OPTI 544. Foundations of Quantum Optics (3). Foundations of quantum optics, interaction of two-level atoms with light; basic elements of laser theory; fundamental consequences of the quantization of the light field; introduction to select topics in modern quantum optics.

Course Outline:

1. Classical linear optics. Maxwell's equations, Lorentz atom, dipole approximation, dipole force. Lorentz atom with damping. Classical theory of absorption. Complex polarizability and index of refraction.
2. Two-level atom and classical electric field. Rabi solutions. Comparison to Lorentz atom.
3. Multi-level atoms, selection rules for electric dipole transitions, Raman coupling in 3-level s ystems.
4. Density-matrix formalism. Application to two-level atom. Relaxation. Spontaneous emission and collisions.
5. Population rate equestions. Einstein A and B coefficients.
6. Optical Bloch equations. Photon echoes, free-induction decay, self-induced transparency. Maxwell-Bloch equations. Solitons.
7. Introduction to semiclassical laser theory. Fundamental laser equation. Stability analysis, laser threshold, frequency pulling. Small signal and saturated gain. Laser linewidth.
8. Field quantization in the Coulomb gauge. Field observables, vacuum fluctuations. Number states, coherent states, squeezed states, wave packets. The quantum beam splitter.
9. Atom-field interaction in the dipole approximation. Two-level atom. The Jaynes-Cummings model. Dressed states. Weisskopf-Wigner theory of spontaneous emission.
10. Quantum theory of photodetection. Classical and quantum theories of optical coherence. Correlation functions. Hanbury Brown and Twiss interferometry. Photon antibunching. Two-photon interferometry.