Northeastern University

SEMINAR
Quantum Materials and Sensing Institute (QMSI)

"From Embedding to Hybrid Architectures: New Frontiers in Quantum Simulation with Qubits and Oscillators"

Prof. Dr. Yuan Liu

Assistant Professor

Quantum Computing & Information Science Faculty

North Carolina State University

Friday, October 10, 2025, 11:00 am-12:00 am
Venue: QMSI Conference Room, Elliott Hall, Burlington Campus
145 South Bedford St, Burlington, MA

The seminar is both in person and Online

Abstract:

Quantum computing with discrete-variable (DV, qubit) hardware is rapidly approaching the scales required for computations beyond the reach of classical methods. Separately, platforms with native continuous-variable (CV, oscillator) systems have emerged as promising alternatives. In this talk, I will introduce hybrid CV-DV quantum processors, devices that combine the strengths of both architectures, and highlight novel quantum algorithms and applications enabled by them. I will start with the qubit land, and present a novel quantum bootstrap embedding method that allows simulation of large electronic structure problems with small quantum computers. I will highlight the first benchmarking study of this method on real quantum hardware for a chemically relevant problem size. I will then switch to the hybrid CV-DV, and begin with a pedagogical overview of CV-DV processors, their instruction set architectures, and universal programmability. I will show how hybrid oscillator-qubit devices can enable the simulation of dissipative, nonadiabatic vibronic dynamics in molecular systems. These developments together open new frontiers for quantum simulation on near-term devices, with implications extending across science and engineering. I will conclude with open questions and future opportunities for hybrid CV-DV quantum computation.

Bio: Dr. Yuan Liu is an Assistant Professor and Quantum Computing & Information Science Faculty Fellow at North Carolina State University, with joint appointments in Electrical & Computer Engineering, Computer Science, and Physics. He leads the Laboratory for Quantum Engineering and Simulation Theory (QUEST Lab), a multidisciplinary group dedicated to advancing quantum information science for applications in computing, simulation, sensing, and beyond. Dr. Liu is a Scialog Fellow and recipient of the ECE Rising Star Award. Before joining NC State, he was a postdoctoral researcher at MIT. He earned his B.S. in Physics from Tsinghua University, a M.S. in Electrical Engineering, and a Ph.D. in Chemical Physics with the William R. Potter Prize from Brown University