# Project 3: Quantum Algorithm as a PDE Solver for Computational Fluid Dynamics (CFD)

**Team Name:**

Start-QC

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## Task

Solve the **Burgers' Equation for 1D Shock Tube**:

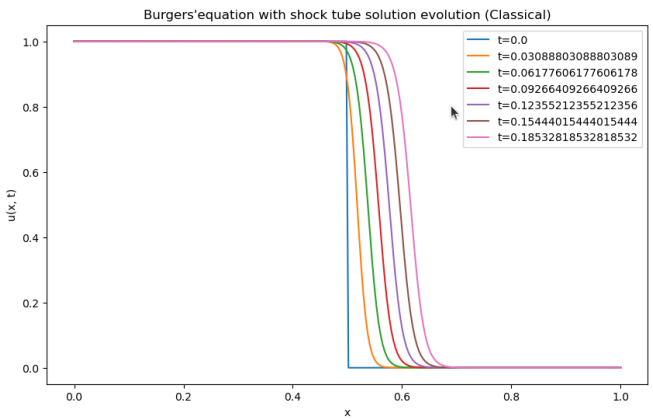
$$\frac{\partial u}{\partial t} + \frac{u \partial u}{\partial x} = \frac{\nu \partial^2 u}{\partial x}$$

Domain: $x \in [0,1]$
IC: Riemann step $u(x,0) = 1$ for $x \leq 0.5$, 0 otherwise
BC (Dirichlet): $u(0,t) = u_L$, $u(L,t) = u_R$ for all $t > 0$

This is done using:

- a quantum solver: **Quantum Tensor-Network (QTN)** via Matrix Product States (MPSs) [1,2], and
- a classical solving technique: **Euler Forward + Upwind convection + Central diffusion** for comparison.

# Numerical solution for both methods



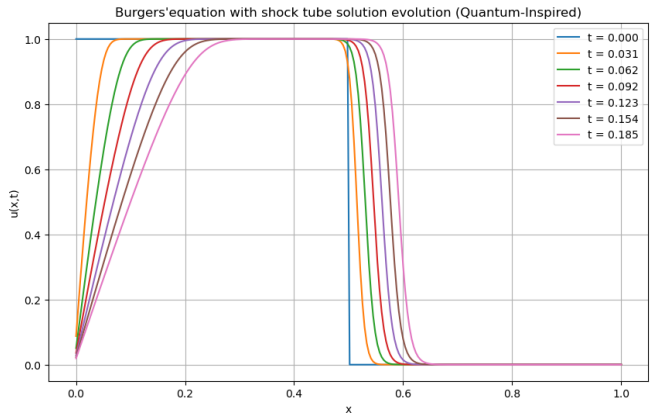




Figure 1: Numerical solution for Burgers' equation: Classical (left) vs Quantum (right)

## Main results and perspectives

- Very long time execution duration for the quantum-inspired algorithm (about 12 min) compare to classical duration (a few second).
- Investigate the integration of coarse-grained evaluation or pixel sampling [1] in the time evolution loop for the quantum-inspired algorithm.

1. Jacob C. Bridgeman and Christopher T. Chubb. Hand-waving and interpretive dance: An introductory course on tensor networks. Journal of Physics A: Mathematical and Theoretical, 50(22):223001, 2017. https://arxiv.org/pdf/1803.08823.

2. Raghavendra Dheeraj Peddinti, Stefano Pisoni, Alessandro Marini, Philippe Lott, Henrique Argentieri, Egor Tiunov, and Leandro Aolita. Quantum-inspired framework for computational fluid dynamics. Communications Physics, 7:135, 2024.