Unsteady growth and collapse of microscopic gas bubbles

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Small bubbles form by diffusion of a dissolved gas during several industrial processes (e.g. glass manufacturing) : their arrangement and size can have a critical impact on the product's quality.

The growth (or collapse) of an isolated bubble can be modelled in detail ; however, this is not the case for the collective dynamics of multiple bubbles, due to the geometric complexity of the fluid domain surrounding them. Yet, the growth/collapse dynamics of neighbouring bubbles significantly influences the kinetics of the process and the final state of the system, and must therefore be taken into account accurately. We recently established a novel semi-analytic method to take into account such effects based on the Method of Reflections for diffusion and Stokes flow problems in the quasi-steady limit where diffusion is fast [1]. Unsteady effects can however profoundly alter the dynamics at the scale of a large bubble clouds, but are currently absent from existing models (except for direct but costly numerical simulations).

This project therefore aims to extend the method mentioned above to account for the finite diffusion time of the gas emitted/captured by the bubble in its collapse/growth, and evaluate the impact of these effects on the final arrangement and size of the bubbles. This would provide a simple yet efficient tool to predict the detailed unsteady growth/collapse dynamics as well as characterise the final state of the system.

Note : depending on the student's interest and progress on the topic, this internship can be continued onto a PhD.

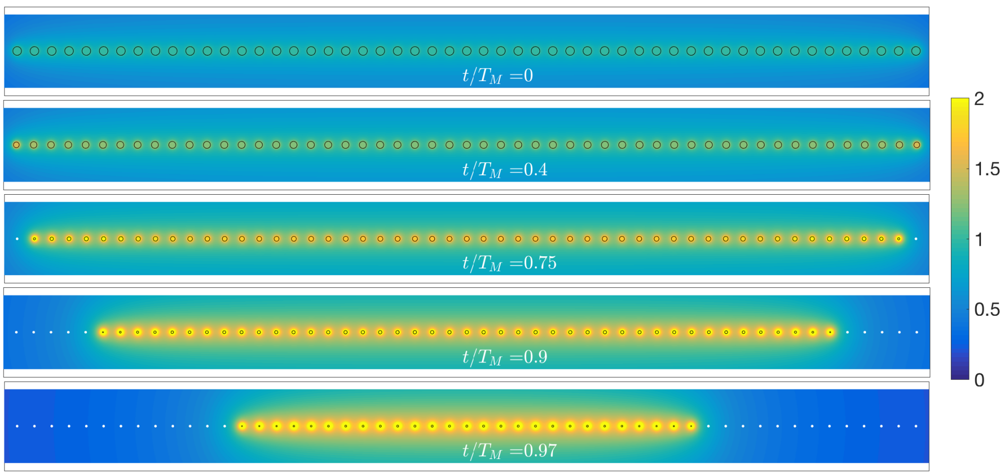

FIGURE 1 – Collective effects (and dissolved gas concentration) in the quasi-steady diffusion-driven collapse of a line of microscopic gas bubbles. The central bubbles are "shielded" by the others, that act as sources of dissolved gas [1].

References

[1] S. Michelin, E. Guérin & E. Lauga, 2018 : Collective dissolution of microbubbles, *Phys. Rev. Fluids*, **3**, 043601

[2] S. Michelin, G. Gallino, F. Gallaire & E. Lauga, 2019 : Viscous growth and rebound of a bubble near a rigid surface, *J. Fluid Mech.*, **860**, 172-199