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

Task

Solve the **1-D Burgers' Equation with 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 $t > 0$

Instruction:

This open challenge tasks participants with designing and prototyping resource-lean quantum-enhanced PDE solvers based on either **Quantum Tensor-Network (QTN)** or **Hydrodynamic Shrödinger Equation (HSE)**; **hybrid QTN-HSE** approaches are also welcome.

Resource & Noise analysis

For the quantum-inspired algorithm, some resources are summarized in the table below Table 1:

Characteristic	Value
Number of qubits	8
Number of gates involved (MPO)	2
Execution duration	About 12 min

Table 1: Summary of resources for quantum-inspired algorithm

This is a significantly huge amount of time for execution (far bigger than the classical execution time). This is mainly due to multiple MPOs/MPSs conversion to dense arrays which is highly resources consuming. One way to address this could be to modify the way of extracting the informations from MPSs during time evolution, by using coarse-grained evaluation or pixel sampling (Peddinti et al., Commun. Phys. 7, 135, 2024) for example.