The role of deformation in the bouncing droplet problem.

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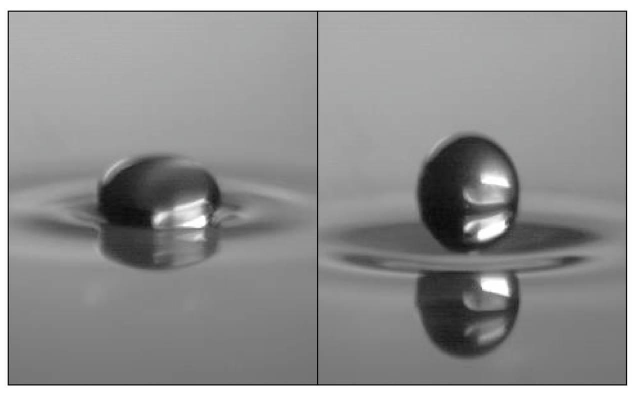

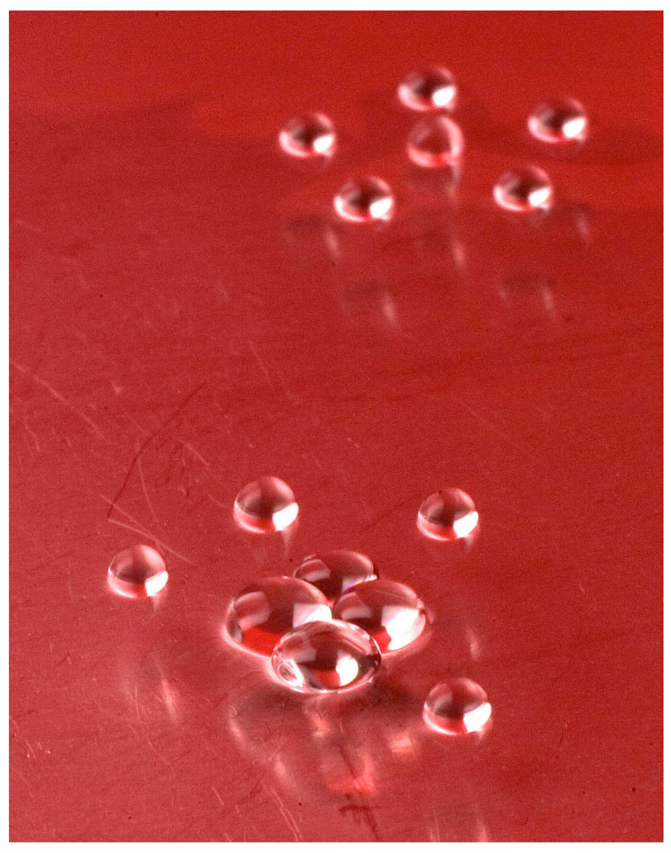

Abstract

When a droplet is gently laid on the surface of the same liquid, it stays at rest for a moment on the surface. This is due to the slow drainage of a thin air layer between the droplet and the bath surface. When the critical thickness of the thin air layer is obtained coalescence occurs. The coalescence is delaied and sometimes inhibited by injecting fresh air under the droplet. This happens when the surface of the bath is vertically oscillating, the droplet simply bounces on the interface.

