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DLR – DAAD Fellowships

Fellowship No. 542

Research Area : Space

Research Topic: **Scale-resolving numerical analysis and simulation of turbulent boundary layers in the super- and hypersonic flow regimes**

DLR Institute: Institute of Aerodynamics and Flow Technology, DLR Göttingen

Position: Doctoral Fellow

Openings: 1

Job Specification:

Correct modeling of compressible turbulent boundary layers in numerical simulation tools is of major importance for design and performance assessment of super- and hypersonic flight vehicles such as space transportation or atmospheric re-entry configurations. Boundary layer properties determine thermal loads on the surface, aerodynamic characteristics and operational limits (e.g. due to boundary layer separation).
Accurate prediction of boundary layer properties, particularly in the intake, is also essential for the characterization of the operability of airbreathing propulsion systems such as Ramjets and Scramjets.

The behavior of highly compressible boundary layers subject to strong external pressure gradients is still a topic of active research. Such conditions occur predominantly in intakes of propulsion systems and at lifting- and control surfaces. Here, flow separation usually leads to severe performance interference. Hence it needs to be accurately and reliably predicted by simulation methods. Further modelling challenges are imposed by strong density gradients which occur at cooled walls and by significant compressibility effects at high Mach numbers.

Numerical methods with scale-resolving turbulence approaches such as LES provide an adequate potential to analyze the associated complex physical phenomena. This is primarily due to their large modeling depth. Results can also be used to improve less expensive statistical turbulence models (RANS) which are commonly used in design tools.

In this context, the main goal of this project is to further develop scale-resolving turbulence models in the numerical flow simulation software CODA for the application to hypersonic boundary layers with strong wall cooling. The code shall then be used to investigate the effects of adverse pressure gradients. Assessment of accuracy will be based on comparison with available experimental data from the High Enthalpy Shock Tunnel Göttingen (HEG).

The work is subdivided into the following steps:

- Study of the applicability and properties of different numerical modeling approaches.
  Assessment of the Discontinuous-Garlerkin (DG) methodology in CODA in comparison to other higher order methods such as spectral models.
- Performance of canonical numerical tests to quantitatively characterizes the DG method (e.g. Decaying Isotropic Turbulence, Taylor-Green-Vortex, Backward Facing Step)
- Participation in the layout of the HEG validation experiments. Design of the aerodynamic shape of the test model for reproduction of characteristic adverse pressure gradient scenarios.
- Consolidation of a numerical modeling strategy for the scale-resolved boundary layer simulations. Performance of initial tests to analyze the impact of grid resolution and boundary conditions. Setup of a near-field inflow boundary condition with characteristic turbulence.
- Performance of initial simulations and analysis of the results. Identification of errors and model deficiencies.
- Further development of the CODA based on the analysis of the initial results with special focus on non-reflecting near-field boundaries, synthetic inflow turbulence
- Performance of a final set of numerical simulations. Detailed validation and accuracy assessment based on the experimental data. Analysis of the influence of external pressure gradients and density variations due to wall cooling on heat transfer and skin friction characteristics.

Required Qualification:

- Good knowledge in numerical methods for compressible flow simulation
- Knowledge of flow physics, gas dynamics and turbulence modelling
- Completed university studies (master's degree or diploma in physics, mathematics, aerospace engineering, mechanical engineering, process engineering or similar)
- Programming experience in C/C++ on Linux systems
- Good knowledge of the English language

Advantageous Skills:

- Basic knowledge of the German language
- Knowledge of scale-resolving methods for turbulence modelling
- Experience with high temperature thermo-chemistry

English competence: See requirements on www.daad.de/dlr

Earliest Start Date: 1.6.2022

Application Deadline: Until position filled

Further Information: http://www.dlr.de
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