Chair of Aerodynamics and Fluid Mechanics
Department of Mechanical Engineering
Technical University of Munich

Surfactant Modeling for Two Phase Flows

Semester's Thesis, Master's Thesis

Contact: Felix Schranner Mail: schranne@tum.de Start date: As of now

Motivation

The two images in figure 1 depict types of bubbles evolving in a denser (left) respectively lighter (right) fluid. Flows of air bubbles in water are two phase flows similar to the left image and common for many academic, industrial and natural environments or applications.

Studying two phase flows is highly interesting and quite challenging due to the complexity of the interfacial physics. Only by means of high-fidelity numerical simulations the interface physics can be studied and knowledge gained.

High-fidelity modeling of these interface physics is ongoing research at the Chair of Aerodynamics and Fluid Mechanics, see e.g. [1–4]. The in-house CFD solver ALPACA incorporates state-of-the-art numerical models, algorithms and software design.

Objectives

In two phase flows e.g. soap or dispersed particles accumulate at the interface where they effect the *surface tension*, thus they are denoted surface active agents (surfactants).

Within this thesis you will extend the solver ALPACA with the interfacial surfactant transport and couple the surfactant concentration to the surface tension coefficient of the fluid-fluid interface. Hence you will enable to simulate e.g. Marangoni flows, see [3]. To sum up your thesis project you will apply the surfactant-extended ALPACA to study selected test flows such as *the motion of bubbles in a vertical temperature gradient* [5].

Requirements

- Interest in two phase flows
- Interst in surfactants
- Experience with unix systems and the C++ programming language is helpful, but not required

What you learn during this thesis

- Deeper understanding in the physics of realistic two phase flows
- Insights into the simulation of complex flows with a state-of-the-art CFD code
- Working on modern HPC computing systems of the Leibniz-Rechenzentrum (LRZ)
- State-of-the-art software development

References

[1] Kaiser, J. W. J., Adami, S., and Adams, N. A. "Three-Dimensional Direct Numerical Simulation of Shock-Induced Bubble Collapse Near Gelatin". In: *11th International Symposium on Turbulence and Shear Flow Phenomena*. 2019.

[2] "Numerical Symmetry-Preserving Techniques for Low-Dissipation Shock-Capturing Schemes". In: *Computers & Fluids* 189 (2019), pp. 94–107. ISSN: 00457930. DOI: 10.1016/j.compfluid.2019.04.004.

[3] Schranner, F. S. "Weakly Compressible Models for Complex Flows". Dissertation. München: Technische Universität München, 2017.

[4] Winter, J. M., Kaiser, J. W. J., Adami, S., and Adams, N. A. "Numerical Investigation of 3D Drop-Breakup Mechanisms Using a Sharp Interface Level-Set Method". In: *11th International Symposium on Turbulence and Shear Flow Phenomena*. 2019.

[5] Young, N. O., Goldstein, J. S., and Block, M. J. "The motion of bubbles in a vertical temperature gradient". In: *Journal of Fluid Mechanics* 6.3 (1959), pp. 350–356. DOI: 10.1017/S0022112059000684.

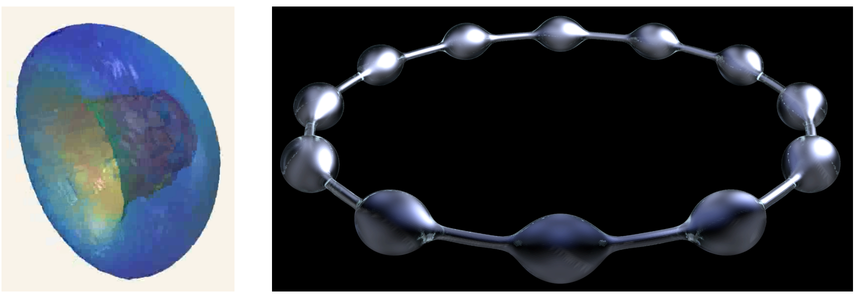

Figure 1: Bubble evolution scenarios