resistance gets superior to the force due to the air flow, the drop begins to slow down. The wave dissipates the drop's energy. (d) When the velocity drops under a critical value, it is not sufficient to produce a wave on the surface of the oil

bath anymore. The drop continues to slow down.
The black cross indicates the theoretical velocity under which wave cannot be generated anymore. As the wave is still propaging on the surface, the time the wave is not generated anymore cannot be measured properly. However, the red cross indicates the wave's disparition time we identified on the images, at 310 ms.
To determine the moment of emergence of the wave, it is assumed that the velocity of wave disparition is the same as the velocity of wave emergence : it is the lowest velocity allowing the propagation of a wave on the oil. Following that logic, the wave should appear between 60 and 70 ms, but it is not noticeable on the images. Indeed, this critical velocity is valid for a uniform linear motion, but here the drop is accelerating. It is thus possible to see a wave under the critical velocity.