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Formation and rupture of liquid film formed at resting and vibrating oil/air interface by colliding bubble

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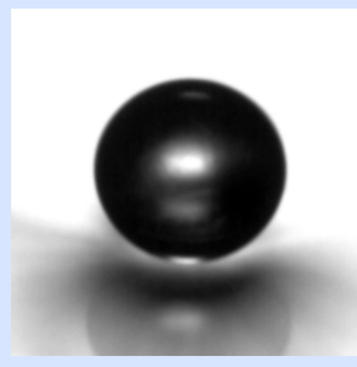
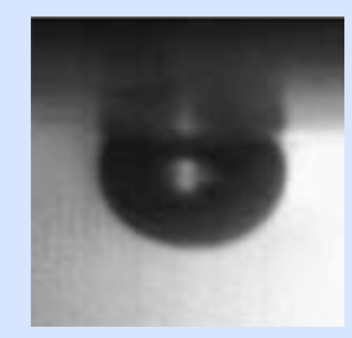


droplet



bubble

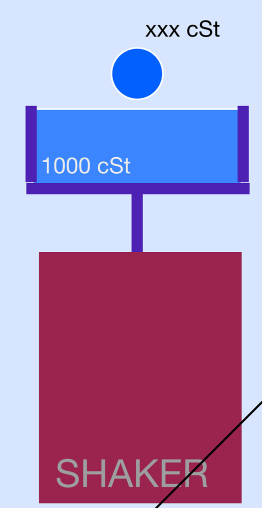
Introduction

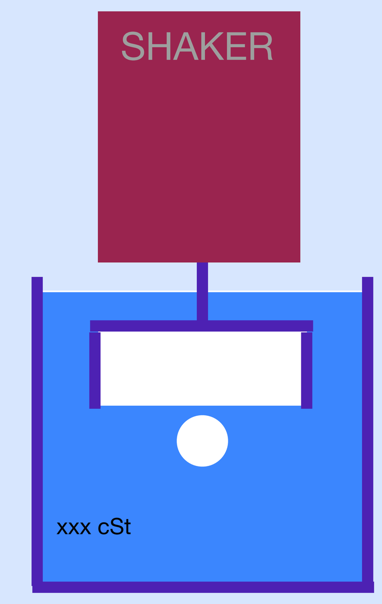
It is possible to avoid the coalescence of a droplet with a bath when the bath is sinusoidally vibrated with a sufficient acceleration defined as the acceleration threshold. The main mechanism is the lubrication force exerted by the squeezed air film located between the droplet and the bath [1]. More recently, we showed the role of the deformation of the droplet on the bouncing threshold [2].

In the bubble world, Krasowska et al demonstrated that a bubble that collide with the surface of the bath does not coalesce instantaneously but may bounce [3]. The main mechanism is the lubrication force exerted by the liquid film located between the bubble and the air. The role of deformation is predominant for determining the bouncing condition.

In this work, we merged both subjects. By vibrating an interface, we studied the bouncing conditions for a bubble [4]. This poster sums up the common points and the differences between a droplet and a bubble that bounces on a vibrated interface.

Experimental details





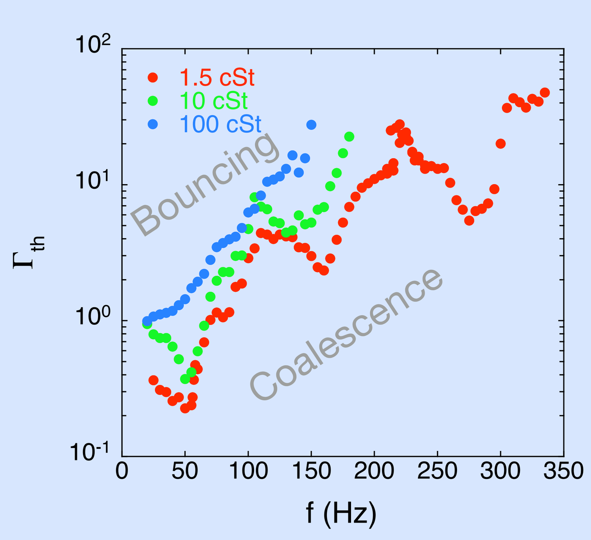
Silicone oil (Dow Corning 200) is used.