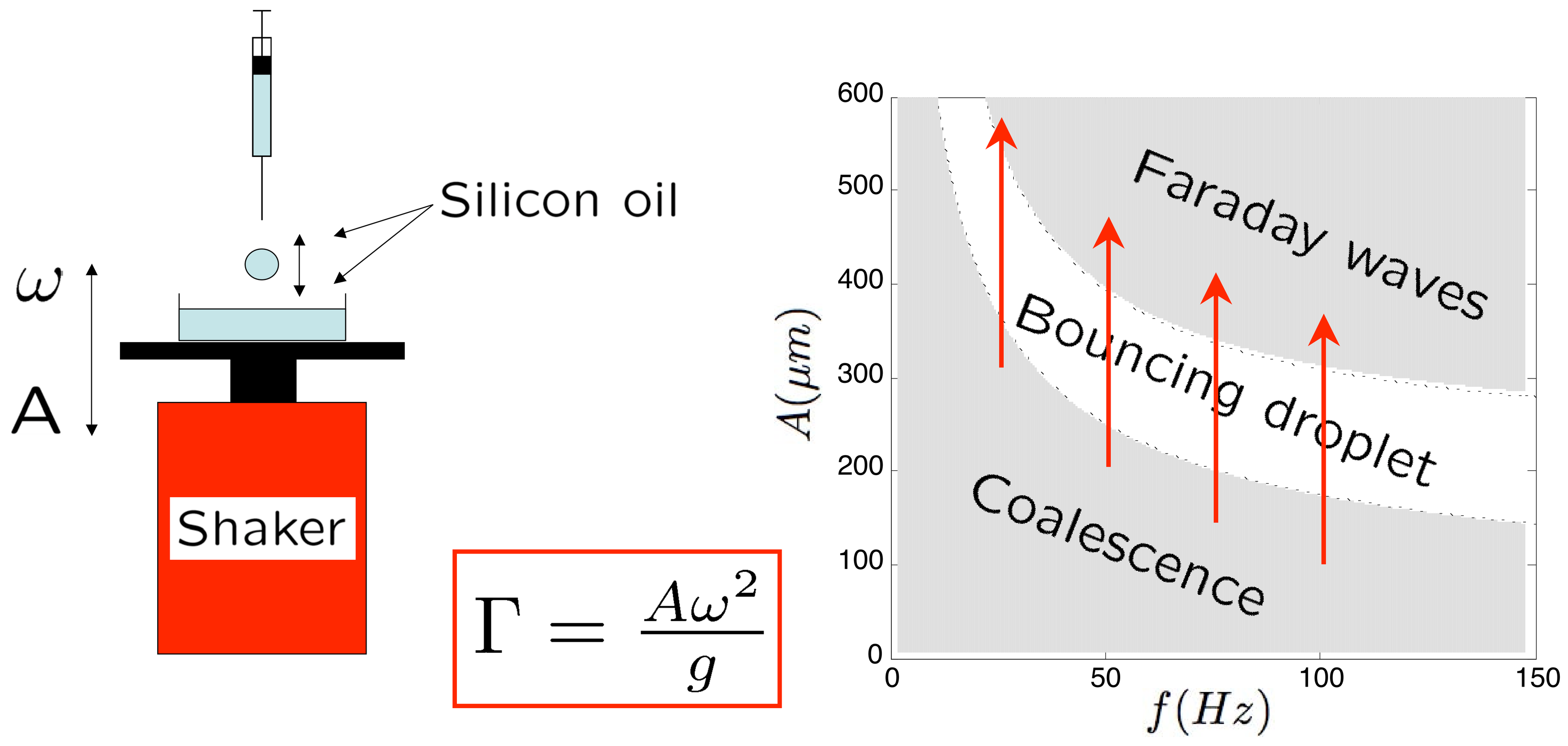

Fig. 1

Experimental setup

In this experiment, a container is filled with silicon oil (DC200-50cSt). The container is vertically shaken with an oscillation amplitude A and an angular frequency ω. The oscillation is characterised by the reduced acceleration Γ. The vibration A,ω is set below the Faraday instability threshold. A 1.5 mm diameter droplet is placed on the vibrating surface. Due to the vibration, the air film below the droplet is constantly regenerated. The droplet does not coalesce for a long time.

That phenomenon is observed in a tiny range in the amplitude/frequency diagram of the oscillation. When the amplitude of the oscillation is not sufficient the film air below the droplet is not completely regenerated and the droplet coalesces nearly instantaneously. The threshold exists between the Bouncing region and the Coalescence region, it has been recently explained by Couder's team (ENS, Paris)[2]. We investigate the droplet behaviour by sweeping the diagram in amplitude at different frequencies.

Lifetime of droplets

First of all, we observe that bouncing droplets have a finite lifetime. Lifetimes of droplets give us information on the stability of the droplet over the threshold (white area in Fig. 1).

Observations :

- Maximum stability is at the thresholds Γ_{th} for each considered frequency.
- An increase in the amplitude or frequency induces a reduction in the lifetime.
- Stability (infinite lifetime) is obtained for a certain frequency and a certain acceleration (Here f=25Hz and Γ=1). That suggest the existence of a resonance phenomenon.

