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Quantum Algorithm for the Streaming Step of the Lattice-Boltzmann method

Term paper

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Motivation

In quantum computing, special properties such as quantum entanglement and quantum state superposition are used to develop algorithms that are superior to their classical counterparts in terms of efficiency and speed. Quantum advantage has been proven for algorithms regarding unstructured search, solving linear systems of equations or factorization of large prime numbers. This raises the question whether other areas such as CFD could benefit from the potential speed up.

Objectives

The objective is the further development of the streaming step for the existing implementation of the in house quantum Lattice-Boltzmann solver. Two different approaches should be considered. In the first approach a quantum Fourier transformation is used to perform the streaming step in the Fourier basis [2]. The second approach improves the existing implementation by applying parallelized streaming [1]. In the end the implemented streaming operator will be quantified in terms of efficiency.

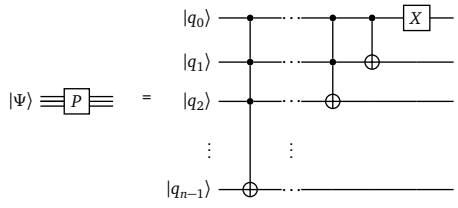

Figure 1: Quantum circuit of the positive streaming operator.

Requirements

- Good programming skills in Python
- Mathematical proficiency
- Ability to work independently
- Beneficial: Basic knowledge in Quantum Computing and the Lattice-Boltzmann method

Tasks

- Familiarize yourself with the existing Quantum Lattice-Boltzmann solver
- Implementation of the streaming operator as a quantum algorithm
- Validate and test your implementation
- Evaluate the implemented streaming operator in terms of efficiency

References

[1] Budinski, L., Niemimäki, O., Zamora-Zamora, R., and Lahtinen, V. “Efficient parallelization of quantum basis state shift”. In: *arXiv preprint arXiv:2304.01704* (2023).

[2] Schalkers, M. A. and Möller, M. “Efficient and fail-safe collisionless quantum Boltzmann method”. In: *arXiv preprint arXiv:2211.14269* (2022).