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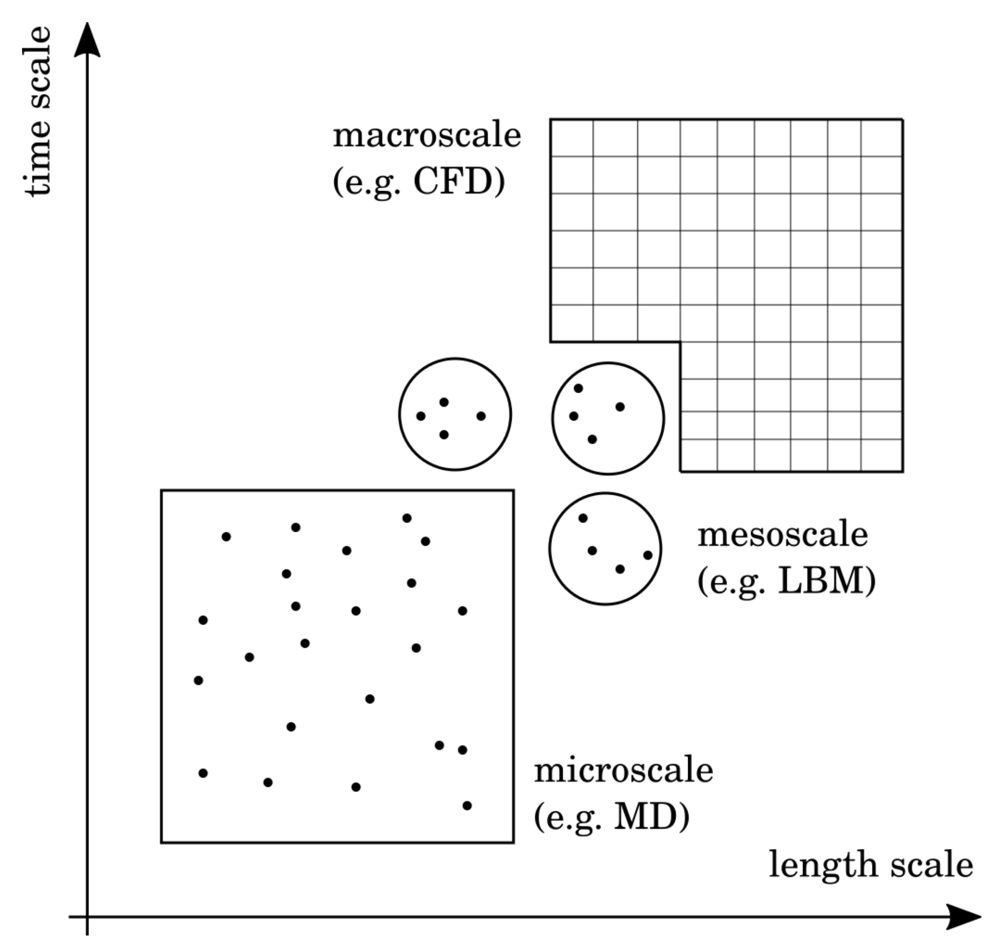
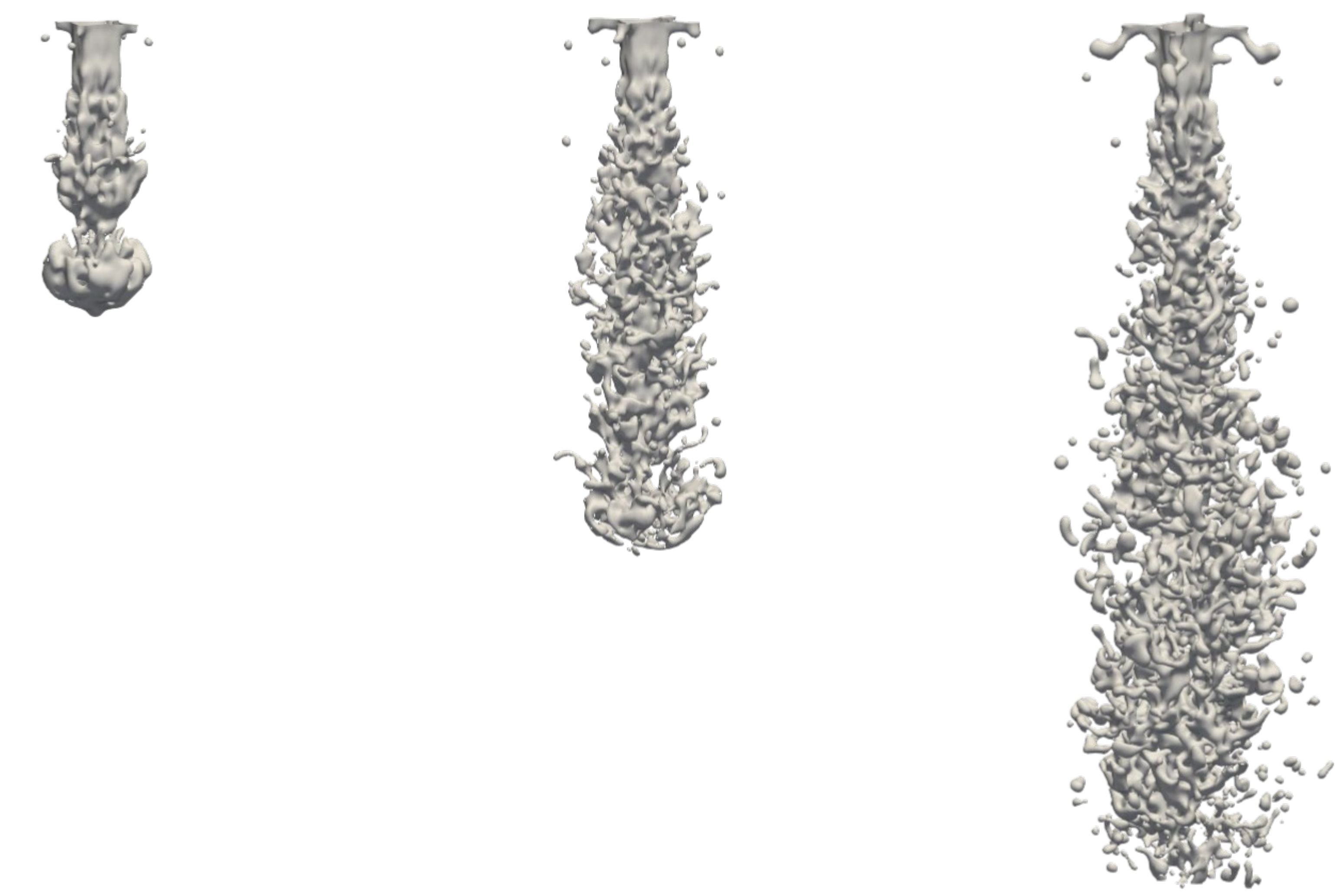
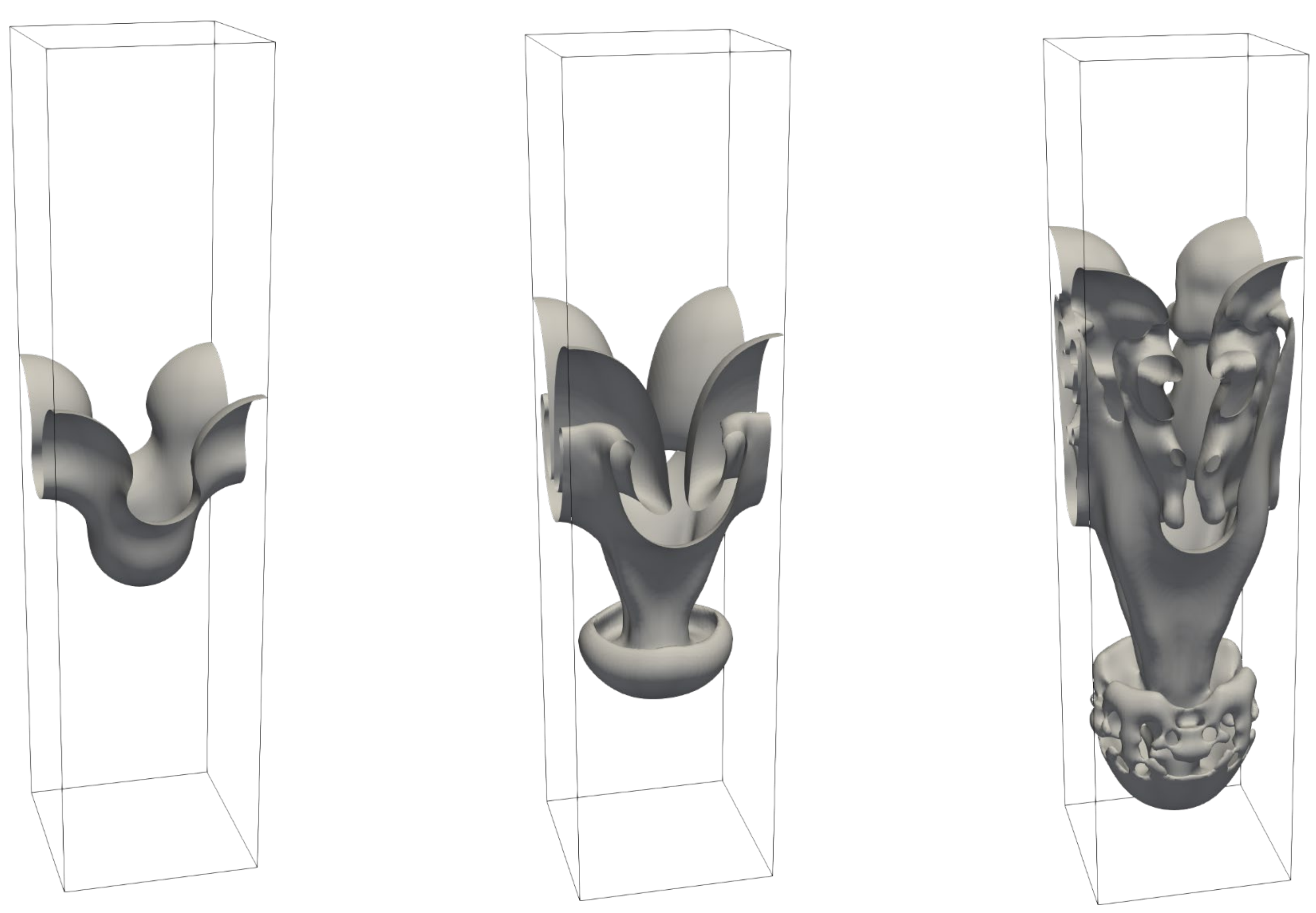
MSE | MASTER OF SCIENCE IN ENGINEERING