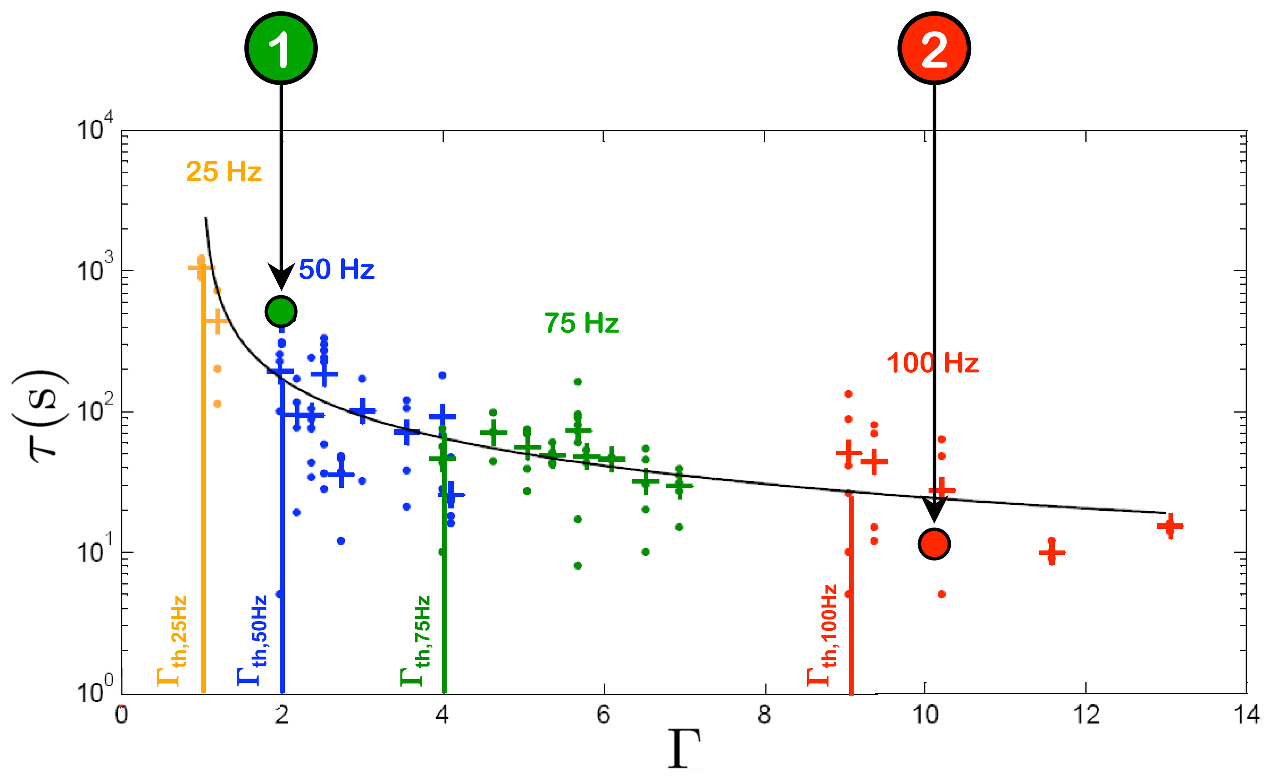

Fig. 2

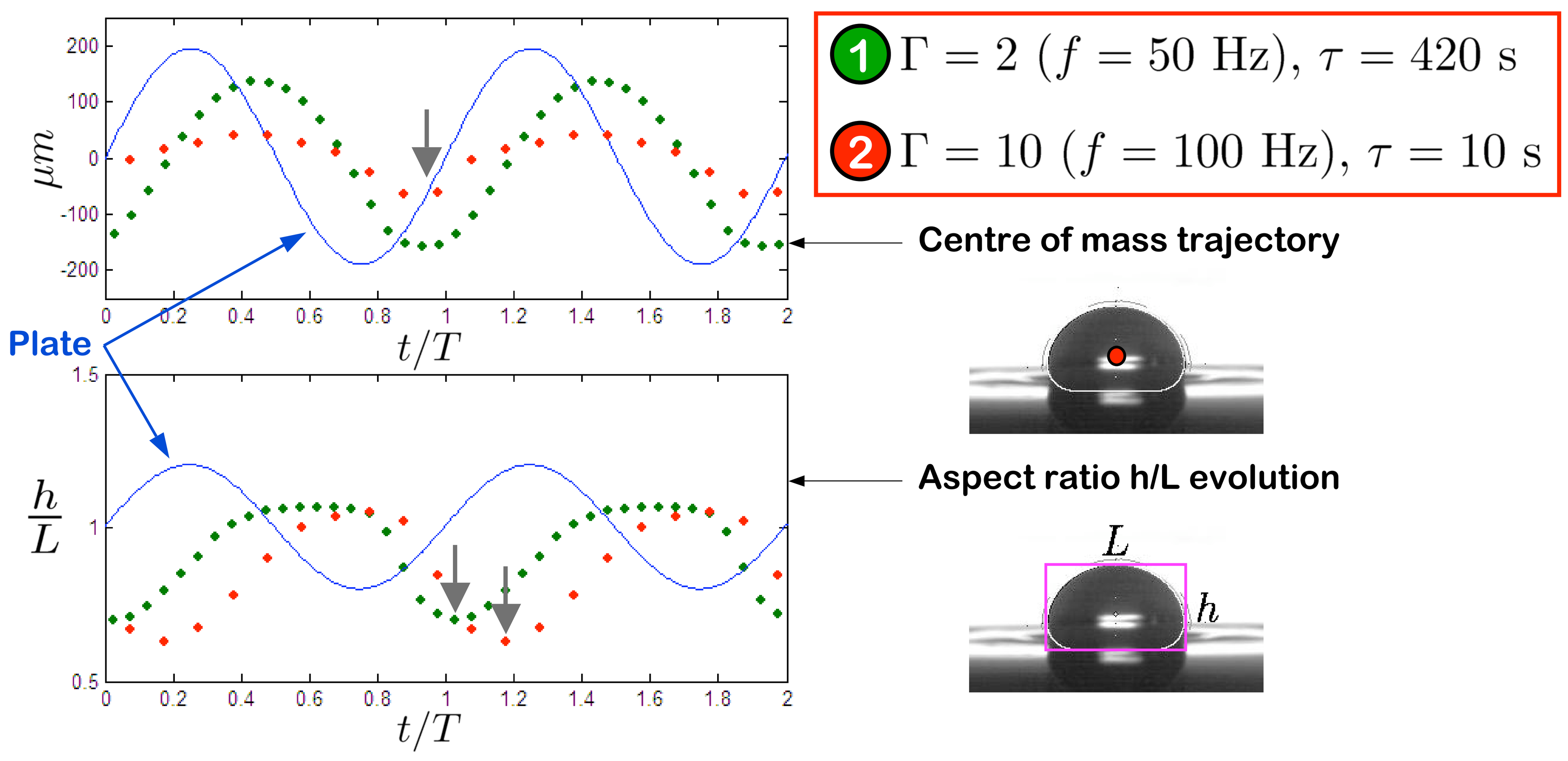

Fig. 3

Trajectory and deformation of droplets

Secondly, the motion and the shape of the droplets have been studied using image analysis. We compare here two cases characterized by very different lifetimes, namely τ = 420 s and τ = 10 s (resp. green and red colour in Fig. 3)

Observations :

- Minimum of centre of mass and the maximum of deformation occur at different phases at high frequencies.
- Minimum of centre of mass in both cases is located at the same phase of the plate oscillation.
- Maximum of deformation in both cases is located at different phase of the plate oscillation.

The difference of lifetime comes from the dephasing between the minimum of centre of mass and the maximum of deformations. In fact, lifetime is shorten because the droplet and the surface interact a longer time by period.

Conclusions

A bouncing droplet is the most stable when the motion of the centre of mass is in phase with the deformation.

The lifetime is a function of the time spent in squeezing the air film during one oscillation.

References

[1] N. Vandewalle, D. Terwagne, K. Mulleners, T. Gilet & S. Dorbolo, Phys. Fluids **18**, 091106 (2006)

[2] Y. Couder, E. Fort, A. Boudaoud & C. H. Gautier, Phys. Rev. Lett. **94**, 177801 (2005)