

2531cs1103

Locally Optimised Variational Quantum Evolution

[Back to contents](#)

ProjectID	2531cs1103
Project title	Locally Optimised Variational Quantum Evolution
EPSRC theme	Physical Sciences
Principal supervisor name	Andrew Green
Principal supervisor UCL profile website	https://profiles.ucl.ac.uk/34170-andrew-green
Host faculty and host department	Mathematical and Physical Sciences (MAPS) London Centre for Nanotechnology (LCN)
Lead department website	https://www.ucl.ac.uk/mathematical-physical-sciences/london-nano
Department PGR administration email	t.mahjaben@ucl.ac.uk ; lucy.keepking@ucl.ac.uk
Standard or collaborative project	Standard project
Restrictions for candidates applying	Only Home fees candidates can apply

Project summary

Quantum evolution is challenging to simulate classically due to exponentially growing complexity of representing or manipulating the wavefunction with evolution time [1]. However, the eigenstate thermalisation hypothesis [2] provides a way round this for the simulation of local observables and their spatial and temporal correlation; at long times even closed quantum systems thermalise implying an emerging simplicity in the many body wavefunction. Several works have attempted to harness this idea for efficient quantum simulation [3,4,5]. The Green Team have developed the locally optimised MPS (LOMPS) algorithm [6] which performs the evolution by optimising the local similarity (measured by the Hilbert-Schmidt distance of reduced density matrices) of an MPS approximation to the wavefunction at each timestep. This PhD will develop these ideas in several potential directions: i. Modifying the LOMPS algorithm to use a different variational ansatz, namely an MPS representation of a symmetric (thermofield) purification of the density matrix [7]. This has the advantage of being efficient for early-time weakly entangled states and late-time thermal states; ii. extending LOMPS to 2D using a class of 2D variational states known as sequential circuit states [8]; iii. studying the geometry of locally optimised variational evolution and thermalisation - The Hilbert-Schmidt distance between reduced density matrices induces a different metric, geometry and topology on the manifold of MPS states to that implied by the usual fidelity measure [6]; iv. Studying the emergence of a hydrodynamic limit of the long-time evolution.

The project will involve analytics, classical computation and writing code to run on current quantum computers.

[1] Nature Reviews Physics 1, 538-550 (2019)

[2] Nature 452, 854-858 (2008)

[3] PRB 97, 035127 (2018)

[4] Phys Rev B 105, 075131 (2022)

[5] Phys Rev Lett 132 100402 (2024)

[6] ArXiv:2609.20802 (2026)

[7] Nat Comm 10, 2708 (2019)

[8] Phys Rev A 77, 052306 (2008)