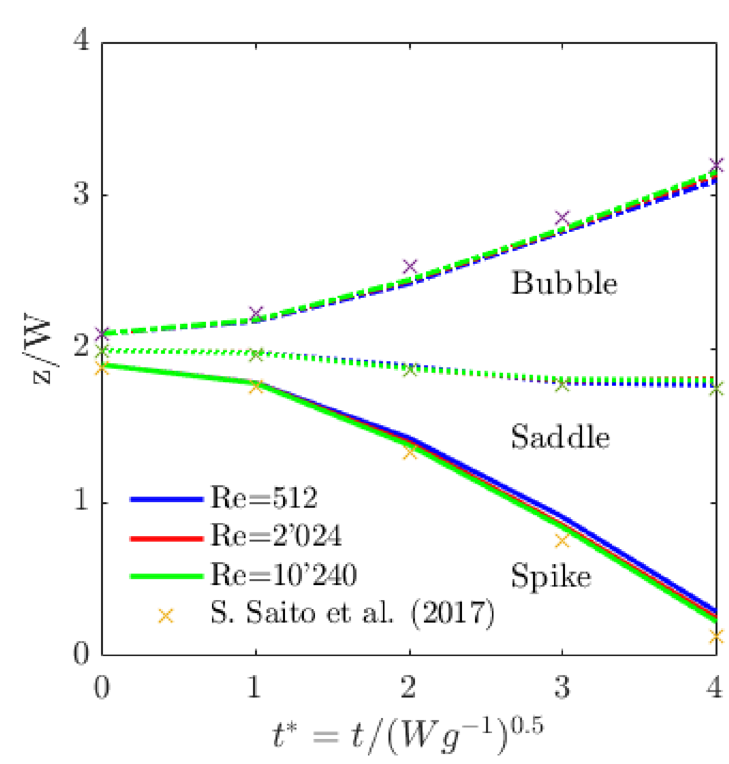
Master-Thesis Engineering, Fachgebiet Energy and Environment

