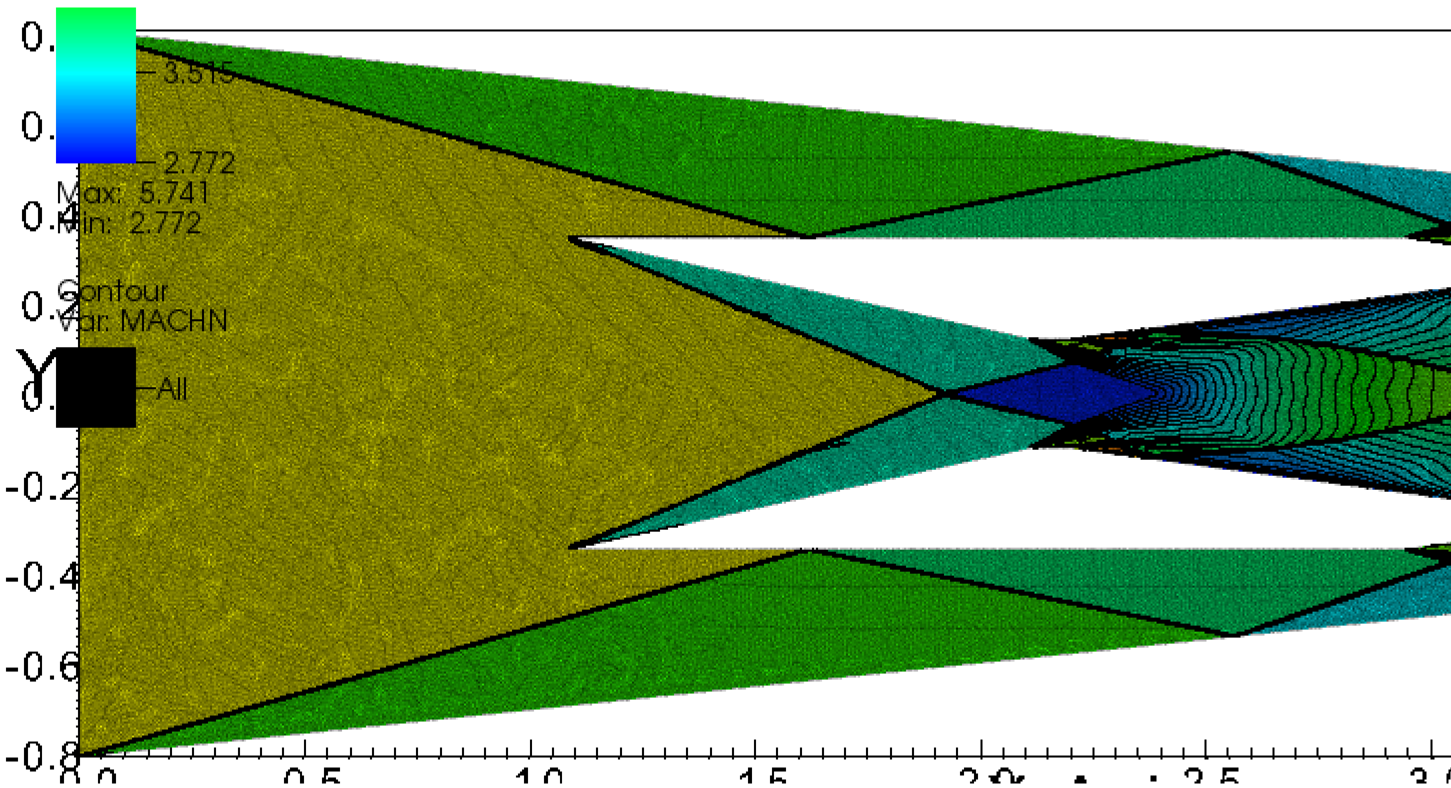
Computational Fluid Mechanics - Compressible Flows



We research in Finite Element Methods for compressible flows covering a wide Mach number range, from (almost) incompressible up to hypersonic, including multi-scale and multi-physics effects such as turbulence and combustion or Fluid-Structure Interaction.

Summary

We work on different topics related to FEM-based method for solving the complete Navier-Stokes equations, from the basics up to the parallel implementation. Some of the several aspects we deal with are stabilisation, local preconditioners, shock treatment, high order, implicit solvers, turbulence modelling, etc. Thanks to the use of Alya as the simulation platform, we develop and implement methods specially well-suited to solve large-scale applied problems.

Objectives

All our methods are programmed following a parallel implementation in a multi-physics environment, targeting to solve complex industrial, biomedical or environmental problems. Therefore, we attack the following issues:

- Stabilisation: we mostly work on designing a FEM-based Variational Multiscale (VMS) extension to compressible flow. VMS belongs to the residual-weighted stabilisation methods familiy. When shocks are present, we complement the stabilization scheme with an in-house developed anisotropic shock capturing technique.
- Local preconditioners: we developed the so-called Preconditioned Variational Multiscale (P-VMS), which integrates local preconditioning with stabilisation. The goal is to solve efficiently problems at all Mach number ranges in an accurate way.
- Implicit schemes: we alternatively use monolithic implicit or explicit time schemes. When solved implicitly with iterative methods, either VMS or P-VMS methods require algebraic preconditioners to improve solver convergence. We explore a wide spectrum of possibilities on the solution scheme design.
- Turbulence modelling: we program, test and improve different turbulence models for compressible flow, especially those of the LES type to solve transient problems.
- Higher order spaces: our methods and their implementation in Alya are designed to work properly in more-than-linear FEM spaces. We explore the high potential of 2nd. order FEM spaces in different regimes, specially the sub-sonic high-Reynolds conditions typically found in aircrafts and high-speed trains and cars.