My research activities

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Division day, 29th August 2018
Agenda

• Challenges with multiphase flows

• Bubbles

• Droplets

• Particles

• Some new ideas/possible collaborations
Challenges

• **Multi-physics:** fluid dynamics- chemistry- heat transfer- mass transfer- phase change-fluid/structure interactions

• **Multi-scale:**
  turbulent regime in industrial processes
  Many temporal and length scales from the large scales proportional to the apparatus length down to Kolmogorov dissipative scales

• **High volume fractions:**
  opaque systems where the classic laser-based experimental techniques fail
Bubble dynamics
Which technique to use?

- MRI
- X-ray
- PIV/CTA/LDS (very dilute systems)
- EL-DNS
- FR-DNS
- EE/EL-LES
- EE-RANS/STOCHASTIC APPROACH

Scale [m]

models and comparisons

experiments

models

IDEAL SIMULATION --> YEAR 2070 --> SIZE GAP

YEAR 2070 --> SIZE GAP

Which RANS/STOCHASTIC APPROACH

IDEAL SIMULATION --> YEAR 2070 --> SIZE GAP

YEAR 2070 --> SIZE GAP
Fully resolved DNS

- VOF
- Open Source Code-GERRIS
- Evaluate drag and lift coefficient
- Detailed dynamics around the single particles
- Limit: DNS low Reynolds number/small number of particles evolved
- Niklas Ph.d. project
Fully resolved DNS

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Eulerian-Lagrangian vs Eulerian-Eulerian
Eulerian-Lagrangian vs Eulerian-Eulerian

EL

Filtered EL

EE-OpenFoam (developer Klas Jareteg FCC)
Droplet condensation/evaporation

- Climate/Weather prediction models are essentially RANS
- A small scale variation can deeply influence larger scales

Clouds are highly turbulent Re $10^6$
Droplet condensation/evaporation

- State of the art DNS ($1024^3 + 10^9$ lagrangian droplets)
- Original stochastic LES model for droplet phase changes (Sardina et al, PRL, 2015)
- Large effects due to turbulence
- Novel prediction for the droplet radius growth
- The new theory has been verified by experimental measures (Chandrakara et al, PNAS, 2016)
Particle transport in turbulent flows

- Most interestingly, the addition of polymers leads to a decrease in concentration values, as displayed in the inset of the figure.
- The qualitative behaviour observed in the instantaneous snapshots of figure 4. For the Newtonian and viscoelastic cases (figure 4.4)
- Considering first the Newtonian case (figure 4.6), showing values lower than the fluid on the positive side of the wall and its augmentation in the channel bulk region deeply affects the total particle mass flux, assuming its minimum value for the most accumulating particles (figure 4.10, where the concentration decreases by more than 10, although also in 4.20, where the concentration is recovered and the particle bulk Reynolds number is equal to the bulk Reynolds number of the carrier phase (34).
- The combined effect of the reduction of the particle concentration close to the wall and its augmentation in the channel bulk region deeply affects the total particle mass flux. In order to quantify this flux, we introduce a new physical quantity named mass flux. In order to quantify this flux, we introduce a new physical quantity named mass flux.
- The turbophoretic drift induces a mean particle migration towards the wall that is quantified by the mean particle concentration defined as the averaged particle velocity in the streamwise direction (\(V_{b, p}\)).
- For the Newtonian and polymer flows we observe high concentrations of particles at the wall (turbophoresis) as compared with the bulk.
- For the Newtonian case and (figure 4.12), it is apparent that accumulating particles are dispersed throughout the channel with only slight accumulation at the wall (turbophoresis) as compared with the bulk.
- Figure 4.2 shows the behaviour of the steady-state particle bulk Reynolds number for the flat-wall case, respectively). Thus, the mass flux for the flat-wall case is larger than that of the rough-wall case, because of the roughness function. In the flat-wall case, the particle bulk Reynolds number is equal to the bulk Reynolds number of the carrier phase (38, 40, 41, 42, 43, 44, 45, 46).
- The Fig. 12 shows the streamwise velocity field (contours, indicating the non-dimensional instantaneous value) and the distribution of particles (black particles have positive vertical velocity and move upward, light grey particles have negative vertical velocity and move downward) with lighter tones being highest and darker lowest.
Possible collaborations

Particle transport in an urban environment
PM (10/2.5) preferential accumulation

- Stable stratified boundary layer
- Code for complex geometry
Possible collaborations

- Bubble implosion/droplet phase changes
- Compressible schemes (TVD, WENO) to capture shock waves/density-viscosity jumps across the interface

Developing a new multiphase (VOF/diffuse interface) compressible code
Drag reductions for marine applications

- DNS of turbulent channel flows/boundary layer
- Polymeric flows (Fene-p model)
- Microbubble injections
- Superhydrophobic surfaces