Lattice Boltzmann method (LBM) to solve multiflow problems









Abstract Many industrial fluid problems involve more than one fluid and are called multiphase problems, when the fluid consists of more than one phase or a change phase occurs. Multi-component flow problems occur, if the fluid is a mixture of multiple fluids with individual properties.

In this thesis, a multicomponent model is developed to simulate immiscible flow problems as they are found for example in spray applications. The model is based on the Lattice Boltzmann Method (LBM) which has its root in the molecular kinetic and was first published in 1940 by Stanislaw Ulam and John von Neumann. Compared to conventional computational fluid dynamics (CFD), which solve the macroscopic governing equations directly. The LBM uses the Boltzmann equation and the solution can be used to find the macroscopic field variables such as velocity, density and pressure. The LBM has gained a lot of popularity in the last two decades and is still a very active research field. As a result, many multi-phase and or multicomponent models exist and fight for supremacy.

The present work is based on the model first published by Rothmann-Keller (RK) in 1988. TheRK model, also called the Color-Gradient (CG), was improved over the last few years and has crucial advantages, like a sharp interface between the omponents, the control of surface tension by single parameter and multiple approaches to handle simulations with variable density ratios. It is well known in the LB community that simulations tend to become unstable as soon as the flow is turbulent. The simplest approach is to refine the grid resolution, however in most cases this is not feasible due to the limitation of computational resources. Thus so-called Multi-Time-Relaxation (MRT) schemes are developed to allow the relaxation of each individual moment at its appropriate rate. These countermeasures make the LB simulation stable without refining the grid resolution. Unfortunately, the problem is often to find suitable relaxation rates, since they depend on the problem at hand. The model developed by Karlin, Bösch and Chikatamarla (KBC) circumvents this issue, and is able to find suitable parameters during the simulation and adjust them if needed.

The core of this work is to combine RK and KBC model, as this has not been investigated previously. The target is to achieve a model which does not depend on prior knowledge and is easy to use for different cases.

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