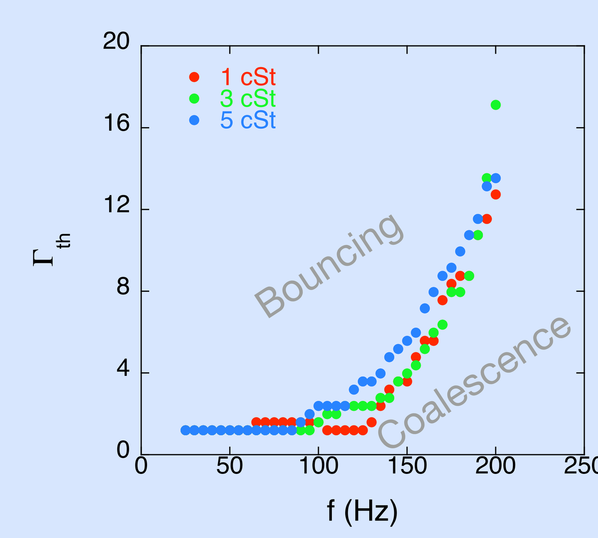
Droplet typical size: 2R=1.0 mm
The range of viscosity can be chosen between 0.65 and 100 cSt for droplet.

Bubble typical size: 2R=0.5 mm
The range is much reduced in the bubble case. If the viscosity is too low, Faraday instability is triggered at low frequency. If the viscosity is too large, the bubble cannot move because of viscous forces.

The acceleration is measured using an accelerometer positioned on the plate. The exciting frequency, f, is then fixed. Increasing the acceleration of the plate, the minimal acceleration Γ_{th} required for the bouncing is determined as soon as a bouncer is observed.

Bouncing threshold





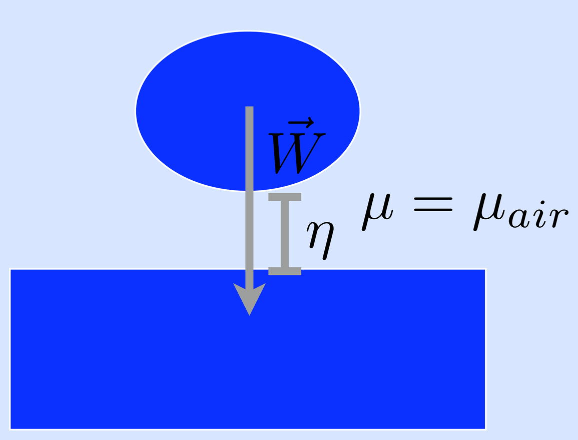
Droplet

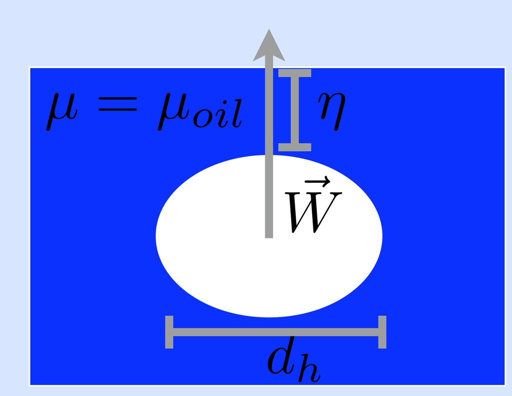
The acceleration threshold for bouncing increases monotonously in the case of high viscous droplets. On the other hand, in the case of low viscous droplet, minima are found at given frequency suggesting resonance modes. Indeed, at high viscosities, any deformation of the droplet is damped. The behaviour of the acceleration threshold with the frequency indicates clearly that the deformations play a key role in the bouncing mechanism.

Bubble

The acceleration threshold for bouncing increases monotonously. The higher the viscosity, the higher is the threshold. Indeed, more energy is required to move the bubble. The deformation of the bubble does play a role which was observed using high speed camera.

