Low Mach number models: some advantages for numerical simulations of weakly compressible flows

Yohan Penel*

in collaboration with S. Dellacherie, G. Faccanoni, B. Grec

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Solving weakly compressible flows raise several issues from modelling and numerical points of view. Accuracy and efficiency are related to singular terms due to the smallness of the Mach number. Then many strategies have been proposed in the literature to cure these issues. In particular, deriving new models dedicated to such low Mach number flows enable to provide more accurate results as well as reliable tools to assess purely compressible numerical codes.

The present work deals with the modelling of a heated fluid in an open bounded domain at low Mach number. The Lmnc model was presented in [3] resulting from an asymptotic expansion with respect to the Mach number applied to the Navier-Stokes equations. This simplified system incorporates a decomposition of the pressure field involving the thermodynamic pressure (in the equation of state) and the dynamic pressure (in the momentum equation). This decomposition has a major impact on numerical aspects as the equation of state is evaluated once and for all. In a series of papers [1, 2, 4–6], we applied this strategy to the simulation of flows in a nuclear core:

- In dimension 1, a finite-difference scheme based on the method of characteristics was built and assessed by means of explicit analytical solutions.
- In dimension 2, a weak formulation was derived to be implemented in FreeFem++.
- In dimension 3, an incompressible method is extended to the weakly compressible framework.

Methods and numerical results will be presented in this talk to emphasise the advantage of low Mach number models in the simulation of such flows.

References

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*Team ANGE (CEREMA-Inria-UPMC-CNRS)

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