Instability of a vortex roll-up at a fluid-fluid interphase

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A local deposition of a droplet of soluble surfactant solution on a water layer creates a surface tension difference along air/water interphase. The resulting surface tension gradients sets the fluid in motion on each side of the interphase. This effect is called the Marangoni effect. A continuous injection $Q_{\rm a}$ of the surfactant solution (TTAB) at the interphase leads to a quasi-steady Marangoni flow of finite size $R_{\rm M}$. $R_{\rm M}$ results from the competition between the transport of the surfactant molecules by the flow and their diffusion into the bulk water after their desorption from the interphase. The Marangoni flow has been well characterised in refs. [1,2]. In this abstract, we present results corresponding to the study of the

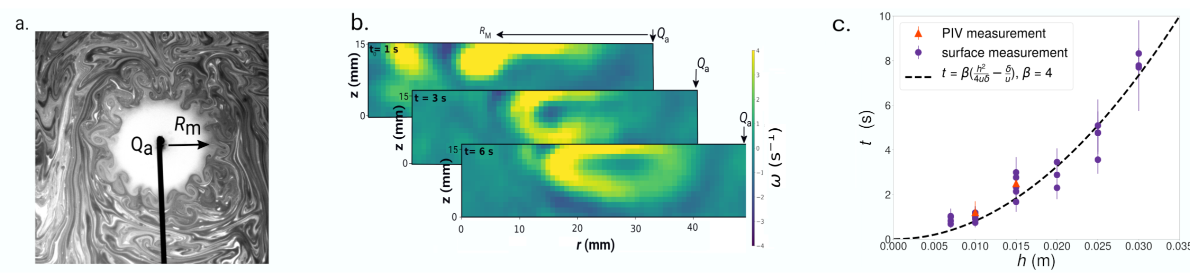

Figure 1. a) Top view of a continuous Marangoni flow created at a constant molar flow rate $Q_{\rm a} = 1.8\ \mu{\rm mol}\cdot{\rm s}^{-1}$ and height of water $h = 15$ mm. **b)** Vortex strength fields deduced from LS-PIV measurements in a single plane. $Q_{\rm a} = 0.5\ \mu{\rm mol}\cdot{\rm s}^{-1}$ at $h = 15$ mm. The boundary layer rolls up at $t = 1$ s, near the fluid-fluid interphase. At $t = 3$ s, the roll-up has diffused in the bulk. At $t = 6$ s it touches the bottom and start destabilising. **c)** Comparison between experimental emission time and the theoretical predictions up to a prefactor.

outer region of the Marangoni flow *i.e.* the region beyon $R_{\rm M}$. We use tracers, 50 μm olive oil droplets, to visualise the surface flow (Fig.1.a.). It shows several pairs of in-plane vortices growing outwards along the perimeter of the Marangoni border. These vortices are emitted periodically with a period $t_{\rm w}$ (Fig.1.c). $t_{\rm w}$ depends mostly on the thickness of the water layer h (Fig.1.d.). It highlights the need to investigate the flow in the bulk. To do so, we use a laser-scanning particle image velocimetry (LS-PIV) that allows to reconstruct 3D maps of the velocity field. The existence of a recirculation in the bulk is confirmed by the measurements (Fig.1.b.). The boundary layer starts to roll-up near the interphase at time t_0, then diffuses into the bulk towards the bottom of the tank. Growth occurs untill roll-up size is comparable to h, at which point, the roll-up interacts with the bottom of the tank and destabilises. The duration of this process is similar to $t_{\rm w}$. The predictions of the characteristic times $t_{\rm w}$ obtained from the roll-up are in good agreements with the experimental data (Fig1.c.). Future work will consist in studying the stability of the roll-up in the frame of the Rayleigh Criterion [3]. In addition we would like to compare the experimental results to simulations.

Références

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