Acrobatics of viscous marbles

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While viscous drops are expected to be slow, their dynamics can be markedly different when they non-wet their substrate [1]. The Mahadevan-Pomeau model consists in two ideas. Firstly, non-wetting drops are flattened at their base due to gravity. Secondly, when the Reynolds number is below unity, the liquid exhibits solid-like rotation, characterized by minimal dissipation localized in the contact region. The law predicts the drop velocity to be proportional to the slope of the substrate, when considering its gravity-driven movement on a tilted plate.

As an archetype of non-wetting drops, we consider liquid marbles, obtained by shaking a drop on a bed of hydrophobic micrograins : the grains stick to the surface of the drop, which they armor without without however modifying its softness (and surface tension) [2]. In our experiment, a long wooden plate (a few meters in length) is inclined at an angle α, and we place a millimeter-sized marble of glycerol one thousand times more viscous than water at its top. We track the marble with a high-speed video camera as it moves down the slope. In Figure 1, we present two consecutive sequences showing side views of the marble moving on a plate inclined at 30°, with the camera tilted by the same angle. These chronophotographs allow us to capture both the instantaneous velocity and the shape of the droplet.

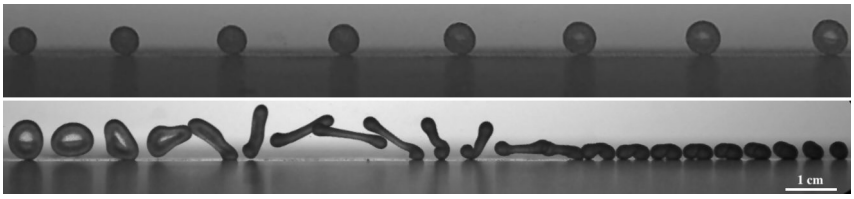

Figure 1. Chronophotography of a marble of glycerol (initial radius $R_o = 1.7$ mm) as it runs down a plate tilted by $\alpha = 30^\circ$. Images are separated by **a.** 32 ms and **b.** 8 ms.

The experiment reveals that increasing the slope makes the drop speed 10 times quicker than expected from the Mahadevan-Pomeau model. This can be understood by taking into account the strong deformations of the marble, due to its centrifugations, whose effect is to minimize even further the solid/liquid contact - and thus the viscous dissipation. From an applied perspective, this means that non-wetting, viscous materials can be transported at speeds comparable to that of water.

Références

1. L. Mahadevan & Y. Pomeau, Rolling droplets, *Physics of fluids*, **11**, 2449–2453 (1999).
2. P. Aussillous & D. Quéré, Liquid marbles, *Nature*, **411**, 924–927 (2001).