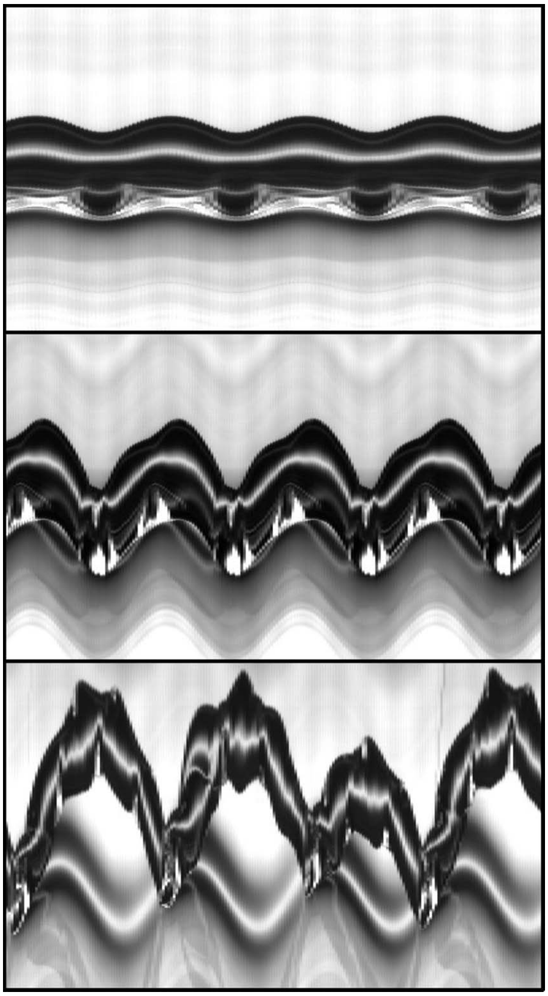

FIG. 1. Successive snapshots of the bouncing droplet have been juxtaposed for $\gamma=0.4$ (top), 0.9 (middle), and 1.3 (bottom) times the gravity.

From bouncing to boxing

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When a droplet is laid on a liquid bath, it eventually coalesces as soon as the air film located between the droplet and the bath is drained out. A way to avoid this issue is to vertically shake the bath according to a sinusoidal signal $A\sin(\omega t)$, where A is the amplitude, ω is the angular frequency, and t is the time.[1] Sustained bouncing is possible when the maximum acceleration of the bath $A\omega^2$ is larger than a threshold value γ_{th} that depends on the droplet size, the droplet viscosity, and the frequency of the forcing oscillation.[2,3]

Recently, we studied what happens when the oil bath is about 100 times more viscous than the droplet. In such a system, the deformations of the droplet are much more important than those of the bath. These experiments have shown that the deformation of the droplet has to be taken into account to explain the bouncing.[2] Indeed, some resonance effects have been observed, i.e., a decrease of the threshold acceleration at given frequencies: various deformation modes may be excited. Basically, these modes correspond to the natural excitation modes discovered by Lord Rayleigh.[4]

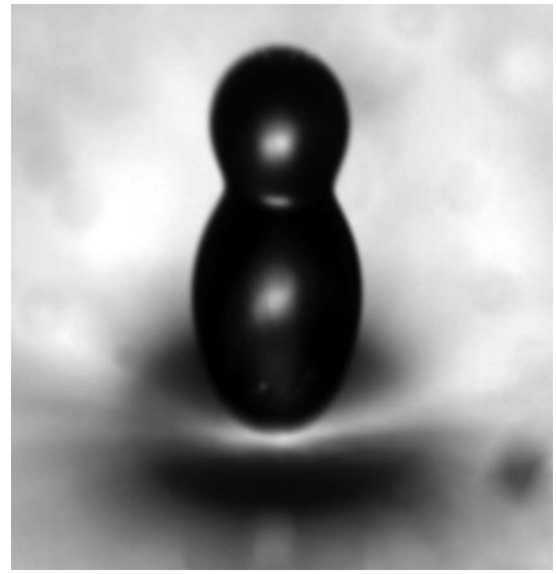

FIG. 2. Peanut shape of the droplet obtained when the acceleration is large ($\gamma=1.3g$) (enhanced online).

On the other hand, at constant frequency, a single deformation mode is excited. However, different bouncing modes are observed in an analogous way as a bouncing ball. A droplet with viscosity 1.5 cSt and radius 0.94 mm is dropped on a 1000 cSt oil bath that is vertically vibrated at a frequency of 20 Hz. The amplitude A is tuned, which modifies the acceleration γ. Three accelerations have been considered: 0.4, 0.9, and 1.3 times the gravity g. Note that sustained bouncing may be observed for accelerations below g thanks to the droplet deformation. In order to show evidence of the bouncing mode, vertical slices from each successive snapshot have been juxtaposed. The results are shown in Fig. 1 and correspond to the movie on the Gallery of Nonlinear Image (http://chaos.aip.org/chaos/gallery/index.jsp). The upper border of the black area corresponds to the top of the droplet while the regular sinusoidal curves located at the bottom of each figure represent the motion of the bath. For a low acceleration $\gamma=0.4g$, the droplet bounces at the same frequency as the bath (Fig. 1, top). For an intermediate acceleration $\gamma=0.9g$, a big jump is followed by a small one (Fig. 1, middle); the bouncing period is doubled. That is particularly visible when tracking the top of the droplet. For a large acceleration $\gamma=1.3g$, the bouncing is chaotic and the droplet is enormously deformed: peanut shapes (Fig. 2), invaginations, jets, and expulsions of small droplets are observed. The droplet eventually coalesces with the bath.

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[1] Y. Couder, E. Fort, C.-H. Gautier, and A. Boudaoud, Phys. Rev. Lett. **94**, 177801 (2005).
[2] T. Gilet, D. Terwagne, N. Vandewalle, and S. Dorbolo, Phys. Rev. Lett. **100**, 167802 (2008).
[3] D. Terwagne, N. Vandewalle, and S. Dorbolo, Phys. Rev. E **76**, 056311 (2007).
[4] Lord Rayleigh, Proc. R. Soc. London **29**, 71 (1879).

