OBJECT ORIENTED UNSTRUCTURED GRID SOLVER FOR HIGH ENTHALPY FLOWS IN LOCAL THERMODYNAMIC EQUILIBRIUM

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The goal of this project was the further improvement of an unstructured grid finite volume solver in order to deal with hypersonic flows in Local Thermodynamic Equilibrium (LTE).

This solver has been implemented in the COOLFluiD (Computational Object Oriented Library for Fluid Dynamics) framework which is under development at the von Karman Institute.
The objective of the COOLFluiD project is to build a framework for scientific research and simulation of multi-physical problems on unstructured grids, via a multitude of methods and numerical tools working together as libraries under a plug-in architecture.

As part of this project, the new LTE solver inside COOLFluiD has been coupled with the Mutation Library. This latter provides us with all the thermodynamic and transport properties in terms of pressure and temperature (composition, density ρ(p,T), internal energy e(p,T), dynamic viscosity μ(p,T), thermal conductivity κ(p,T)…) for different kind of mixtures in LTE (air with five species, air with eleven species).

The interface between COOLFluiD and Mutation, the former implemented in C++, the latter in Fortran77, has then been further improved and the link between these two codes has been extensively tested and validated.

Finally, in order to validate the implementation of the LTE solver, tests on blunt bodies and reentry applications have been carried out and comparisons with available literature and previous studies have been analyzed.

In conclusion, a solver for Euler 2D LTE, Euler 3D LTE and Navier-Stokes 2D LTE flows, has been implemented in the COOLFluiD framework, linked to the Mutation Library, tested and validated up to now.

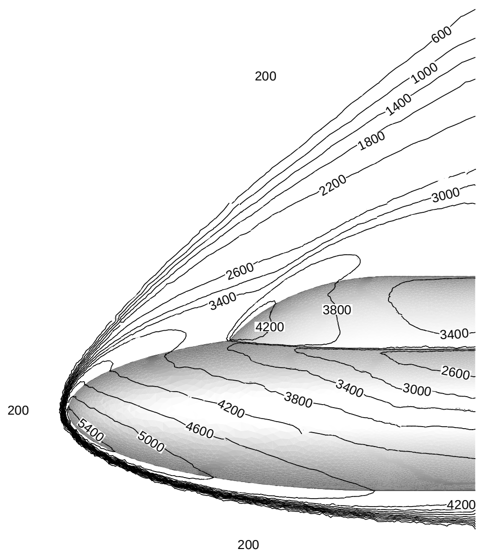

Figure 1: Temperature field around a Double Ellipsoid (3D) in Euler LTE air11 with Lax-Friedrichs scheme.
(Free field: M 25, T_∞ = 205 K, P_∞ = 2.5 Pa)

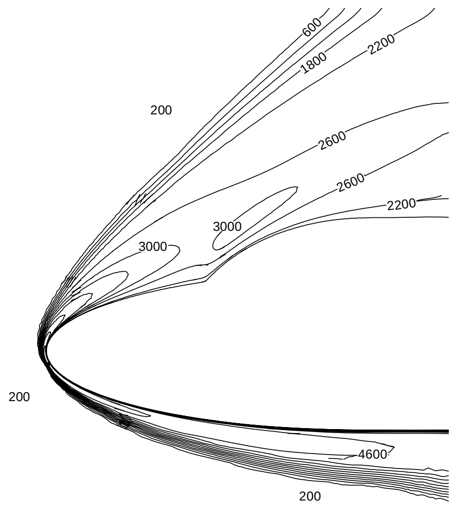

Figure 2: Temperature Field around a Double Ellipse (2D) in Navier-Stokes LTE air5 with Lax-Friedrichs scheme. (Free field: M 25, T_∞ = 205 K, R_e = 22000; Wall condition : T_{wall} = 1500 K)