Department of Physics and Astronomy
SPRING 2023 Colloquium Series

"Quantum State Engineering through Weak Measurement"

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The fragility of quantum states continues to present difficulties for the commercialization of quantum technologies. Superposition and entanglement are essential quantum properties which can be easily destroyed, rendering quantum devices useless. Isolating quantum systems from external disturbances has therefore been the primary mode of preserving quantum coherence, but it is difficult to scale to large quantum systems. New modes of harnessing system-environment coupling can enable robust, entangled quantum phases in open systems. Weak measurement is one such route, which enables the extraction of targeted information from a quantum system while minimizing decoherence due to measurement backaction. However, in many-body quantum systems, backaction from weak measurements can have novel effects on wavefunction collapse. I will provide an overview of weak measurement and discuss a theoretical study of continuously measured non-interacting fermions in one dimension, starting in a ground-state Fermi sea. Repeated measurement of on-site occupation number drives the system from the completely delocalized Fermi sea toward a Fock state with well-defined atom number on each site. We find that the spatial measurement resolution---in relation to the Fermi length---strongly affects both the collapse dynamics and the final state. We compare small-system exact numerical results to an analytical model and find that the quantum state undergoing measurement is described by a modified diffusion equation. These results indicate that weak measurement may be a powerful tool for state engineering in many-body quantum systems. If time allows, I will also provide a brief overview of the interdisciplinary coursework being developed at San José State University to expand access to training in quantum information science and engineering.

Thursday, March 16, 2023
4:00 – 5:20PM
MND1015
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