Polarized Light and Polarimetry, OPTI 484/584, Spring 2024

Course contents: Polarization states. Diattenuation. Retardance. Depolarization. Partially polarized light. Polarized light in nature. Electromagnetic description of polarized light. Jones and Stokes vectors. Poincaré sphere. Interference of polarized light. Polarization elements. Jones and Mueller calculus and polarimeter design.

Pre-requisites: OPTI501: EM Waves, OPTI330: Physical Optics II, or equivalent

Expected 484/584 Learning Outcomes:
- Understand the relationship and differences between the Jones vector and Stokes parameter descriptions for polarized light.
- Explain the operation of polarization elements, *e.g.* polarizers and retarders.
- Be able to measure Stokes parameters and interpret Stokes images.
- Understand the difference between linear, elliptical, and circular retarders/diattenuators and their Jones and Mueller matrices.
- Describe five polarimetric applications and associated technologies.

Expected 584 Learning Outcomes:
- Evaluate polarimetric designs for various scientific applications.
- Assess performance and calibration metrics used in polarimetry and their appropriate applications.

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Class Hours: Monday & Wednesday 12:30 – 1:45 pm in Meinel 305

Office Hour: Monday 2:00 pm ONLY in person Meinel 727

D2L Web Site: is set up for posting problem sets, solutions, and submitting homework. Homework is assigned about once per week on a Monday and due the following Monday at 11:59 PM-MST. Homework is submitted through D2L. In order to publish solutions within a week of the due date, the late policy is as follows:
- Within 24 hours of due date: -10%
- Within 1 week of due date: - 20%
- More than 1 week late: -50%

i.e. the *maximum* score attainable for submissions more than one week late is 50%. All students will receive a one time late submission grace period of one week without any grade reduction. On time homework will be graded and returned within a week of submission, late assignments will be graded within 2 weeks of submission.

Please put the problem number and your name on every page to facilitate grading. Only D2L homework submissions will be accepted.

Polarization Element Kit: A kit with small sheet polarizers and retarders will be distributed for performing home demonstrations and homework. Please procure a set of polarizing sunglasses.

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Required Textbook: Polarized Light and Optical Systems, 1st Edition, ISBN 9781498700566

Russell A. Chipman, Wai Sze Tiffany Lam, Garam Young

https://wp.optics.arizona.edu/kupinski/resources/

Suggested Reading: Polarized light in Nature by G.P. Können,
free download: http://www.guntherkonnen.com

Polarization Imaging Project: Data collection and analysis will be part of homework assignments. First commercially-available polarization camera by LUCID (Sony sensor): https://thinklucid.com/tech-briefs/polarization-explained-sony-polarized-sensor/

Grading:

• 10 Homeworks	30%	Jan: 22, 29 February: 5, 12, 19, 26 March: 18, 25 April: 1, 8	
• Spring Break Polarization Observation	10%	March 11	
• Final report	40%		
• Draft for blind review		April 15	
• Peer feedback		April 22	
• Final submission		May 29	
• Presentations in-class	20%	April 29, May 1	

Course Outline:

Chapter 2
- **Polarized light.** Plane waves. Jones vectors. Polarization states and ellipses.

Chapter 3
- **Partially polarized light**. Stokes vectors. Poincare sphere. Polarization elements. Depolarization. Partially polarized light.
- **Polarized light in nature**. Polarization of the sky. Polarization sensitivity in the human eye and animal eyes. Natural and manmade polarization signatures. Polarization of astronomical objects.

Chapter 4
- **Interference of polarized light.** Coherence. Relative phase.

Chapter 5
- **Polarization elements.** Polarizers. Dichroism. Diattenuation. Retardance. Optical activity. Birefringence. Uniaxial/biaxial materials. Birefringence. Jones calculus.

Chapter 6
- **Polarization material interactions.** Unitary and Hermitian matrices. Mueller calculus. Depolarization. Relating Jones and Mueller matrices.

Chapter 7
- **Polarimetry.** Light measuring polarimeters. Sample measuring polarimeters. Polarization modulation. Spectropolarimetry. Imaging polarimetry and artifacts. Mueller matrix polarimetry. Discrete Fourier transform.

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Absence and Class Participation Policy

The UA's policies concerning Class Attendance, Participation, and Administrative Drops is available at: https://archive.catalog.arizona.edu/2021-22/policy/class-attendance-participation-and-administrative-drop.html

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: https://deanofstudents.arizona.edu/sites/default/files/2022-05/2022_official_activity_exc_absence_request-writable_0.pdf

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. *To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu.* If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog: https://deanofstudents.arizona.edu/policies/code-academic-integrity The UA Libraries have some excellent tips for avoiding plagiarism, available at: http://new.library.arizona.edu/research/citing/plagiarism. Selling or sharing class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Students with a Learning Disability

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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. https://drc.arizona.edu/instructors/syllabus-statement

Nondiscrimination and Anti-harassment Policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others. The UA is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.