Chair of Aerodynamics and Fluid Mechanics
TUM School of Engineering and Design
Technical University of Munich

Cavitation modeling in JAX-FLUIDS: A fully-differentiable high-order CFD solver for compressible two-phase flows

Master's Thesis

Cavitation is the formation of small vapor bubbles/vapor-filled cavities in a liquid due to the static pressure dropping below the liquid vapor pressure. When subjected to higher pressures, these vapor bubbles may collapse generating strong shock waves. Cavitation is important in many engineering applications as the shock waves of collapsing bubbles may damage nearby materials.
In this work, we will implement and compare two different cavitation models in our in-house computational fluid dynamics (CFD) code JAX-FLUIDS. JAX-FLUIDS is a differentiable high-performance CFD code written entirely in the JAX Python package and runs on CPU/GPU/TPU. First, we will implement a simple single-fluid equilibrium cavitation model (barotropic model, see for example Buddicht et al. 2018) to gain experience in simulating cavitating flows with JAX-FLUIDS. After implementation, the model is to be validated by comparing simulation results with well-known academic test cases, e.g. collapse of a single isolated bubble, collapse of a bubble near a wall. Second, we will implement a more complex multi-fluid non-equilibrium cavitation model. After validation of both models, we will simulate the transition from sheet to cloud cavitation over a wedge as a final showcase .

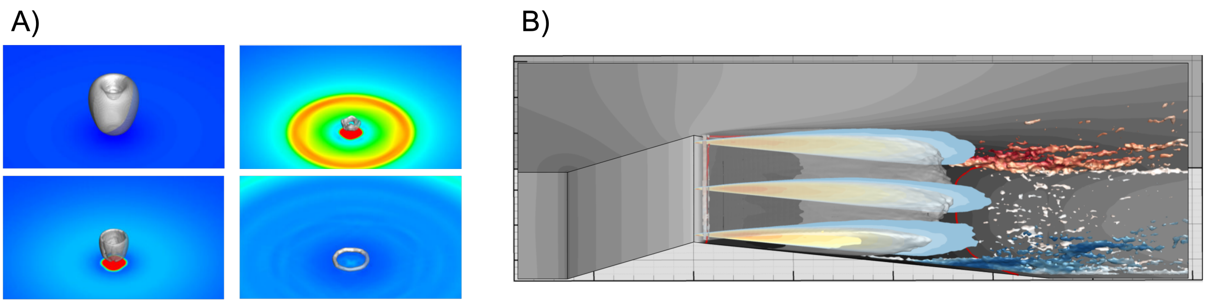

Figure 1: A) Single bubble collapsing over a wall. Taken from Örley 2016. B) Vapor structures over a wedge. Taken from Budich 2018.

Tasks

- Familiarize yourself with the JAX-FLUIDS CFD code.
- Implement and validate a simple single-fluid equilibrium cavitation model in JAX-FLUIDS.
- Implement and validate a more complex multi-fluid non-equilibrium cavitation model in JAX-FLUIDS.
- Simulate as a final test case the transition from sheet to cloud cavitation over a wedge.

Requirements

- Programming experience in Python.
- Interest in computational fluid dynamics / partial differential equations.
- Beneficial: Gas Dynamics, Applied CFD, Turbulent Flows, Numerical Methods for Conservation Laws.

Contact

Deniz Bezgin deniz.bezgin@tum.de, Aaron Buhendwa aaron.buhendwa@tum.de, and Dr. Steffen Schmidt steffen.schmidt@tum.de.