Simulation of Non-Equilibrium Gas Flows Using the FEniCS Computing Platform

Lambert Theisen*

October 15, 2019 (12:15)
Room (1090|328)

Abstract

This thesis provides a framework to simulate non-equilibrium gas flows using the finite element method within the FEniCS computing platform[1]. The main model equations, i.e. the R13 equations, are introduced after a motivational discussion about the classical models, given by Navier–Stokes and Fourier. The resulting system of equations is simplified to obtain a set of steady-state and linearized balance laws for two-dimensional domains.

During a validation process of the numerical method with exact solutions, particular focus is put on the intuitive implementation using the tensor capabilities of FEniCS. This allows having an almost one-to-one correspondence between the mathematical formulation and the implemented source code. A documented and validated solver is developed and can be obtained from[2]. This solver allows simulating gas flows for arbitrary shaped two-dimensional geometries using a variety of boundary conditions.

In order to justify the use of extended model equations for gas flows with moderate Knudsen number, typical examples, with occurring rarefaction effects, are presented and solved. In these application cases, the Knudsen paradox and a thermal transpiration flow are observed.

Keywords: R13 equations, FEniCS project, Non-equilibrium gas flows, Finite element method, CIP stabilization

---

*lambert.theisen@rwth-aachen.de

[1] *FEniCS Project: Bitbucket Repositories*. FEniCS Project. URL: https://bitbucket.org/fenics-project/ (visited on 08/28/2019).

[2] Lambert Theisen and Manuel Torrilhon. *fenicsR13: Solver Repository*. RWTH Aachen University, 2019. URL: https://git.rwth-aachen.de/lamBOO/fenicsR13 (visited on 09/15/2019).