MSc Thesis Student: Extracting turbulence statistics in large-scale two-phase flows using direct numerical simulation

Introduction

NRG Pallas is one of the major institutes responsible for nuclear research in the Netherlands. NRG Pallas is internationally recognized as the foremost provider of nuclear medicine, supporting over 30,000 patients per day. A significant focus of NRG's research is dedicated to enhancing nuclear reactor safety by utilizing Computational Fluid Dynamics (CFD) tools.

Background and goal

The **modeling of turbulent two-phase flows** holds significant importance in **nuclear engineering applications**. Understanding turbulence in two-phase flows allows engineers to better predict and control mixing, heat transfer, mass transfer, and momentum exchange between phases. Thus, it is crucial to deepen our understanding of the development and evolution of such flows and their potential impacts on the safety and performance of nuclear reactors. To achieve this goal, NRG Pallas is developing an in-house **Direct Numerical Simulation (DNS) solver, Briscola,** capable of efficiently simulating turbulent two-phase flows.

This project focuses on developing tools to extract **turbulence statistics in turbulent two-phase flows**. These include Reynolds stresses, turbulent kinetic energy, heat flux, and other turbulent quantities that can be calculated separately for each phase or across the interface. These statistics provide insights into phase-specific turbulence behavior and interfacial transport. As a validation benchmark case, DNS of **co-current turbulent stratified flow** for which reference data already exists is considered (See Figure 1).

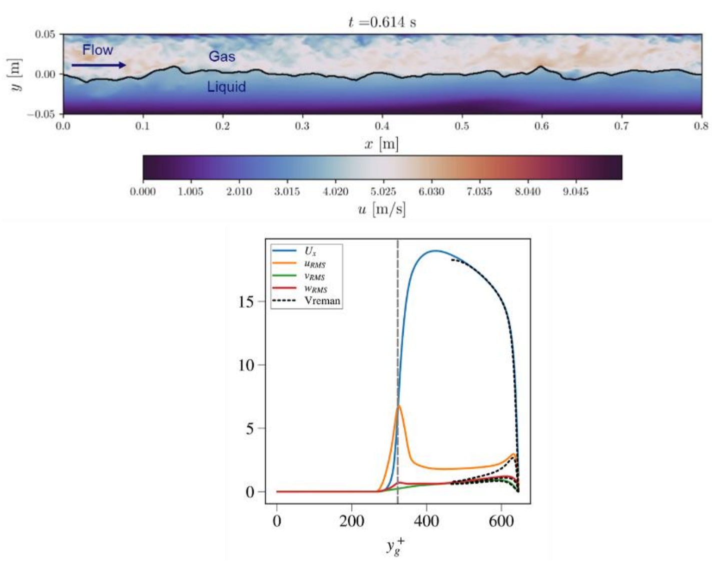

Figure 1: Instantaneous streamwise velocity in a turbulent stratified channel flow (top). Mean streamwise velocity and root mean square of velocity fluctuations in the gas phase compared to single-phase DNS results (bottom).

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Tasks

The main tasks within this project include:
- Implementing averaging tools to extract spatiotemporal statistics of the flow field.
- Performing preliminary DNS simulations, followed by post-processing, analysis, and reporting of results.
- Contributing to the development of a passive scalar transport model within the current solver to explore the combined effects of flow dynamics and heat/mass transfer.
- Testing and validating the implementations against existing DNS data.

Your profile:

- MSc student in applied science with a specialization in computational fluid mechanics
- Good knowledge of fluid mechanics and numerical methods
- Required computer experience: Linux, Windows, C/C++
- Good analytical and problem-solving skills
- Dedicated, good communication and social skills
- Prior knowledge of OpenFOAM is a plus (Briscola's coding syntax is similar to that of OpenFOAM)

Our offer:

- A challenging thesis project to be executed within a successful team with an informal atmosphere and an excellent reputation
- Strong support from enthusiastic members of the CFD team
- Monthly allowance/stipend for housing and transportation for the period of your stay.

Only European citizens (or non-Europeans currently enrolled in a Dutch university) will be considered for security clearance.

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