Lubrication-Deformations-Dissipation

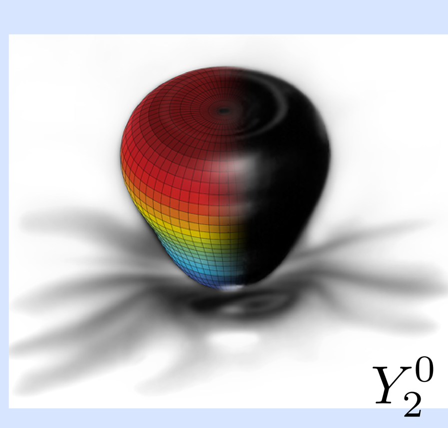


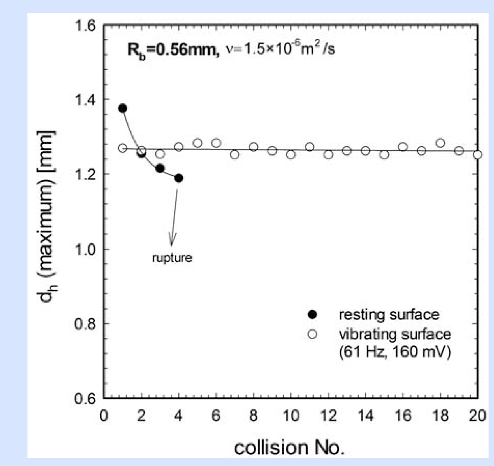


The bouncing mechanism is based on the lubrication force F_L generated when the intervening film (air for droplet and oil for bubble) is squeezed between the droplet or the bubble and the main phase.

The lubrication force must be sufficient to avoid the coalescence
and
the interaction time with the interface is to be lower than the drainage time.

$$F_L \approx \frac{\mu R^4 \dot{\eta}}{\eta^3}$$



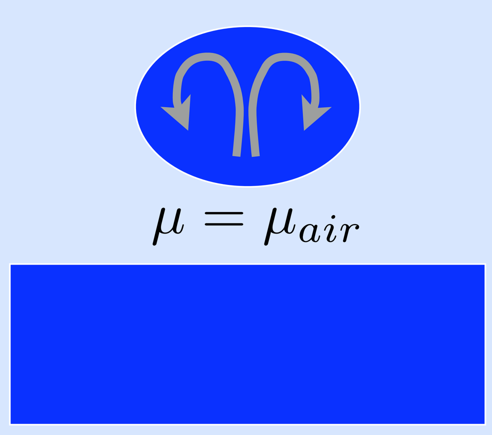


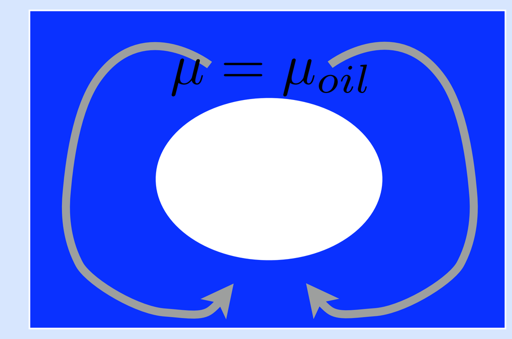
Droplet:

Eigen modes are Raileigh modes described by spherical harmonics functions. For given frequency, the system droplet+air film resonates which decreases the value of the threshold.

Bubble

The maximum deformation (d_h) of the bubble is imaged by measuring the maximum diameter of the bubble during the impact. This deformation must be sufficient, i.e. larger than a critical value, in order to bounce.





Droplet:

The main dissipating process occurs in the droplet as a motion is observed inside (PIV). The oscillation of the bath has to provide enough energy for the motion of the center of mass, for the work produced by the lubrication force, for the deformation and finally for the motion of the fluid inside the droplet

Bubble

The energy is mainly dissipated around the bubble. The mechanism and a precise determination of the flows have to be performed in order to allow to calculate the threshold acceleration.

Conclusion

The bouncing of a droplet and of a bubble presents a lot of similarities:
1. The lubrication force must be detailed to explain the bouncing threshold
2. The deformation of the object is of importance

On the other hand, the dissipation of the energy occurs at different places. Consequently,
1. the range of viscosity of the liquid used is very different whether a droplet or a bubble is considered
2. a model should be built in order to rationalise the motion of the liquid during the bouncing process.

Acknowledgement
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