SUPER – Stuttgart University Program for Experiencing Research
Project Information

Institute’s Information
Name of Institute: Institute of Aerodynamics and Gas Dynamics
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Duration of Project/Number of Students
June/July: 1
June/July/August: 2
Number of Students: 1-2

Project Information
Name of Project: Flow Control using Plasma Actuators
Beneficial Skills & Knowledge: Minimum 1.5 years of study
Basic knowledge in Fluid Mechanics, CFD and Unix

Description of Work

The Transition and Turbulence group at the Institute of Aerodynamics and Gas Dynamics uses direct numerical simulations (DNS) to study complex boundary-layer flows. Massively parallel super computers allow highly accurate simulations, providing a detailed insight into the physical processes of the transition to turbulence. The findings are used to develop both active and passive laminar flow control methods.

In the past decade there has been an increasing interest in plasma actuators for active flow control. Low power consumption, fast response time and the fact that they are fully electronic with no moving parts make them appropriate for controlling air flow. So far mainly experimental studies have been conducted to investigate the usability of plasma actuators for laminar-to-turbulent transition control. However, DNS are necessary to gain a deeper insight into how the actuator manipulates complex flows such as boundary layers. For the simulations the effect of the plasma actuator can be modelled by a body force (and in case a heat source). The force distribution can be defined using an empirical model based on retroactive estimation from experimental results, a so-called velocity-information-based body force model.

During the work the influence of various parameters on the flow manipulation, such as actuator strength, range, position, orientation, ordering and temporal force fluctuation, shall be examined for topical problems using the in-house DNS Code NS3D.

For respective publications see, e.g., ResearchGate (Dörr & Kloker).
Figure 1. Velocity profile $U(y)$ of oncoming air flow (left) and modeled wall-parallel body force $f_x$.

Figure 2. Resulting velocity manipulations. Top: wall-parallel disturbance velocity $u'$, bottom: wall-normal disturbance velocity $v'$, both normalized by $U$ at boundary-layer edge ($U(y>0.04)$).