INSIGHT SEMINAR: Quantum Chaos and Dual Unitary Systems: Pushing the Boundaries of Science with Quantum Computers

SABRINA MANISCALCO

November 28, 2024

12:00 to 13:00

Elements Room

ABSTRACT:

Quantum computers are unlocking possibilities in science that were once thought beyond reach. While we are still exploring the full potential of these remarkable machines, their power is already helping to push the boundaries of what we know-and bringing tangible benefits to science and humanity.

In a joint study led by Algorithmiq, in collaboration with Trinity College Dublin and IBM Quantum, we use quantum computers to explores the behavior of quantum systems that exhibit chaotic dynamics [1]. This field is essential for understanding complex systems, the

spread of information, and thermalization, with impacts on quantum computing, condensed matter physics, and even astrophysics.

Recently, dual unitary (DU) systems have garnered attention as rare, exactly solvable models that exhibit maximum chaos. These systems are "dual" because their unitarity holds in both time and space, allowing for the analytical computation of typically intractable properties, such as correlation functions. DU circuits serve as exceptional benchmarks for quantum simulations, helping us study critical phenomena like quantum scrambling, entanglement growth, and the decay of correlations-all fundamental to quantum chaos and many-body physics. Their analytic tractability also aids in designing and testing quantum algorithms for real-world applications.

In this talk, I will present how we leverage our own state-of-the-art error mitigation techniques (TEM) [2] to simulate the decay of auto-correlation functions in quantum chaotic many-body systems. These functions are vital for understanding transport properties, such as conductivity and diffusion, and for addressing fundamental questions in non-equilibrium quantum dynamics.

Our simulations achieved unprecedented accuracy on a cloud-based 127-qubit Eagle processor, using up to 91 active qubits and 91 entangling gate layers, amounting to over 60,000 gates and about 4,100 CNOT gates. This marks the largest-scale digital simulation of correlation functions in an interacting quantum many-body system to date. This breakthrough demonstrates that we can already benefit from this technology by advancing scientific understanding today.

BIO:

Sabrina Maniscalco is CEO and co-founder of Algorithmiq Ltd, a startup focusing on quantum algorithms and software, a Professor of Quantum Information and Logic at the University of Helsinki, and an Adjunct Professor at Aalto University, Finland.?

She is the Vice Director of the Finnish Centre of Excellence for Quantum Technologies an serves in the scientific advisory board of several international institutions, such as th Institute for Quantum Optics and Quantum Information (Austria) and the Quantu Technology initiative at CERN

Sabrina Maniscalco has been working for over twenty years on quantum science an technology, her specific field of expertise being the effects of noise and errors on quantu devices. She obtained her PhD in Theoretical Physics at the University of Palermo (Italy) i 2004. She has held academic research positions around the world, in Sofia (Bulgaria), Durba (South Africa), Turku (Finland) and Edinburgh (UK). She returned to Finland in 2014 to lead th Theoretical Physics Laboratory in Turku. She then moved to the University of Helsinki i November 2020, at the same time co-founding Algorithmiq.

? She has published over 250 scientific publications on quantum science and technologies n international refereed journals, receiving over 10 000 citations. She has coordinated sever l international and interdisciplinary projects and is recognised as one of the leading experts n Quantum Technologies

She presently works primarily at Algorithmiq, leading her team in the ambitious mission of redefining healthcare and life sciences by combining quantum computing, complex netw rk approaches, and AI.

Hosted by: Prof. Dr. Antonio Acin