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DLR – DAAD Fellowships

Fellowship No. 526

Research Area : Aeronautics

Research Topic: **Development of a numerical modeling strategy for fluid flow with combined rarefied and continuum regions.**

DLR Institute: German Aerospace Center
Institute of Aerodynamics and Flow Technology
Aerospace Department
DLR Göttingen

Position: Postdoctoral Fellow

Openings: 1

Job Specification: The aerothermal analysis and assessment of launch vehicle operation at high altitudes and satellite propulsion systems requires the simultaneous and coupled treatment of both rarefied and continuum flow fields. Examples include high-pressure propulsive exhaust jets embedded within a low-density external atmosphere. There are well established and successful numerical simulation approaches for both flow regimes. Lagrangian particle methods are generally used to simulate the gas-kinetic behaviour of rarefied flows. The most prominent one is the Direct Simulation Monte-Carlo (DSMC) method. The continuum flow is treated by solving the Navier-Stokes-Equations (NS) in a Eulerian reference frame. However, the coupling of these methods imposes significant challenges. This is mainly due to the dissimilar properties of the numerical results and different modelling assumptions used to design the numerical solution algorithms. The DSMC result is generally subject to statistical noise, the velocity distribution of the particles is arbitrary, chemical and thermodynamic effects are treated with simplified models. The NS solution is continuous without statistical noise, the velocity-PDF of the gas molecules is assumed to be a linearly distorted Maxwell-distribution and sophisticated models for thermal- and chemical non-equilibrium are applied. Further, numerical grids including their partitioning on massively-

parallel high-performance computing architectures are fundamentally different.

The present project aims in this context at the development and implementation of a coupling interface between a DSMC- (*SPARTA*) and a NS-solver (DLR-*TAU*). The main focus is on the applicability on high performance computing systems which requires data transfer- and management between different numerical grid structures and partitions.

The multidisciplinary coupling interface *FlowSimulator*, which is available at DLR, includes many of the required methods and is closely interlinked to the Navier-Stokes-Solver *TAU*. It forms the basis for the present development. The applicant is expected to implement an interface between *FlowSimulator* and *SPARTA* and design the required data reduction, manipulation and simplification techniques on the DSMC-side. The functionality of the coupled scheme shall be demonstrated on the basis of generic test cases.

Another activity associated to the present fellowship is to provide numerical support for ground tests in the hypersonic wind tunnel HEG of DLR. The Navier-Stokes-solver *TAU* will be used to assess and analyse the wind tunnel flow prior to the design of experiments. The results are expected to assist the optimization of the sensor-layout, the setup of optical measurement techniques and the interpretation of experimental results.

Required Qualification: PhD in Engineering, Mathematics or Physics, experience in numerical flow simulation techniques

Advantageous Skills: Experience in the development and application of numerical methods for compressible continuum flow (CFD) and rarefied flows (DSMC)

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

Earliest Start Date: 01.04.2022

Application Deadline: **31.03.2022**

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