OPTI 484/584: Polarized Light and Polarimetry

Effective Spring 2015

Replaces: OPTI 623

Course Description:

Polarized light and the Poincare sphere. Polarization in natural scenes and animal vision. Polarization elements: polarizers, retarders, and depolarizers. Jones and Mueller polarization calculus. Polarimetry: measuring the polarization properties of optical elements and materials. Polarization modulators and controllers. Polarization dependent loss and polarization mode dispersion in fiber optics. Advanced polarization issues in optical devices and systems.

Pre-requisites:

OPTI 501: Electromagnetic Waves/OPTI 330: Physical Optics II, or equivalent

Number of Units/ component:

3 units/ lecture

Locations and Times:

T/R: 2:00 – 3:15 pm, Meinel Optical Sciences room 305

Instructor Information:

Russell A. Chipman, Professor
College of Optical Sciences, Room 737
The University of Arizona
1630 East University Boulevard
Tucson, AZ 85721
Phone: 520-626-9435
russell.chipman@optics.arizona.edu

Expected Learning Outcomes:

1. Understand the relationship and differences between the Jones vector and Stokes parameter descriptions for polarized light.
2. Explain the operation of polarizers and retarders.
3. Be able to measure Stokes parameters and interpret Stokes images.
4. Understand the difference between linear retarders, elliptical retarders, and circular retarders and their Jones and Mueller matrices.
5. Describe five ways to electrically control polarization state.
6. Explain how liquid crystal displays can be fabricated from Twisted Nematic cells and VAN-mode cells.

Required Texts:

Course Notes:

The instructor's notes are used as the text and will be distributed periodically throughout the term. No other texts are required. Course notes are not available in electronic form. Notes are not to be copied or scanned into electronic form.

Recommended text (not required):

For those seeking additional reference materials, the following texts are a useful supplement to the instructor's notes for additional material or alternative presentations.

- Masud Mansuripur, Classical Optics and its Applications, 2d edition (Cambridge U Press, 2009)
- Dennis Goldstein, Polarized Light, 3d Edition, (CRC Press, 2010)
- Jay Damask, Polarization Optics in Telecommunications, (Springer, 2005)
- C. Brosseau, Fundamentals of Polarized Light, (Wiley, 1998)
- D. Kliger, J. Lewis, C. Randall, Polarized Light in Optics and Spectroscopy (1990).
- R.M.A. Azzam, and N. M. Bashara, Ellipsometry and Polarized Light, 2d ed. (North-Holland, Amsterdam, 1987).
- P. Yeh and C. Gu, Optics of Liquid Crystal Displays, (John Wiley & Sons, 1999).

Recommended Software

Mathematica, from Wolfram Research

Mathematica is strongly recommended for performing some of the more numerically intensive problems. Some Mathematica code will be made available to support some of the class work. Other mathematical programs, including Matlab, are just as acceptable for these homework problems if the student prefers.

Student version of Mathematica is available from U of Arizona bookstore, 520.621.2426.

Polarization Element Kit

A kit with small polarizers and retarders will be distributed for performing home demonstrations and homework.

Please procure a set of **polarizing sunglasses** for some of the homework problems.

Topics and/or general calendar:

* **Polarization overview.** Polarization states. Polarization ellipse. Polarization elements. Diattenuation. Retardance. Depolarization. Partially polarized light.
* **Polarized light in nature**. Stokes polarimeters. Polarized, partially polarized, and unpolarized light. Black body polarization. Polarization of the sky. Polarization sensitivity in the human eye

and animal eyes. Natural and manmade polarization signatures. Polarization of astronomical objects.

* **Electromagnetic description of polarized light**. Jones vectors. Stokes vectors. Poincare sphere. Coherence. Interference of polarized light. Fresnel equations.
* **Anisotropic materials and polarization elements.** Uniaxial and biaxial materials. Birefringence. Dichroism. Optical activity. Polarizers. Retarders. Polarization dependent loss. Polarization mode dispersion. Achromatic elements. Field of view effects.
* **Polarization calculus.** Jones calculus. Mueller calculus. Depolarization. Pauli matrix decompositions and the structure of the polarization calculi. Matrix roots and order independent decompositions.
* **Polarimetry.** Light measuring. Sample measuring. Spectropolarimetry. Imaging polarimetry. Ellipsometry. Mueller matrix polarimetry. Discrete Fourier transform. Singular value decomposition.
* **Polarization modulators.** Electro-optic. Magneto-optic. Liquid crystal. Photo elastic. Complete vs. endless polarization control.

Number of Exams and Papers:

Two exams: midterm exam and final exam

One project

Homework: Homework is assigned about once per week. Assignments are due one week later at the beginning of class.

Please put the problem number and your name on every page to facilitate grading.

Course Policies:

Grading Policy

Homework	30 %
Midterm exam	20 %
Project	20 %
Final Exam	30 %
Total	100 %

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E.

OPTI 584 students will receive additional reading materials on the Jones Calculus and the Mueller Calculus. Each problem set will include at least one extra problem with a more mathematical nature and each test will include at least one additional problem.

Academic Integrity (http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity)

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.