Building a novel quantum light-matter interface with cold atoms coupled to a nanophotonic circuit

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TUESDAY, March 10th @ 2:00 pm in BRK 1001

Coffee and snacks served before seminar

also on MS Teams

Abstract: Interfacing cold atoms with nanophotonic circuits offers a promising route toward scalable quantum technologies, from quantum nonlinear optics to quantum networking, by leveraging the indistinguishability of neutral atoms and the scalability of photonic circuits. Cold atom-integrated nanophotonic circuits can particularly build up quantum phase coherence to greatly enhance the fidelity of photon storage in an unprecedented way. Densely packed atoms that are collectively coupled via multiple photonic modes (or channels) could exhibit dissimilar emission dynamics into these modes depending on their configuration and how they are excited. One striking example is "selective radiance" in subwavelength-spaced atom arrays [1], where a collective excitation couples superradiantly to a phase-matched photonic channel while being strongly suppressed in coupling to all other modes due to phase-mismatch and subradiance.

In this talk, I will discuss the challenges we have overcome in recent years to achieve efficient loading, laser cooling, and trapping of many cold atoms, for the first time, on a nanophotonic microring resonator [2,3]. I will discuss our combined experimental [4] and theoretical [5] investigations of the collective emission dynamics of a dense atomic ensemble interacting simultaneously with a resonator mode of the microring and with free-space radiative modes. Our results show that, when controllably driven by the resonator to different collective states, the trapped atoms can superradiantly couple to the resonator, while exhibiting either subradiant or superradiant signatures in free-space emission. I will discuss the implication of these effects for optimizing collective light-matter interfaces and the prospects of further using ordered atom array on our platform for select quantum applications.

References

[1] Asenjo-Garcia et al, Phys. Rev. X 7, 031024 (2017).

[2] Xinchao Zhou et al, Phys. Rev. Lett. 130, 103601 (2023).

[3] Xinchao Zhou et al, Phys. Rev. X 14, 031004 (2024).

[4] Xinchao Zhou et al, Phys. Rev. Lett. 135, 113601 (2025).

[5] Deepak Suresh et al, Phys. Rev. A 112, 043717 (2025).

Bio: Dr. Chen-Lung Hung is a Professor of Physics at Purdue University. He received his bachelor's degree from National Taiwan University in 2003 and PhD in Physics from the University of Chicago in 2011, where he studied quantum phase transitions and nonequilibrium dynamics in two-dimensional atomic quantum gases. Before joining Purdue in 2015, he held an IQIM postdoctoral fellowship at the California Institute of Technology and developed one of the first photonic crystal atom-photon interfaces. His research directions at Purdue span from studying quantum many-body physics using atomic quantum gases to interfacing cold atoms with integrated photonic circuits for many-body quantum optics and quantum network applications. He received the AFOSR Young Investigator Award and the NSF CAREER Award, and was named a Moore Foundation Experimental Physics Investigator in 2025.

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