

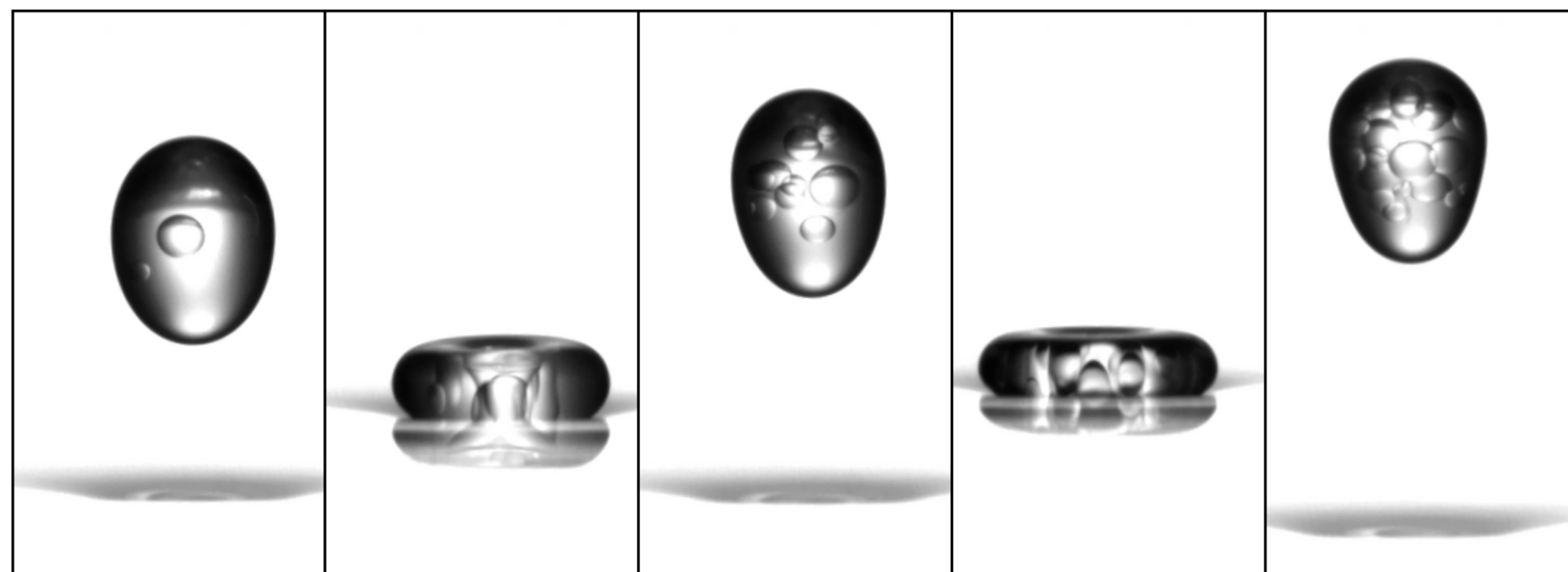
The mayonnaise droplet

D. Terwagne, T. Gilet, N. Vandewalle and S. Dorbolo

GRASP, Physics Department, Université of Liège, B-4000, Belgium

Introduction

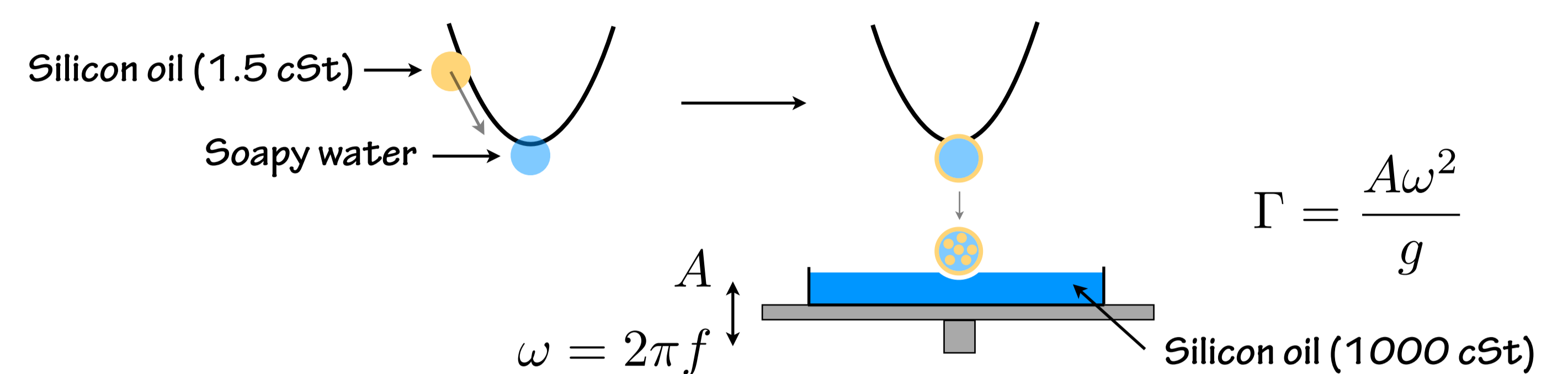
A compound drop is made of a millimetric soapy water drop encapsulated in an oil shell. They are obtained by merging two drops, one of each component (water and oil). Afterwards, they are laid on a high viscosity oil bath which is vertically vibrated.



When the forcing acceleration is higher than a certain threshold, compound drops can bounce on the surface. We show that above another acceleration threshold some oil contained in the shell enters in the inner water droplet forming a stable double emulsion.

Experimental setup

The water drop in which we added sodium dodecyl sulphate (SDS) and the oil drop are created on a wire that forms a vertical parabola. They merge at the minimum of the parabola, the compound drop falls on the oscillating liquid surface of the container as it is too heavy to be sustained by the wire.

