ECE 792-072
Open Quantum Systems

Instructor(s): Demitry (Dima) Farfurnik, dfarfur@ncsu.edu

Objective or Description: This course prepares you to conceptually understand, analytically derive, and numerically simulate the dynamics of quantum systems under the influence of an external environment and coherent control. The materials of the course form the basis for conducting state-of-the-art research in quantum science and engineering with a variety of hardware platforms.

Prerequisites: PY501, quantum engineering course TBD, or equivalent knowledge of quantum mechanics.

Textbook: N/A

Optional Textbooks:

- The Theory of Open Quantum Systems, Breuer, Petruccione
- Quantum Optics, Scully, Zubairy
- Quantum Computation and Quantum Information, Nielsen, Chuang
- Exploring the Quantum, Haroche, Raimond
- Quantum Measurement and Control, Wiseman, Milburn
- Quantum Noise, Gardiner, Zoller
- The Quantum Theory of Light, Loudon

Topics:

- Quantum dynamics in the Schrodinger, Heisenberg, and interaction pictures
- Two-level systems, Bloch-sphere, methods of coherent control
- Quantization of the electromagnetic field, quantum light
- Light-matter interaction, Jaynes-Cummings Hamiltonian
- Density matrix formalism, reduced density matrix, purity, entanglement
- Krauss representation, quantum maps and generalized operations
- Quantum dynamics under Markovian noise, Lindblad equation
- Dephasing (i.e., transversal decoherence) and longitudinal relaxation
- Quantum correlation functions, Hanbury-Brown and Twiss and Hong-Ou-Mandel experiments, photon purity and indistinguishability
- Jaynes-Cummings Hamiltonian with losses, introduction to cavity QED
- Microscopic derivation of Markovian dynamics, quantum optical master equation
- Semi-classical treatment of quantum dynamics under non-Markovian noise
- Coherent control for noise spectroscopy and mitigation, dynamical decoupling
- Generalized treatment of non-Markovian dynamics (Nakajima-Zwanzig, TCL)
- Quantum hardware platforms

Grading:

- Homework: 40 (analytical problems & simulations using quantum photonic toolbox)
- Paper review and oral presentation: 30
- Midterm exam: 20
- Participation: 10

Cross-listing in other departments: PY