

*Cavity-enabled measurements
and interactions in neutral atoms*

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Wednesday, March 12, 2025
10:30 AM • MSEE 112



Zoom link: <https://purdue-edu.zoom.us/j/94598372602>

Meeting ID: 945 9837 2602

Abstract

Cavity-enabled measurements and interactions in neutral atoms

Precise control over interactions and measurements in quantum systems is crucial for applications ranging from simulating collective many-body dynamics to enabling fault-tolerant quantum computation. In this talk, I will highlight our work on realizing nondestructive readout and long-range interactions in atomic tweezer arrays using a strongly coupled optical cavity. The cavity photons serve dual roles: they efficiently transfer quantum information from the atomic system to external measurement devices and act as force carriers, facilitating long-range interactions among the atoms. By selectively coupling a single atom to the cavity mode, we achieve rapid mid-circuit measurements without perturbing the quantum coherence of the other atoms—a crucial step toward quantum error correction. Conversely, the collective emission from multiple atoms into the cavity can be coherently enhanced or suppressed. We demonstrate atom-by-atom control over collective atom-light interactions, observing both super- and sub-radiant cavity emissions from the constructed atomic ensembles. This collective atom-cavity coupling sets the stage for engineering long-range interactions through photon exchange and enables the observation of self-organization phase transitions in both motion and spin degrees of freedom. Continuous measurements of the atom array further reveal key hallmarks of mesoscopic physics, such as the dependence of the state of matter on the measurement duration. Finally, I will briefly outline my future research plans to develop quantum systems that are robust against decoherence and noise using atoms and light.

Bio

Zhenjie Yan is a postdoctoral scholar at University of California, Berkeley. He is currently working on exploring new methods of controlling and detecting individual atoms using an optical cavity with Prof. Dan Stamper-Kurn. Before joining Berkeley, Zhenjie earned his Ph.D. at MIT. His Ph.D. research focused on the many-body behavior of a strongly interacting Fermi gas and his Ph.D. advisor is Prof. Martin Zwierlein.

Host

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