Viscous Cheerios Effect

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Academic level: Licence or Master.
Experimental techniques: Synthetic schlieren, particle image velocimetry (PIV), Lagrangian tracking, electrowetting.

Motivations and context

This project focuses on the so-called Cheerios effect, which refers to the interactions between two floating objects. Objects such as cereal pieces, insects, or bubbles floating on a liquid interface interact due to gravitational or capillary deformations they cause (menisci). While the capillary interactions between two floating objects were thoroughly examined on low viscosity liquids [1] or viscoelastic solids [2], the additional effect of viscosity on the dynamics of these two objects still requires a comprehensive understanding. This project aims to experimentally study the influence of the liquid's viscosity in the approach dynamics between two objects floating at the surface of a liquid.

Research focus

Preliminary experiments have shown that the liquid's viscosity plays a crucial role in the approach's dynamics between the objects. As the objects draw closer, the shear generated in the flow intensifies, significantly increasing the viscous dissipation and slowing down the objects' relative velocity. To better explore these phenomena, we will use model systems consisting of laser-cut particles floating on the surface of low-wetting liquids with varying viscosities (water/glycerol mixtures, water/Ukon oil).

Experimental approach

Laboratory experiments will be built to measure the positions of floating objects using high-speed cameras (>1,000 fps), and image correlation techniques will measure the flow induced by the objects' motion. The forces will be estimated by measuring the elastic deflection of slender glass fibers connected to the floating objects. Additionally, we will employ a synthetic spectrometry technique (by printing a fine checkerboard pattern beneath the liquid bath) to measure the deformation of the liquid interface during the objects' attraction.

Figure 1: Demonstrating the Cheerios effect with coins: The curvature of the water surface around the coins is evident through light reflections. Several coins have settled at the bottom of the cup, indicating that these coins are not inherently buoyant.

References

[1] D. Vella and L. Mahadevan, The "Cheerios Effect", Am. J. Phys. **73**, 817 (2005).
[2] S. Karpitschka, A. Pandey, L.A. Lubbers, J.H. Weijs, L. Botto, S. Das, B. Andreotti, and J.H. Snoeijer, Proc. Natl. Acad. Sci. U.S.A. **113**, 7403 (2016).