OPTI 549- Atom Optics

Course Description:
Introduction to the experiments and theoretical concepts of atom optics and matter-wave optics. In atom and matter-wave optics, the wave-like properties of matter are utilized for the manipulation and control of matter (often by laser light), and are centrally important for an understanding of physics at the atomic level and for modern quantum optics applications. This course will introduce some new concepts, but will primarily cover foundational and groundbreaking atom optics ideas and experimental results. Prerequisites: OPTI 511R or OPTI 570A. Recommended: OPTI 546 or OPTI 505 (previous or concurrent enrollment).

Grading Policy:
- 20% Classroom participation
- 20% Homework
- 30% Midterm project
- 30% Final project

Schedule
Two 50-minute lectures per week

Outline
A. Concepts and Foundations (~2 weeks / 4 lectures)
   1. Planck’s constant
   2. deBroglie’s relations
   3. Bose’s hypothesis and Einstein’s modifications
   4. Schrodinger’s equation
   5. The first matter-wave experiments and their limitations
B. Enabling technologies (~2 weeks / 4 lectures)
   1. Development of our understanding of light and of the laser
   2. Review of the 2-level atom
   3. Light forces on real atoms
   4. Magnetic forces on atoms
   5. Atom cooling and trapping
C. Linear Atom Optics and Atom-optical elements. (~4 weeks / 8 lectures)
   1. The Schrodinger equation revisited: the wave equation for matter
   2. Atom-optical lenses: collimation and focusing
   3. Atom diffraction
   4. Atom-optical mirrors
   5. Atom traps and cavities
Additional reading and discussion topics will be selected from the following list:

6. Optical Lattices
7. Atom waveguides
8. Atom and molecule interferometry
9. Atom holography

D. Quantum and Nonlinear Atom Optics. (~6 weeks / 12 lectures)
   7. Atomic interactions
   8. Nonlinear Schrodinger Equation

Additional reading and discussion topics will be selected from the following list:

4. Phase imprinting
5. Bragg diffraction
6. Atom lasers
7. Matter-wave solitons
8. Angular momentum and quantized vortices
9. Nonlinear wave mixing and matter-wave amplification
10. Squeezed states

E. Introduction to advanced concepts (time permitting, ~1 week / 2 lectures)
   4. Multi-component condensates
   5. Molecules
   6. Fermions
   7. Emerging technologies: atom-optical devices and applications