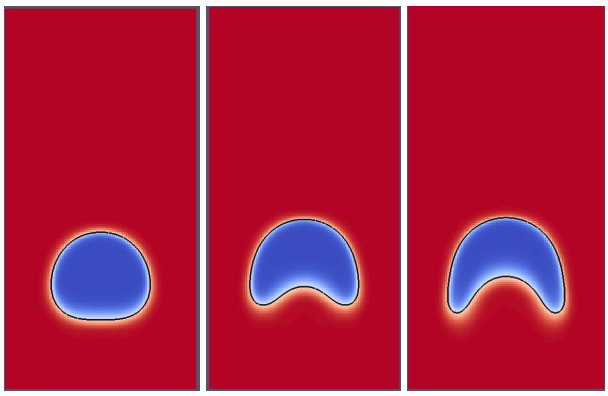
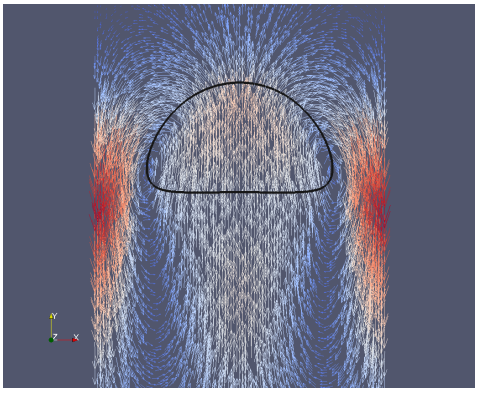
Multiple-Relaxation-Time Lattice Boltzmann Model for Multiphase Flows in Three Dimensions

FIU's Applied Research Center is assisting the Department of Energy's Hanford Site by developing a computational program based on the lattice Boltzmann method in order to generate computer simulations of engineering problems involving multiphase flows.

As a result of atomic weapons production, millions of gallons of radioactive waste was generated and stored in underground tanks at various U.S. Department of Energy sites. The Department of Energy is currently in the process of transferring the waste from single shell tanks to double shell tanks during which various waste retrieval and processing methods are employed. One such method, pulsed-air mixing, involves injection of discrete pulses of compressed air or inert gas at the bottom of the tank to produce large bubbles that rise due to buoyancy and mix the waste in the tank as a result of this rising motion. Pulsed-air mixers are operated by controlling the pulsing frequency and duration, the sequence of injection plates and gas pressure. Understanding the physical nature of the mixing process by injection of bubbles and the effects of the gas release process to the tank environment needs to be studied by considering various waste properties. Such an analysis can be made possible by developing a numerical method that can simulate the process of air bubble generation inside tanks filled with liquid.



Simulation test case # 1 for multi-phase flow: Density contours for a single rising bubble in a liquid (ρ_1/ρ_2=1000, μ_1/μ_2=100).



Simulation test case #2: Velocity vectors in the flow field with the bubble at terminal shape (ρ_1/ρ_2=10, μ_1/μ_2=10).

Project Objectives

The overall objective of this project is to develop a computational program that can be used as a numerical tool at DOE Sites in order to investigate and understand the physics of multiphase fluid flows that occur during mixing in waste tanks, gas generation in wastes, etc. The software that will be produced at the end of this task can be used as a virtual experiment environment that will complement experimental data for various scenarios of flow conditions and fluid properties.

Project Benefits

Benefits of developing MRT LBM software for multiphase flows are:

- Reduce the cost and time for conducting extensive experiments on multiphase flows.
- Provide quick, accurate and detailed flow field information for design optimization and problem mitigation for multiphase flow applications.

Project Accomplishments

- Completed a literature review on multiphase models proposed for lattice Boltzmann method.
- Finished the single-phase version of the MRT LBM software.
- Verified the multi-phase model that will be used in the MRT LBM software and simulated evolution of static and dynamic bubbles in multiphase fluid flow cases.

ARC Contact: Seckin Gokaltun, gokaltun@fiu.edu, (305) 348-6340 | FLORIDA INTERNATIONAL UNIVERSITY