RIKEN QUANTUM COMPUTING

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36th RQC Colloquium

Benchmarking and Fault-Tolerant Operation of a Neutral Atom Quantum Processor

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July 23, 2025(Wed) **11:00 – 12:00**(JST)

This colloquium will be held in **HYBRID format**.

On-site Venue: Wako C32 Okochi Hall, 1F Laser Science Laboratory
Online Venue: Zoom. To receive the link, register in advance at
https://krs2.riken.jp/m/rqc_registration_form

Neutral atoms have emerged as a strong candidate for scalable, fault-tolerant quantum computing. A popular approach for neutral atom gates involves shuttling atoms to and from a shared interaction zone. While atom shuttling enables parallel execution of multiple gates, local qubit addressing comes with distinct advantages, such as faster overall execution speed and the ability to perform non-identical gates in parallel. We present benchmarking results from a full-stack universal quantum computing architecture featuring individual optical addressing of single atoms for fast gate execution without the requirement for atom shuttling. We demonstrate reduction in computational error by encoding physical qubits into logical qubits using the [[4,2,2]] quantum-error-detecting code where performance is evaluated by executing a variety of quantum circuits with and without logical encoding. We show that logical performance surpasses physical performance for Bell state generation (12x error reduction), Gottesman random circuits (15x), and an Anderson Impurity Model ground state solver for materials science applications (up to 6x). Finally, we present preliminary results on scaling to larger qubit arrays and implementing more complex quantum error correction codes, laying the groundwork for larger, fault-tolerant systems.