Universität Stuttgart

INSTITUT FÜR AERODYNAMIK UND GASDYNAMIK

Direktor : Prof. Dr.-Ing. Ewald Krämer

IAG

Prof. Dr. Claus-Dieter Munz

Master Thesis

Filter forms of Discontinuous Galerkin methods for Large Eddy Simulations

Large Eddy Simulation is based on the idea of scale separation in physical space and the subsequent solution of the resulting coarse-scale equations. The filter operation is typically described by a known, linear filter kernel. Rigorous application of this concept leads to explicitly filtered LES, however, almost all practical LES codes are based on an implicit filter definition in which the numerical operator or grid defines the cut-off frequencies. While some analysis of LES models for explicitly filtered approaches have been published, implicitly filtered LES is a lot less well understood due to the additional non-linear agent introduced by the discretization scheme.
The goal of this thesis is to investigate the nature of the resulting LES closure terms in the implicitly filtered approach for different a priori prescribed filter forms, to evaluate their respective importance and correlations to classical closure models like Smagorinsky's model or an implicit closure. Beyond this work, an optimization based approach for approximating the filter form of a given Discontinuous Galerkin method is to be developed from theoretical as well as data-informed considerations.
This thesis is suitable for candidates with a strong interest in mathematics, theoretical aspects of LES and basic knowledge of data analytics / and or machine learning. Applicants who have taken classes on DG and/or are familiar with the FLEXI framework are particularly suited.

Work Packages

- Literature study: LES, implicit and explicit filtering and modeling, analysis of LES
- Extension of an existing framework to arbitrary filter functions
- Analysis of closure terms, errors, and correlations for homogeneous isotropic turbulence
- Development of a framework for DG filter optimization
- Optimization of DG filter kernel based on 1D solution data
- Critical appraisal of results and documentation of the work

Prerequisites:

- Basic knowledge in Linux, Fortran and Python or ability to pick it up quickly
- Self-reliant, strong interest in theoretical aspects of LES and optimization

Advisors: Dr. Andrea Beck, Marius Kurz, M.Sc.

Starting Date: as soon as possible

Auf das "Merkblatt für die Anfertigung von Bachelor- und Masterarbeiten" wird hingewiesen.