Master / Bachelor Thesis or Study Project

Chair of Numerical Fluid and Gas Dynamics · Scientific Computing Lab, Energy Innovation Center (EIZ)
Brandenburg University of Technology (BTU), Cottbus, Germany

Stochastic modeling of turbulent convection with internal sources for application to liquid-phase batteries

Synopsis – Turbulent convection denotes the chaotic flow in a layer of fluid that is driven by buoyancy forces due to an unstable mass density stratification. Buoyancy forces are primarily caused by heating/cooling [1], but also phase changes [2], or even electric fields [3]. The flow becomes first unstable and later turbulent when buoyancy and inertial forces are much larger than viscous forces. This type of flow instability is encountered in numerous applications that range from technical to geophysical scales. Internal sources/sinks due to condensation/evaporation [2] or electric fields and space charge [3], have been modeled by a reference laboratory experiment that utilizes absorption of radiation [4]. The resulting fluid-internal heat sources have been reported to modify the attainable heat transfer but the dynamical processes are not yet fully understood. Here, a high-fidelity stochastic turbulence model [5,6] is used to investigate the turbulent flow regimes and parameter dependencies of the heat transfer first for the radiatively-driven set-up, and later also for an electrical set-up [7]. The goal is to contribute to the understanding of transport processes, boundary layers, and scaling properties using novel stochastic modeling approaches.

[1] Chillà & Schumacher (2012) *Eur. Phys. J. E* **35**:58 — [2] Chandrakar *et al.* (2019) *J. Fluid Mech.* **884**:A19 — [3] Mani & Wang (2020) *Annu. Rev. Fluid Mech.* **52**:509 — [4] Lepot, Aumaître & Gallet (2018) *PNAS* **115**:8937 — [5] Wunsch & Kerstein (2005) *J. Fluid Mech.* **528**:173 — [6] Klein & Schmidt (2019) *Proc. 11th Symp. Turb. Shear Flow Phen. (TSFP11)* **1**:14 — [7] Klein & Schmidt (2020) *Proc. Appl. Math. Mech.* **20**:e202000128

Modes

- **a) Master / Bachelor Thesis (1 semester):** Data analysis; stochastic simulations using ODT
- **b) Study Project (2 semesters):** Same as a), but for various control parameters
- **c) Study Project and Master Thesis (3 semesters):** Same as b), but for additional configurations, or utilization of ODTLES

Tasks

- Review of relevant literature and theoretical foundations
- Visualization, post-processing, and analysis of numerical data
- Comparison with relevant reference data
- Own numerical simulations with stochastic solvers and model development

Desired skills

- Solid knowledge of fluid mechanics, atmospheric dynamics, boundary layers, or related topics
- Affinity to programming (preferably Python, Matlab, C/C++, or Fortran)
- Scientific attitude (curiosity, self-motivation, and critical reasoning)
- Experience with data analysis, numerical simulation, multiphysics modeling, or CFD is an asset

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