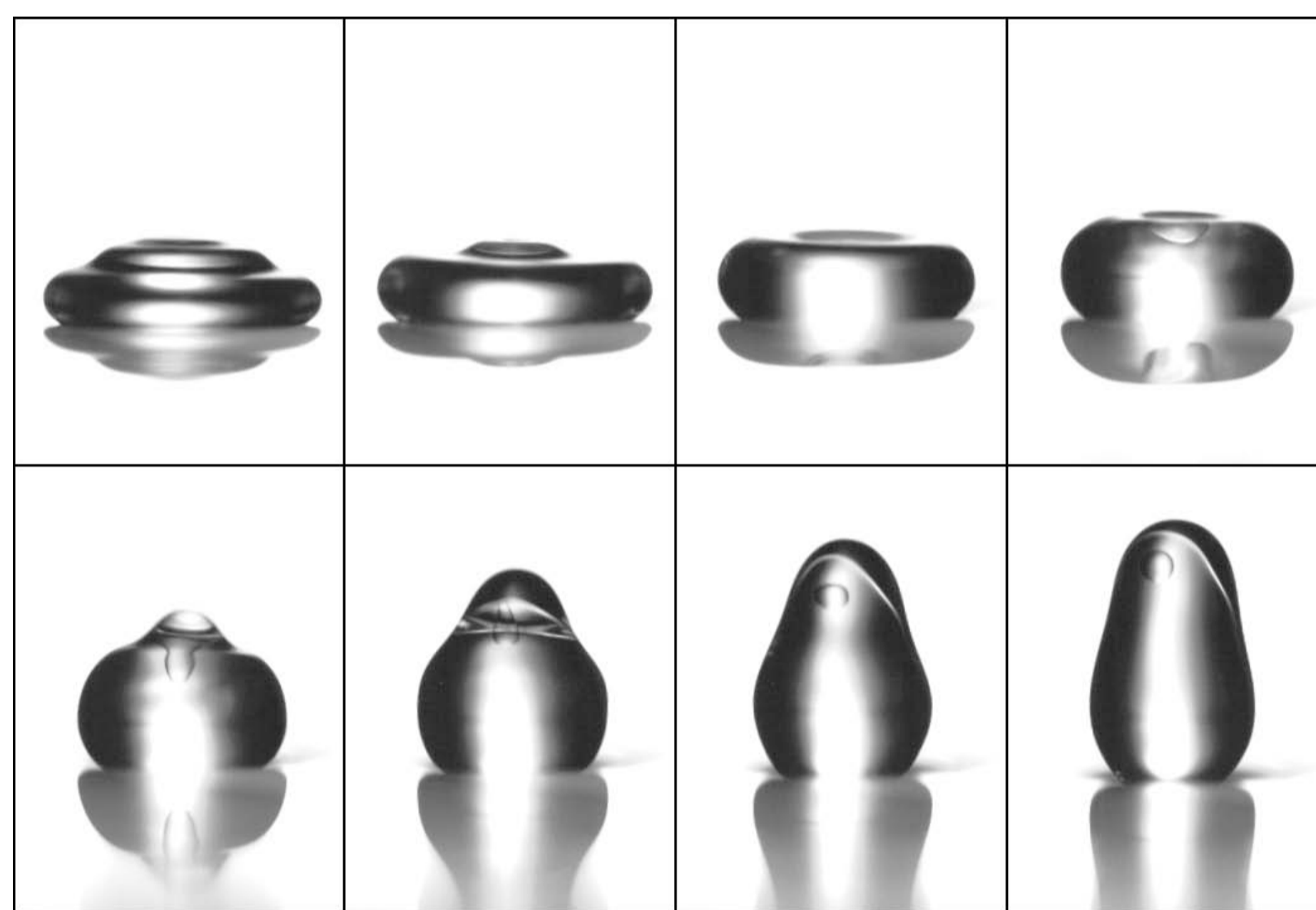


When the forcing acceleration Γ is higher than the bouncing acceleration threshold Γ_{th} , the compound drop bounces on the surface. Above another threshold, Γ_e , an emulsion is initiated in the compound drop. Note that we consider low viscosity drops on a high viscosity bath which leads to highly deformed droplets and negligible bath deformations.

Emulsion process

At the impact, capillary waves are generated at the bottom of the drop and propagate on the surface of the drop [1]. They converge at the top and greatly deform the drop. That leads to the formation of an oil drop coming from the shell in the water core.

To start emulsification in the drop, capillary waves have to deform enough the shape of the drop. That occurs above an impact speed threshold [2]. The emulsion threshold can be correlated with a relative impact speed threshold.



Emulsion stability

Above the emulsion threshold, droplets coming from the oil shell enter in the water core until capillary waves are too damped (by the emulsion) to create more oil droplets.

If we decrease the forcing acceleration to the region where the compound drop only bounces, the emulsion is stabilized. Actually as fluids are maintained in motion, the droplet coalescence is prevented.

