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Capillary phenomena in miscible fluids

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Abstract :

Interfacial tension between immiscible fluids is a well-defined, well-known quantity occurring in a wide range of phenomena. By contrast, this quantity is neither easily defined nor fully understood for miscible fluids. Following the work of Korteweg in 1901 [1], an "effective interfacial tension" (EIT) is supposed to exist between miscible fluids, which stems from spatial gradients of concentration or density in a multifluid system. Nevertheless, the existence of these so-called "Korteweg stresses" is still debated [2-3], since they are hardly detectable in simple miscible liquids, where diffusion rapidly smears out interfaces.

In order to investigate EIT, we perform a series of spinning drop tensiometry (SDT) experiments. In SDT, a drop of one fluid is injected in a background fluid contained in a cylindrical capillary. The capillary is rapidly spun and one follows the evolution of the drop shape by video imaging. We modify a commercial apparatus and use fluorescent drops in order to retrieve the full three-dimensional concentration profile of the drop, allowing us to follow the dynamics of the interface with unprecedented detail.

We first investigate the model case of immiscible molecular fluids, for which we find that the time evolution of the drop shape agrees nicely with theoretical predictions [4] that where not tested so far. These results constitute a solid starting point for SDT on miscible fluids. We find that the shape of a miscible drop continuously evolves, in contrast to the saturation effect reported in previous investigations that explored a smaller temporal range. By varying systematically the compositions of the fluids, we determine that the shape of miscible drops during elongation is not only determined by the density and viscosity contrast with respect to the background fluid, but also by the chemistry of the fluids. This crucial result rules out the possibility that the drop dynamics are purely dictated by hydrodynamics and strongly hints at the existence of an effective interfacial tension.

Our experiments strongly support the presence of an off-equilibrium EIT at the interface between miscible simple liquids, and pave the way for a thorough understanding of the very nature of Korteweg stresses.

References

[1] D. Korteweg, Arch. Neerland. Sci. Exact. Nat., 6, 1 (1901).
[2] D. Truzzolillo and L. Cipelletti, Soft Matter, 13, 13-21 (2017).
[3] D. Truzzolillo, L. Cipelletti et al., Phys. Rev. X 6, 041057 (2016)
[4] H. Stone and J. Bush, Q. Appl. Math., 3, 551-556 (1996).