Quantum@SUN

South African Quantum Technology Initiative

NITheCS National Institute for Theoretical and Computational Sciences

Stellenbosch University iYunivesithi Universiteit

SEMINAR

Analog quantum simulation of partial differential equations

Prof Nana Liu (Shanghai Jiao Tong University)

Friday, 22 September 2023 @ 14h00 SAST

Venue: Physics Seminar Room, Stellenbosch University, and online

ABSTRACT

Quantum simulators were originally proposed to be helpful for simulating one partial differential equation (PDE) in particular – Schrodinger's equation. If quantum simulators can be useful for simulating Schrodinger's equation, it is hoped that they may also be helpful for simulating other PDEs. As with large-scale quantum systems, classical methods for other high-dimensional and large-scale PDEs often suffer from the curse-of-dimensionality (costs scale exponentially in the dimension D of the PDE), which a quantum treatment might in certain cases be able to mitigate. To enable simulation of PDEs on quantum devices that obey Schrodinger's equations, it is crucial to first develop good methods for mapping other PDEs onto Schrodinger's equations.

In this talk, I will introduce the notion of Schrodingerisation: a procedure for transforming non-Schrodinger PDEs into a Schrodinger-form. This simple methodology can be used directly on analog or continuous quantum degrees of freedom – called qumodes, and not only on qubits. This continuous representation can be more natural for PDEs since, unlike most computational methods, one does not need to discretise the PDE first. In this way, we can directly map D-dimensional linear PDEs onto a (D + 1)-qumode quantum system where analog Hamiltonian simulation on (D + 1) qumodes can be used.

I show how this method can be applied to linear PDEs, certain nonlinear PDEs, nonlinear ODEs and also linear PDEs with random coefficients, which is important in uncertainty quantification.

BIOGRAPHY

Nana Liu is an associate professor and PI of the Quantum Information and Technologies (QIT) group in the Institute of Natural Sciences at Shanghai Jiao Tong University and the University of Michigan-Shanghai Jiao Tong University Joint Institute. She received her PhD from the University of Oxford as a Clarendon Scholar and was a Postdoctoral Research Fellow at the Center for Quantum Technologies in the National University of Singapore and the Singapore University of Technology and Design. She is the 2019 recipient of the MIT Technology Review's 10 Innovators under 35 in the Asia-Pacific region. Her current research interests include quantum algorithms for scientific computing and quantum protocols relevant for a future quantum internet.

REGISTER: https://ury1.com/isXtm