Energie-Innovationszentrum Cottbus

Brandenburgische Technische Universität Cottbus - Senftenberg

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

Multi-fidelity flow modeling for thermal applications: Heat and momentum transfer in concentric pipes and channels

Synopsis – The detailed representation of coupled heat and momentum transfer processes in internal turbulent flows is of interest for numerous engineering applications, like heat pipes and heat exchangers [1] or chemical reactors [2], to name a few. Fine-structure resolving, direct numerical simulation (DNS) yields accurate predictions, but full resolution of all flow scales is only feasible for weakly and moderately turbulent flows. Therefore, turbulence modeling strategies are required for highly turbulent flows encountered in applications. Modeling addresses unresolved subgrid-scale processes in large-eddy simulation (LES) and unresolved ensemble effects in Reynolds-averaged Navier–Stokes simulation (RANS). For internal flows, additional challenges arise from small interacting thermal and momentum boundary layers [3,4,5]. Conventional wall modeling (WM) [6] utilized in state-of-the-art LES and RANS only provides average information based on universality assumptions, lacking fluctuation details and backscatter that is crucial for the applications mentioned above. Here, we strive to overcome the limitations of conventional wall models by utilizing stochastic modeling strategies like the one-dimensional turbulence (ODT) model. We focus on concentric pipe and channel flows, for which RANS, LES, DNS, and stochastic simulations have to be conducted.

[1] Fukuda & Tsukahara (2020) *Int. J. Heat Fluid Flow* **82**:108555 — [2] Balestrin *et al.* (2021) *Chem. Eng. Res. Des.* **170**:90 — [3] Klein *et al.* (2022) *Int. J. Heat Fluid Flow* **93**:108889 — [4] Medina Méndez *et al.* (2019) *Int. J. Heat Fluid Flow* **80**:108481 — [5] Bagheri & Wang (2021) *Phys. Fluids* **33**:055131 — [6] Piomelli (2008) *Progress Aerospace Sci.* **44**:437

Modes

- **a) Master / Bachelor Thesis (1 semester):** RANS / LES with OpenFOAM
- **b) Study Project (2 semesters):** RANS / LES with OpenFOAM; DNS / ODT with in-house codes
- **c) Study Project and Master Thesis (3 semesters):** Same as b) with model development; ODTLES

Tasks

- Review of relevant literature
- Visualization, post-processing, and analysis of numerical simulation data
- Comparison with relevant reference data
- Own CFD simulations, preferably with in-house or open-source CFD software

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 and modeling, or CFD is an asset

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