OPTI 567: Nanophotonics
Effective Spring 2020

Course Description:

This course will cover the interaction of light with nano-scale features on objects. The course will include mathematical foundations, including those of plasmonics and metamaterials, as well as a review of applications of nanophotonics and recently-published progress in the field. Ways to focus light and image objects beyond the diffraction limit will be presented.

Pre-requisites:

OPTI 501: Electromagnetic waves **or** ECE 381A: Introductory Electromagnetics **or** PHYS 332
Please contact the instructor if you do not meet one of the pre-requisites but would still like to take the class.

Number of Units/ component:

3 units / lecture

Locations and Times:

TBD.

Instructor Information:

Instructor name: Euan McLeod
Office: Meinel 623
Email: euanmc@optics.arizona.edu
Office hours: TBD

Expected Learning Outcomes:

- Understand how scattering from small particles depends on particle size, shape, and composition.
- Be familiar with ways to numerically model light at the nano-scale.
- Explain how both localized surface plasmons and surface plasmon polaritons can be used to concentrate light into nanoscale volumes.
- Describe how photonic crystals can be used to reflect, guide, or confine light.
- Conceptually explain and mathematically derive the diffraction limit of light.
- Explain what optical metamaterials are and how they can be used to image objects with sub-diffraction-limit resolution.
- Learn schemes to perform imaging with resolution beyond the diffraction limit.

Recommended Texts:

Primary textbook (required, but should be available online through the UA library):

- L. Novotny and B. Hecht, *Principles of Nano-Optics*, 2nd edition, Cambridge University Press (2012)

Note that as this is a rapidly-evolving field, there are some significant differences between the 1st and 2nd editions of this book.

The following books are recommended as references, but are not required.

- J. Goodman, *Fourier Optics*, Roberts & Company (2005).
- D. J. Griffiths, *Introduction to Quantum Mechanics*, Prentice Hall (1995).
- C. F. Bohren and D. R. Huffman, *Absorption and Scattering of Light by Small Particles*, Wiley (1998).
- S. A. Maier, *Plasmonics: Fundamentals and Applications*, Springer (2007).
- M. Brongersma and P. G. Kik, *Surface plasmon nanophotonics*, Springer (2007).
- J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade, *Photonic Crystals: Molding the Flow of Light*, 2nd edition, Princeton University Press (2008).

Tentative List of Topics:

- What is nanophotonics?
- Review of electromagnetism fundamentals
- Finite difference time domain modeling method
- Interaction of light with dipolar nanoparticles
- Radiation reaction correction for particle polarizability
- Lorentzian and Fano lineshapes
- Relationship between classical and quantum mechanical dipoles
- Interaction of light with wavelength-scale particles
- Coupled (discrete) dipole approximation modeling method
- Mie scattering
- Quadrupole approximations
- Optical tweezers / optical manipulation of nanoparticles
- Photonic crystals
- Interaction of light with plasmonic metals
- Surface plasmon polaritons
- Localized surface plasmons
- Optical antennas
- Purcell effect
- Transmission through nanoscale apertures
- Near-field scanning optical microscopy
- Physical and mathematical foundations of the diffraction limit

- Metamaterials, including double-negative media, hyperbolic metamaterials, transformation optics, and metasurfaces
- Super-resolution microscopy, including multiphoton, STED, structured illumination, synthetic aperture, fluorescent localization (PALM/STORM), and confocal

Number of Exams and Papers:

There will be one midterm exam and one final exam. Short quizzes will occur periodically, most likely run through the web to accommodate distance learning students. There will be one project, due toward the end of the semester, but before the start of Finals. Project details will be explained during the course.

Assignment Schedule (From 2019):

Assignment	Date assigned	Date due
Homework #1	1/16/19	1/30/19
Homework #2	1/30/19	2/13/19
Homework #3	2/13/19	2/27/19
Midterm Exam	3/13/19	3/13/19
Homework #4	2/27/19	3/20/19
Homework #5	3/20/19	4/3/19
Homework #6	4/3/19	4/17/19
Project	1/9/19	5/1/19
Final Exam	5/3/19	5/3/19 1pm

Course Policies:

Grading Policy

Homework	15%
Quizzes	10%
Project	10%
Midterm	30%
Final Exam	35%
Total	100%

The grading scale is A: 90-100, B:80-89, C: 70-79, D: 60-69, E: <60. The thresholds between grades may be lowered by the instructor depending upon the final distributions of grades, but will not be raised.

Late homework: A 24-hr grace period will be given for homework turned in after the deadline. After 24 hours, late homework will lose 20% of its earned points, and will lose another 20% of its earned points for each additional week it is late thereafter. Depending on the circumstances, extensions may be granted, however they *must* be arranged with the instructor before the deadline. Late projects will lose points in the same fashion as homework. Any projects or homework turned in after the last day of lecture will receive zero credit.

Distance Learning:

The class will be offered via distance learning provided sufficient enrollment.

Academic Integrity (http://web.arizona.edu/~studpubs/policies/cacaint.htm)

According to the Arizona Code of Academic Integrity, "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student's submitted work must be the student's own." Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academics misconduct.

Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade
- Referral to the Dean of Students for consideration of additional penalty, i.e. notation on a student's transcript re. academic integrity violation, etc.

Attendance Policy

It is important to attend all classes, as what is discussed in class is pertinent to adequate performance on assignments and exams. If you must be absent, it is your responsibility to obtain and review the information you missed. This is especially important in this course where a substantial amount of course material will emerge through class discussion.

"All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students (or Dean's designee) will be honored."

Classroom Behavior

The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.web.arizona.edu/threatening-behavior-students.

Students with Disabilities

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (http://drc.arizona.edu/instructor/syllabus-statement.shtml).

The information contained in this syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.