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Site-selective cavity readout and fault-tolerant connection of neutral atom arrays

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Wednesday, March 5, 2025
10:30 AM • MSEE 112

Zoom link: https://purdue-edu.zoom.us/j/97685225280
Meeting ID: 976 8522 5280

Abstract
Neutral atom arrays coupled to optical cavities are a promising platform for quantum information science. Optical cavities enable fast and non-destructive readout of individual atomic qubits; however, scaling up to arrays of qubits remains challenging. We recently addressed this by using locally controlled excited-state Stark shifts to achieve site-selective hyperfine-state cavity readout across a 10-site array. To further speed up array readout, we demonstrated adaptive search strategies utilizing global/subset checks, paving the way for faster quantum error correction cycles. As a step toward fault tolerance, we demonstrated repeated rounds of classical error correction, showing exponential suppression of logical error and extending logical memory fivefold beyond the single-bit idling lifetime. In addition to these experimental results, I will present my recent theoretical work on fault-tolerantly linking atom arrays using cavity-based photonic interconnects. By tailoring our quantum error correction scheme to the strengths of the neutral atom array + cavity platform, we can lower the bar for communication fidelity, bringing fault-tolerant connection of error-corrected modules within reach of existing neutral atom technology.

Bio
Josiah Sinclair is a postdoctoral associate in the Vuletić group at the MIT-Harvard Center for Ultracold Atoms where he researches quantum computing and quantum simulation on a programmable Rydberg array in an optical cavity. Josiah received his B.S. in physics from Calvin University in 2013. He then continued his studies at the University of Toronto and graduated with his PhD in physics in 2021. Josiah's research interests concern what we can discern about the 'history' of quantum particles, the harnessing of light-matter interaction and Rydberg blockade for the development of new quantum technologies, and quantum error correction and quantum computing.

Host
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