OPTI/ASTR 428/528 Adaptive Optics and Imaging through Random Media

Course Description:
This course provides an overview of adaptive optics fundamentals with an emphasis on astronomical applications. The course consists of lectures and team projects. For each of the team projects during the semester, astronomy and optics students will work together to design, assemble and/or carry out experiments on an adaptive optics instrument, using material presented during the lectures. Each team project will conclude with an oral presentation to the class. There will be an optional evening trip to the 6.5 m MMT telescope south of Tucson on Mt. Hopkins in the Santa Rita range, where an adaptive optics system supports astronomical observations at near infrared wavelengths.

Prerequisites:
None required.
Please note: familiarity with Fourier optics is assumed!

Location and Times:
8:00 – 9:15 Tuesday and Thursday
Meinel 422
D2L site: https://d2l.arizona.edu/d2l/home/520005

Instructor
Prof. Michael Hart
Meinel 629
(520) 626-5265
mhart@optics.arizona.edu
Office hours: M 1 – 2 pm, Th 9:15 – 10:30 or by appointment

Expected Learning Outcomes:
- Understand the fundamentals of light propagation in random media, in particular Earth's atmosphere.
- Understand wavefront sensing and correction techniques, their strengths and limitations.
- Students will be able to design adaptive optics systems

Required Texts:
No required text.
Recommended text: Principles of Adaptive Optics, R. K. Tyson, CRC Press
(N.B. Latest edition is #4, but earlier editions are perfectly adequate and *much* cheaper.)

Syllabus

1. 8/23 Introductions and overview of the course; atmospheric effects on light; overview of an AO system.
2. 8/25 Building blocks of an AO system; examples; applications of AO; background optical concepts.
3. 8/30 Practical optical design of an AO system.
4. 9/1 Wave-front sensors 1: Shack-Hartmann, shearing interferometer. *Team Project #1 assignments.*
5. 9/6 Kelvin-Helmholtz instabilities; development of turbulence; inertial subrange; outer and inner scales.
6. 9/8 Derivation of Kolmogorov power law; atmospheric C_n^2 profiles.
7. 9/13 Phase structure function; characteristic scales: Fried coherence length, Greenwood frequency, isoplanatic angle.
8. 9/15 Review of Fourier optics; the Parabolic Wave Equation.
9. 9/20 Imaging through a phase screen; scintillation; effects on the PSF.
10. 9/22 Statistical imaging metrics: Strehl ratio, mean MTF, encircled energy, contrast.
11. 9/27 Deriving basic requirements of an AO system; sources of residual wave-front error.
12. 9/29 Deformable mirrors: rigidly actuated facesheets, MEMS devices, adaptive secondaries, bimorphs, LC arrays.
13. 10/4 *Team Project #1 presentations.*
14. 10/6 Reconstructor matrices and feedback servos. *Team Project #2 assignments.*
15. 10/11 No class. Field trip to MMT in the evening. (Transportation will be arranged; please bring dinner with you.)
16. 10/13 Building a simple AO simulation.
17. 10/18 Wave-front sensors 2: linear curvature, pyramid, self-referenced interferometer.
18. 10/20 Guest lecture: differential Optical Transfer Function (Dr. Johanan Codona)
19. 10/25 Laser guide stars; focal anisoplanatism; sodium and Rayleigh LGS; range gating. *Team project #2 check-in.*
20. 10/27 Controlling non-common-path aberrations; PSF calibration; speckle statistics.
21. 11/1 Optimizing an AO system design; minimizing total MS wave-front error.
22. 11/3 Nasty practical problems; tuning and tricks.
23. 11/8 Tomographic WFS approaches and issues.
24. 11/10 Multi-conjugate AO, multi-object AO, ground-layer AO.
25. 11/15 AO for opthalmology.
26. 11/17 AO from different perspectives: horizontal, downward-looking.
27. 11/22 *Team Project #2 presentations.*
28. 11/29 Guest lecture: overcoming challenges to exoplanet science (Prof. Olivier Guyon)
29. 12/1 Guest lecture: extreme AO for high-contrast imaging (Prof. Olivier Guyon)
30. 12/6 Final exam review.

Exams and Papers:
Final oral exam (50%)
Two team projects with oral presentations (50%)

Course Policies:

Grading Policy

Team Projects (2)	50%
Final Exam	50%
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.

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.

http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity

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***.**