VA 1: Rarefied gas flows and novel approaches for particle simulation

Time: Monday 9:30–11:30 Location: HSZ 301

Invited Talk VA 1.1 Mon 9:30 HSZ 301

Deterministic and stochastic numerical approaches in Rarefied Gas Dynamics — •Stylianos Varoutis, Christos Tantos, and Christian Day — Karlsruher Institut für Technologie (KIT), Institut für Technische Physik (ITEP), Karlsruhe, Germany

During the last decade research in the field of rarefied gas dynamics has attracted a lot of attention. This refreshed interest is due to applications in the emerging field of nano- and micro-fluidics, as well as to the more traditional fields of vacuum technology and high altitude aerodynamics. Some of these applications may include important phenomena such as those related to polyatomic gases, chemical reactions, evaporation and condensation. The gas rarefaction is specified by the Knudsen number (Kn), which is defined as the ratio of the mean free path over a characteristic length of the problem. In general, when the flow is considered as far from local equilibrium, then the well-known Navier-Stokes equations are not valid anymore. In this case, two main numerical approaches can be implemented. The first approach is based on the kinetic theory of gases as expressed by the Boltzmann equation or its associated kinetic models, in which a deterministic numerical solution is performed. The second approach is the Direct Simulation Monte Carlo (DSMC) method. Within the above framework, the first part of this talk will be devoted to the presentation of the aforementioned numerical approaches, while the second part will be devoted to the presentation of illustrative examples, as for instance, the modelling of the particle exhaust of a nuclear fusion reactor and the numerical modelling of a cryopump.

VA 1.2 Mon 10:10 HSZ 301

Deterministic modeling of neutral gas flows in tokamak nuclear fusion devices — •Christos Tantos, Stylianos Varoutis, and Christian Day — Karlsruhe Institute of Technology, Institute for Technical Physics, Karlsruhe, Germany

Over the last few years much effort has been invested in modeling the complex geometry of the divertor region in tokamak fusion devices. Depending on the upstream plasma conditions, the flow reference Knudsen number, defined as the ratio of the mean free path over a characteristic length, may vary over a wide range. The rarefied flow behavior in these systems cannot be properly captured by the typical Navier-Stokes-Fourier approach and must be described by the integro-differential Boltzmann equation or reliable kinetic model equations. The Discrete Velocity Method (DVM) has been developed into one of the most common techniques for solving the Boltzmann equation and the kinetic models. As it is well known simulating multidimensional rarefied gas problems based on the Boltzmann equation is computationally time consuming. Therefore, successful implementation of reliable kinetic models in such problems is important. In the present work the well-established Shakhov kinetic model supplemented by the DVM method is applied to predict the behavior of the neutral gas flow in the divertor region. Results are presented for He and D2 covering a wide range of the involved parameters. Several comparisons between the present deterministic modeling and the stochastic Direct Simulation Monte Carlo are shown and discussed.

20 min. break

VA 1.3 Mon 10:50 HSZ 301

Stochastic Simulation of Mercury Diffusion Pumps Using Direct Simulation Monte Carlo — •Tim Teichmann and Thomas Giegerich — Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Currently, a continuously working pump train for DEMO (the European demonstration fusion power plant) is under active development. Mercury driven diffusion pumps have been chosen as possible candidates for the high vacuum pumping of the exhaust gases. In order to design and optimize diffusion pumps for DEMO, a reliable numerical simulation method is required.

The numerical simulation of the DEMO diffusion pumps is a complex challenge as the gas flow in the pump spans a wide Knudsen number range. Typical inlet pressures of the diffusion pumps for DEMO are expected to be in the order of 10^{-3} Pa during dwell and up to 1 Pa during burn respectively. This is equivalent to estimated Knudsen numbers in the range of 10 to 0.01. As the Navier-Stokes equations lose their validity at $Kn > 0.1$, classic continuum solvers cannot be applied to the problem at hand. Therefore, the Boltzmann equation has to be solved to describe this flow regime. In this case the Direct Simulation Monte Carlo (DSMC) method was chosen to solve the Boltzmann equation.

The application of DSMC for simulating the DEMO diffusion pumps will be discussed. Additionally, an outlook on possible hybrid simulation techniques will be given.

VA 1.4 Mon 11:10 HSZ 301

IFMIF-DONES gas flow modelling using Test Particle Monte-Carlo Simulations — •Volker Hauer and Christian Day — Karlsruhe Institute of Technology, Institute for Technical Physics, Karlsruhe, Germany

IFMIF, the International Fusion Materials Irradiation Facility, is a test facility for materials foreseen in fusion reactors. High neutron fluxes are generated with an energy spectrum and intensity similar to the conditions at the burn phase inside a fusion reactor. The high energy neutrons result from accelerating deuterons onto a lithium target.

Simulations of the gas flow inside the IFMIF-DONES vacuum system were performed with the Test Particle Monte-Carlo code Molflow+. The IFMIF-DONES model is based on the latest design and of the LIPAc accelerator, which is being built for testing IFMIF accelerator components. Both, LIPAc and IFMIF-DONES share the same type of accelerator subsystems.

The model was prepared for simulation by adding different sets of boundary conditions for the pumping of deuterium and hydrogen originating from beam losses and outgassing, respectively.

The simulations of the gas pumping show pressure profiles which are mainly determined by the beam losses in this subsystem except for the Linac modules where the beam losses are very low. As LIPAc and IFMIF-DONES share most sections the pressure profiles are very similar.