Offer for research internship 2026, 5-6 months
Sub-grid scale turbulence modeling for LES using the Lattice-Boltzmann method

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The Lattice Boltzmann Method (LBM) is a powerful tool for simulating fluid flows, capable of handling complex geometries thanks to Cartesian grids. LBM is a mesoscopic kinetic approach based on the discretization of particle velocities in space and time. Despite the low computational cost of LBM and the simplicity of Cartesian meshes, since the mesh nodes do not exactly follow the surfaces of solid boundaries, wall boundary treatment still poses a challenging topic. For high-Reynolds number flows turbulence modeling near the solid adds another layer of complexity to boundary treatment. This internship proposes the development and evaluation of different sub-grid scale turbulence models applied to an industrial LBM LES code. In particular, the adaptation of these models to the non body-conforming mesh near the wall will be the main focus of this work.

THE INTERNSHIP

In LBM we follow the evolution of the particle distribution functions f with different particle velocities $\boldsymbol{\xi}$, using the Boltzmann equation:

$$\frac{\partial f}{\partial t} + \xi_\alpha \frac{\partial f}{\partial x_\alpha} = -\frac{1}{\tau}\left(f - f^{\mathrm{eq}}\right)$$

Which is an advection-relaxation equation, with f^{eq} being the Maxwell-Boltzmann distribution function at equilibrium, and τ being the relaxation time parameter. We can then recover the macroscopic quantities (density and momentum) from the moments of f in the velocity space:

$$\rho = \int f \ \mathrm{d}^3\xi, \quad \rho\mathbf{u} = \int \boldsymbol{\xi} f \ \mathrm{d}^3\xi$$

The internship will focus on the implementation of eddy-viscosity models to represent the sub-grid scale (sgs) turbulence. This class of models assumes that the effect of unresolved motions can be modeled as an additional effective viscosity, which enhances the dissipation of kinetic energy at the resolved scales. In LBM, this additional viscosity is taken into account by the relaxation parameter τ which is a function of the physical properties of the fluid, such as the viscosity:

$$\tau = 0.5 + (\nu + \nu_{sgs})/c_s^2$$

The internship will last for 5 to 6 months and will take place at the M2P2 laboratory (Laboratoire de Mécanique, Modélisation & Procédés Propres), UMR7340, Centrale Méditerranée, Plot 6, 38 rue Joliot-Curie 13451 in Marseille. Under the supervision of Pierre Boivin, Jérôme Jacob and Iason Tsetoglou, the intern will be responsible for the following tasks:

- Conduct a literature review on existing eddy-viscosity models and perform a critical assessment of their performance across various flow configurations.
- Implement selected models within the industrial Lattice Boltzmann code ProLB, with particular attention to the treatment of near-wall nodes.
- Compare and analyze results obtained from the different models through a series of validation test cases.
- Document the outcomes and develop a user guide summarizing best practices and recommendations on model selection for different flow scenarios.

THE CANDIDATE

The candidate should be a final-year student enrolled in an Engineering School (École d'Ingénieur) or Master's program (M2) with a specialization in fluid mechanics, aerospace engineering, numerical simulation, or applied mathematics. A solid foundation in fluid mechanics—and ideally in turbulence modeling—should be demonstrated through coursework, academic projects, or personal study. Programming skills are highly desirable (in C++, Fortran, MATLAB, or Python). The ideal candidate is rigorous, methodical, autonomous, and curious, with good command of English and a strong team spirit.

Your application, along with your CV and academic transcripts from the past two years, should be sent to the following addresses:

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BIBLIOGRAPHY

[1] T. Krüger, H. Kusumaatmaja, A. Kuzmin, O. Shardt, G. Silva, and E. M. Viggen, *The Lattice Boltzmann Method: Principles and Practice* (Springer International Publishing).