The equilibrium-state method for the reactive Euler equations

Supervisor: Johan Romate (Shell/TUD)

Problem background
Fluid flow can be modelled with a system of conservation laws for mass, momentum, and energy. When the flow is chemically reactive the chemical reactions can be modelled via source terms in the component mass balances. For some cases, for instances in combustion and high-speed gas flow, it is well known that for fast reaction rates ("stiff problems") problems can occur with the correct prediction of the propagation speed of discontinuities in the solution, e.g. of a reaction front. The problem is a spurious numerical phenomenon, and is due to the fact that discontinuities in the solution numerically is spread out, which causes the reaction terms to be triggered too early or too late.

Assignment
In [1] a methodology is suggested for addressing this problem for the case of the reactive Euler equations, describing the case of high-speed gas flow. In this assignment the one-dimensional Euler equations described in [1] will be considered. The goal is to reproduce the results presented in the paper for this one-dimensional case, and investigate the model for other options for defining the zone fraction γ_z in the transition cells. Instead of the second order numerical model used in the paper, a first order model can also be used, consisting of the standard upwind method and a Godunov splitting. The assignment consists of the following parts:

1. Literature study.
2. Description of the models and development of the numerical method.
3. Setting up and testing the resulting numerical model.
4. Investigation of different options of defining the zone fraction.
5. Writing the thesis.

Literature

[1] B. Zhang; H. Liu; F. Chen; J.H. Wang: The equilibrium state method for hyperbolic conservation laws with stiff reaction terms.
J. Comput. Physics, vol.263, 2014, pp. 151–176.