FUDAN UNIVERSITY

Applied Math Ph.D. Seminar

Explicit gate construction of block-encoding for Hamiltonians needed for simulating partial differential equations

Speaker: Nikita Guseynov (University of Michigan-Shanghai Jiao Tong University Joint Institute)

Time: 2024-06-06, 16:10 to 17:00

Location: Rm 1801, Guanghua East Tower

Advisor: Nana Liu (Shanghai Jiao Tong University)

Abstract: Quantum computation is an emerging technology with important potential for solving certain problems pivotal in various scientific and engineering disciplines. This paper introduces an efficient quantum protocol for the explicit construction of the block-encoding for an important class of Hamiltonians. Using the Schrödingerisation technique – which converts non-conservative PDEs into conservative ones – this particular class of Hamiltonians is shown to be sufficient for simulating any linear partial differential equations that have coefficients which are polynomial functions. The class of Hamiltonians consist of discretisations of polynomial products and sums of position and momentum operators. This construction is explicit and leverages minimal one- and two-qubit operations. The explicit construction of this block-encoding forms a fundamental building block for constructing the unitary evolution operator for this Hamiltonian. The proposed algorithm exhibits polynomial scaling with respect to the spatial partitioning size, suggesting an exponential speedup over classical finite-difference methods. This work provides an important foundation for building explicit and efficient quantum circuits for solving partial differential equations.