NUMERICAL SIMULATION OF THERMAL NON EQUILIBRIUM EFFECTS IN HYPERSONIC FLOW

Fabio Pinna, Italy
Supervisors: O. Chazot, A. Lani, M. Panesi

Present space missions and the design of future hypersonic vehicles are currently driving the interest for high speed flows. In atmospheric re-entry, the flow around the body forms a shock, thus dissipating and converting most of the kinetic energy in thermal energy. Depending on the conditions, gas temperature can be increased of several thousands degrees just in front of the body nose. Such a high temperature causes the molecule to dissociate, react and even ionize, also thermal non equilibrium can occur. Due to the high risk and cost of typical hypersonic applications an efficient and reliable modeling of this kind of flows is required in order to increase safety while reducing costs and time in the assessment of new designs.

The aim of the project is to extend an existing solver for aerothermochemistry implemented within COOLFluiD (Computational Object Oriented Library for Fluid Dynamics) framework in order to simulate non-equilibrium effects in hypersonic viscous field 2D and 3D. Starting from a previously implemented chemical non-equilibrium Finite Volume solver, a multi-temperature model (one or more vibrational temperature) based on the two temperature model *TTv* proposed by Park has been integrated. The transport and thermodynamic properties of the fluid are computed using the MUTATION library. Part of the work consists also in adapting the interface between the MUTATION library and the non-equilibrium module to take in account thermal non-equilibrium effects.

At the moment only results with five species are investigated. A comparison of COOLFluiD solution with experiments and previous computations is performed using a sphere test case. Finally a 2D axisymmetric computations with thermal and chemical non-equilibrium is performed on a Double Cone according to the one proposed in Task Group 43 Topic N.2 by the NATO Research and Technical Office. Only a qualitative comparison with similar case was available in literature, providing just some hints on the general behavior expected by this configuration.

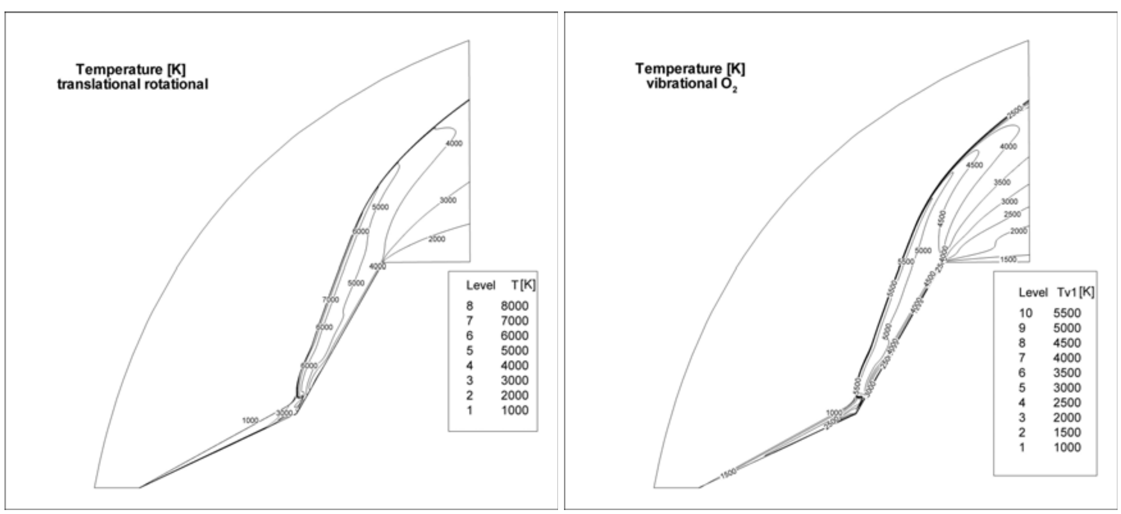

Figure 1: Rotational temperature [K] and vibrational(O_2) temperature [K] distribution around the RTO double cone at Mach 8.8 .