Dynamical study of confined bubbles in cylindrical capillary tubes submitted to a Marangoni stress

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We study a confined bubble without any surfactants in a cylindrical capillary tube put into motion by a pressure gradient. A surface-tension can be monitored by a linear temperature profile in the capillary. Two classical experimental configurations have been reported: a stress-free bubble pushed by an external phase, known as the Bretherton problem [1], and a bubble set into motion using solely a Marangoni stress [2]. In this study we consider the Bretherton problem including a Marangoni stress, using both a theoretical and an experimental approach. The Marangoni stress that is considered stems from a constant temperature gradient.

On the theoretical side the lubrication equations are written using classical approaches and show that the relative importance of the temperature gradient to the bubble velocity is given by the dimensionless number:

$$\alpha = \frac{3}{2}\frac{\frac{\partial \gamma^*}{\partial x^*}}{(3Ca)^{2/3}} \tag{1}$$

The two regimes given by Bretherton (no temperature gradient) and Mazouchi *et al.* (no external pressure gradient) are recovered.

On the experimental side, we intend to explore the range of parameters for which both contributions are of the same order of magnitude. Our final objective is to understand the role of a Marangoni stress on the droplet dynamics. Care has been taken to build a system surfactant free and with no thermomechanical effect (deformation of the cavity due to a temperature increase). These experiments are currently underway.

References

[1] Bretherton, F. P. "The motion of long bubbles in tubes." J. Fluid Mech. 10.2 (1961)
[2] Mazouchi, Ali, and G. M. Homsy. "Thermocapillary migration of long bubbles in cylindrical capillary tubes." Physics of Fluids 12.3 (2000)