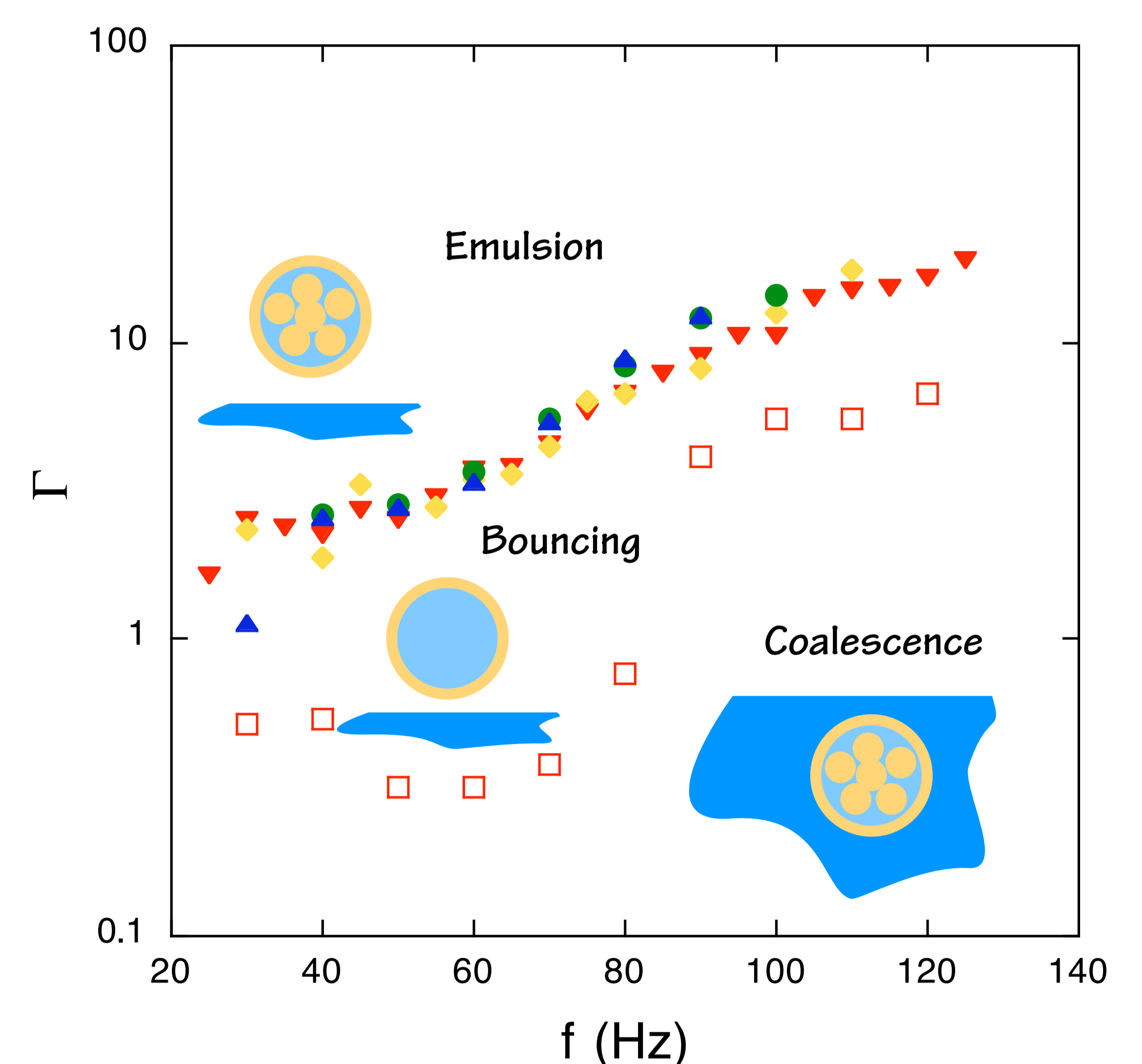
Phase Diagram

The influence of the compound drops radii on the emulsion apparition is tested. If the compound drop is too small, capillary waves can not deform enough the drop. If the compound drop is too big, it can not bounce on the surface. Thus, we test compound drop of different size in the possible size range (see Table below).

symbols	Compound drop radius	SDS water drop volume ratio
□ ▼	0.80 mm	51 %
♦	0.83 mm	72 %
▲	0.94 mm	72 %
●	1.00 mm	40 %

In the (Γ, f) phase diagram (Fig. on the right), we represent the bouncing threshold curve $\Gamma_{th}(f)$ (□) of the compound drop of 0.80 mm of radius and the emulsion threshold curves $\Gamma_e(f)$ (▼♦▲●) for the 4 different compound drops.

We can conclude that if the drop size influences the emulsion threshold Γ_e , this influence is very weak and below our error bars.



Conclusion

We show that it is possible to create a double emulsion inside a compound drop (oil+soapy water) only by making bounce the compound drop on a liquid surface. This emulsion can then be stabilised by adjusting the forcing acceleration Γ to a value between Γ_{th} and Γ_e .

References

- [1] D. Bartolo *et al.*, Phys. Rev. Lett. 96, 124501 (2006).
 [2] Y. Renardy *et al.*, J. Fluid Mech. 484, pp 69-83 (2003)

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