Atomic and Optical Physics (Physics 721)

Time: Wednesday/Friday 2:30 – 3:45

Room (Optional): PLS 1140

Instructor:
Alicia Kollár, akollar@umd.edu, PSC 2112

Course Goals:
This course will provide a graduate level introduction to atomic and optical physics.

Course Format:
This course will be taught in flipped classroom format. "HW" each week will consist of watching a set of prerecorded lecture videos and the class time will be used for interactive problem sessions, which will be held over Zoom. The assigned room (PLS 1140) is large enough to accommodate this course according to university guidelines and will be available for students' use during the problem sessions.

Course Content:
This course is a broad survey of atomic, and optical physics. The content is divided into three sections focusing on 1) the quantum description of light, 2) atomic structure, and 3) light-matter interactions.

Grades:
This course is primarily problem-based with the goal of helping students develop advanced problem-solving skills in AMO.

25% of the grade will be based on participation and presentation during in-class discussion of study problems.

75% of the grade will be derived from three timed quizzes, one on each section of the course. Quizzes will be based off of the in-class study problems in order to gauge individual students' mastery of the group-work done during the problem sessions. Quizzes will be distributed and submitted on line, but administered during the regular class time.

Text:
This course will not use a specific textbook. Instead it will draw from a variety of sources.

For those looking for a more unified foundation
-Atomic Physics [Foot]

-Quantum Optics [Fox]
are two well-written advanced undergraduate textbooks which cover the foundations of the course material.

-Quantum and Atom Optics [Steck, online and unpublished] is a graduate-level textbook which is an excellent resource for going beyond the level of the two advanced-undergraduate texts above.

Additional recommended references are:
-Quantum Optics [Scully & Zubairy]
-The Quantum Theory of Light [Loudon]
-Physics of Atoms and Molecules [Bransden and Joachain]
-Atom-Photon Interactions [Cohen-Tanoudji, Dupont-Roc, Grynberg]
-Laser Cooling and Trapping [Metclaf and van der Straten]

An extended list of recommended references for the course material and further reading will be circulated separately.

Course Outline:

Light

-Quick review of E&M, modes, momentum, Poynting vector
-Quantization of the Electromagnetic Field
-Classical theory of coherence, correlation functions
-Hanbury Brown and Twiss, quantum theory of coherence
-Quantum measurement of light, photon counting and homo/heterodyne
-Coherent states, squeezing, Hong-Ou-Mandel

Atoms

-Spectroscopic notation
-Fine structure and Lamb shift
-Helium and multi-electron atoms
-Wigner-Eckhart
-Hyperfine structure
-Atoms in external fields: Zeeman and Stark

Atoms & Light

-2-level atoms, Einstein A & B coefficients, Rabi spectrum
-Optical Bloch equations, master equations
-Dipole approximation, dipole radiation
-Selection rules
-Line shapes
-Lamb-Dicke effect
-3-level systems. EIT/Raman

-Dressed states

-Non-linear optics, SHG and 4-wave mixing

Atomic Motion in Light Fields (time permitting)

-Light shifts, Doppler cooling

-Subdoppler cooling

Non-class days:

-There will be no class during the thanksgiving recess (Nov 25, Nov 27).