Offer of research internship 2026, 6 months
A numerical study and applications of LBMOOD method for gaseous detonations.

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The importance and popularity of gaseous detonation simulations is gaining its momentum due to the raising demand for advanced technologies that result in improved efficiency and are more favourable to the environment. New engines developed based on high-speed combustion, such as detonation, are of raising interest due to the icreased pressure gain compared with traditional combustion methods. However, reactive and compressible chaotic gas-dynamical events associated with the gaseous detonation waves and which result in multidimensional and unsteady structures make precise experimental studies extremely challenging. In this regard, computational fluid dynamics (CFD) offer an alternative approach to study the flow physics. This internship will be dedicated to the numerical study of detonations by using a hybrid Lattice Boltzmann method (LBM)[1,2] stabilised by MOOD paradigma[3].

THE INTERNSHIP

This internship will be an application of LBMOOD method[3] adapted from[4] and an extension of recent detonation study[2] where a fully conservative hybrid lattice Boltzmann method for gaseous detonations has been presented. Particularly, the MOOD paradigm will be carefully tailored to make it adapted for physics and numerics specific to multi-species reactive flows. Furthermore, realistic 3D simulations, e.g. of rotating detonation engine, are envisioned during this internship. Finally, an extension of the methodology to unsteady detonations in the viscid case will be studied.

The internship will be divided into following parts,

- We, firstly, will reproduce the academic test cases from[2] to establish an appropriate MOOD environment for the multi-species compressible and reactive flows with discontinuities: the convection of inert species, a Sod shock tube with two ideal gases and a steady one-dimensional inviscid detonation wave. At this stage, a possible extension of MOOD paradigm to species and total energy will be examined.
- We then will advance to 1D/2D inviscid unsteady gaseous detonations to establish the ability of LBMOOD to accurately recover detonation structures and associated instabilities for high activation energies.
- We will proceed by introducing LBMOOD to the industrial highly parallelised solver, ProLB, in order to perform more realistic simulations for detonation. The computational efficiency of LBMOOD will be studied, particularly in comparison with more classic stabilisation methods.
- Time permitting, we will perform an extension to unsteady detonations in the viscid case.

This internship will last for 6 months and will take place in M2P2 laboratory in Marseille (38 rue Joliot-Curie 13451) under the supervision by Pierre Boivin, Ksenia Kozhanova and Song Zhao.

THE CANDIDATE

Last year of École d'Ingénieur or Master 2, you are specialising in fluid mechanics (especially the energy major would be an advantage), numerical simulations or applied mathematics. A notion of combustion is a plus. A candidate must have a taste for and (at least some) experience in programming, particularly C++. Some basic knowledge of parallelisation paradigms would be welcomed. The candidate must be fluid in English in both, speaking and academic writing.

Your CV along with cover letter and grades for the last two years are to be sent to:

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BIBLIOGRAPHY

[1] G. Wissocq, T. Coratger, G. Farag, S. Zhao, P. Boivin, and P. Sagaut, "Restoring the conservativity of characteristic-based segregated models: application to the hybrid lattice Boltzmann method," Physics of Fluids **34**, 046102 (2022).
[2] G. Wissocq, S. Taileb, S. Zhao, and P. Boivin, "A hybrid lattice Boltzmann method for gaseous detonations," Journal of Computational Physics **494**, 112525 (2023).
[3] L. R. Z. S. Kozhanova, Ksenia and P. Boivin, "A hybrid a posteriori mood limited lattice boltzmann method to solve compressible fluid flows –lbmoodcompressible fluid flows – lbmood." Journal of Computational Physics (2024).
[4] O. Zanotti, M. Dumbser, R. Loubère, and S.Diot, "A posteriori subcell limiting for Discontinuous Galerkin finite element method for hyperbolic system of conservation laws," J. Comp. Phys. **278**, 47–75 (2014).