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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DAAA-2025-34**
(à rappeler dans toute correspondance)

Lieu : Châtillon

Département/Dir./Serv. : DAAA/NFLU

Tél. :

Responsable(s) du stage : Daniel Huerga, Florent Renac

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DESCRIPTION DU STAGE

Thématique(s) : Quantum computing, computational fluid dynamics, Kinetic modeling

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Intitulé : Quantum algorithms for lattice-based modelling of fluid flows

Sujet : Quantum computers offer the promise of a technology exponentially more powerful than classical computers. However, although recent experiments on different platforms have shown impressive results, the realization of a universal quantum computer is impeded by numerous roadblocks, and the usefulness of currently developed intermediate-scale devices, a subject of strong debate [1]. In this internship, we are interested in assessing the potential of quantum computing for simulating fluid dynamics (FD).

A common approach to solve FD equations on a quantum computer consists in encoding the solution in the amplitude of a quantum state (preparation), and mapping the FD equations to a problem for which efficient quantum algorithms exist. Quantities of interest are then computed through a final measurement step.

However, the design of quantum algorithms requires special consideration of various aspects for their practical implementation on quantum hardware. Namely, the probabilistic nature of qubits, which make computations nondeterministic; their fragility with respect to coherence, a phenomenon introducing different sources of noise; the potentially prohibitive cost of the preparation and measurement steps; and other scalability issues, etc.

During this internship, we will focus on quantum computing approaches to Lattice Boltzmann Methods (LBM), which simulate the streaming and collision of particles on a lattice [2,3]. On complexity theory grounds, these algorithms show a substantial speedup compared to well-stablished algorithms for classical computers [4]. The candidate will evaluate the potential and experimental requirements of existing quantum algorithms for the quantum simulation of the linear transport equation, or the nonlinear equations of fluid mechanics. She/He will compare the performance of these algorithms through their emulation on different available software e.g. myQLM (Atos) or Qiskit (IBM). The results will be analyzed in terms of complexity, accuracy, impact of noise, theoretical performance, etc.

[1] https://en.wikipedia.org/wiki/Quantum_computing

[2] Todorova, B. and Steijl, R., Quantum Algorithm for the collisionless Boltzmann equation, Journal of Computational Physics, Vol. 409, 2020, pp. 109347, https://doi.org/10.1016/j.jcp.2020.109347

[3] Schalkers, M. A. and Möller, M., Efficient and fail-safe quantum algorithm for the transport equation, Journal of Computational Physics, Vol. 502, 2024, pp. 112816, https://doi.org/10.1016/j.jcp.2024.112816

[4] S. S. Bharadwaj, K. R. Sreenivasan, Quantum Computation of Fluid Dynamics, Panorama-Journal of Physics, 123 (2020), https://doi.org/10.48550/arXiv.2007.09147.

Est-il possible d'envisager un travail en binôme ? Non

Méthodes à mettre en œuvre :

☒ Recherche théorique ☐ Travail de synthèse

☒ Recherche appliquée	☐ Travail de documentation
☐ Recherche expérimentale	☐ Participation à une réalisation

Possibilité de prolongation en thèse : A renseigner

Durée du stage : Minimum : 5 mois Maximum : 6 mois

Période souhaitée : February to September 2025

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Background applied mathematics and scientific computing (knowledge in quantum mechanics would be a plus); programming skills in python; motivation to learn	M.Sc. in Physics, Applied Mathematics, Mechanical Engineering or a related discipline, with excellent academic records