2018-00392 - PhD - Boundary conditions for high order simulations of low Mach internal flows

Niveau de diplôme exigé : Bac + 5 ou équivalent
Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle
CAGIRE brings together since May 2016 researchers coming from different horizons and backgrounds (turbulence modelling, applied mathematics, experiment) who elaborated since 2011 a common vision of what should be the simulation tool of fluid dynamics of tomorrow. If not entirely application-driven, this project is based on the will for developing tools that could be useful in a way or another to the companies (big but also small) that are active in the competitive fields of aviation/automotive propulsion and energy production. The targeted flows are (mostly) wall bounded and turbulent. As a consequence, they feature a multiplicity of time and scale fluctuations that renders their simulation extremely challenging. The team’s motto is agility or equivalently a clever use of adaptativity in the developed simulation suite based on i) The capability of being run on any present or future new supercomputer in a way that fully benefits from the hardware evolution while limiting the painful and time consuming phase of machine adaptation by the recourse to an efficient runtime, ii) A high level of accuracy and robustness permitting the use on a large range of flow configurations: ranging from the generic lab scale geometry to that of a practical interest, iii) The capability of adapting on the fly the physical modelling by recourse to dynamic hybridization of the most relevant models of a given class with a focus on the turbulence modeling.

Contexte et atouts du poste
Scientific priorities : Modeling and simulating the environment
Scientific Research context :
Cagire is developing jointly with Cardamom the high-order DG based C++ AeroSol library aimed at simulating, among others, low Mach internal flows. But simulating such low Mach number compressible flows, described either by the Euler or Navier-Stokes systems of equations imposes to adopt a methodology of discretization of the selected continuous system that possesses the capability of handling simultaneously and accurately waves propagating at very different speeds e.g. vorticity and entropy waves (slow) and acoustic waves (fast). This explains why, during the last thirty years, specific strategies have been developed to ensure that low as well as high order finite volume or finite element based schemes behave correctly in the zero Mach limit (Guillard and Viozat, 1999; Bassi et al. 2009, Moguen et al. 2015, to name a few). Thus, the activity of the PhD candidate will be inscribed within that low Mach research activity of the team as a follow-up of the S. Delmas thesis (2015) with a specific emphasis on the development of an enhanced strategy for handling in a proper way the boundary conditions at flow inlets and outlets for steady and unsteady flow conditions.

Mission confiée
The following steps will be concentrating the bulk of the PhD candidate activity :

Step 1 – Establishment of the state of art
By reviewing and analysing the literature on the prescription of boundary conditions for low Mach flows possibly featuring an unsteady behaviour at the boundaries, the candidate will get acquainted in depth with the subject. By simulating different flow configurations appearing in the literature as relevant test cases for establishing the capability of the current version of the AeroSol library, the candidate will be gaining progressively a good expertise in the use of the library and of its development environment. At this stage, the test cases proposed by Toulopoulos and Ekaterinaris (2009) will be of significant interest.

Step 2 - Formulation of a DG based enhanced methodology
On the basis of the output of step 1, the candidate will analyse the specificities brought about by considering the discontinuous Galerkin (DG) framework of AeroSol. Then, he will formulate a DG based methodology suited for setting boundary conditions for low Mach flow at inlets and outlets. As a preliminary stage, simplified systems (Euler, linearized Navier-Stokes) may be considered to identify the key ingredients to be incorporated in the methodology.
Step 3 - Implementation and test of the formulation in AeroSoI

Assessment of the improvement brought about by the new methodology by comparison with the results obtained during step 1.

Step 4 - Simulation of turbulent flows: the handling of turbulence at the boundaries

In this last stage, the candidate will consider the possibility of integrating in the proposed approach the capability of generating synthetic turbulence by using the synthetic eddy method. In that respect, the objective will be to avoid the recourse to precursor simulations as it was the case in Delmas's thesis (2015). The precise way to be followed in this step will be heavily depend on the outputs of steps 1-3.

Principal activités

Keywords : Compressible flow – Discontinuous Galerkin methods – Synthetic turbulence - Unsteady flow

References :

Compétences

Required knowledge and background:

A good background in scientific computing. A strong interest for high order schemes, compressible fluid mechanics and turbulence. A good knowledge of C++ would be a real plus.

Avantages sociaux

- Subsidised catering service
- Partially-reimbursed public transport

Rémunération

PhD grant of 3 years located in Pau, France.

1982€ / month (before taxes) during the first 2 years, 2085€ / month (before taxes) during the third year.