Syllabus

Astronomy 289: Adaptive Optics and its Applications

Winter Quarter 2020, UC Santa Cruz

Instructor: Professor Claire E. Max
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Class Days: Tuesdays and Thursdays. First class January 7th, last class March 10th, 2020.
Class Times: 9:50-11:25 am Pacific Time, with a short break halfway
Location: Center for Adaptive Optics conference room (top floor)
Office Hours: Tuesday and Thursday, noon-1:00 pm Pacific Time
Other meeting times can be arranged by phone, e-mail, or in person

Web Site: The main class web site is http://www.ucolick.org/~max/289/ There is also a class website on UCSC's Canvas collaboration and learning environment. The Canvas title for our site is "ASTR-289-01" Reading material will be posted on the Canvas site. If you do not have access to the Canvas site (e.g. because you are not a UCSC student) please contact me.

Course Description:

Introduction to adaptive optics and its applications. The course is intended both for scientists who will be future users of adaptive optics systems, and for scientists and engineers interested in building and operating adaptive optics systems.

Topics include effects of atmospheric turbulence on astronomical images, basic principles of feedback control, wavefront sensors and correctors, laser guide stars, how to analyze and optimize performance of adaptive optics systems, and techniques for utilizing current and future systems for astronomical observations.

There will be two lectures a week (1.75 hrs each), a laboratory session using methods of inquiry based learning, and a class project in which student teams will design AO systems for applications that they are interested in.

Reading Materials:


b) Reading materials for each lecture, distributed via the UCSC Canvas website. If you do not have access to the Canvas site please contact me.
Active Learning:

How people learn: Researchers studying how people learn have shown that the traditional passive lecture is far from the most effective teaching tool. It is not possible for an instructor to pour knowledge into the minds of students. It is the students who must actively engage in the subject matter and assimilate it in a manner that is meaningful to them. Hence this course will use several departures from the traditional lecture format, in order to encourage active learning and an understanding of the concepts rather than memorization of formulas and details.

Reading assignments will be more important in Astro 289 than in most science courses. Lectures will presume that you have done the required reading beforehand. To provide incentive for you to complete the reading assignments, I will ask you a few questions (either written or oral) about the reading at the start of each lecture.

Lectures will discuss the underlying concepts and key points, elaborate on the reading, and address potential difficulties. As feedback to the professor on whether students have a good grasp of the concepts discussed in class, lectures will include “Concept Questions.” These will consist of short conceptual questions on the subject being discussed in the lecture. Students will be asked to first formulate their own answer, then to discuss their answer with each other, and finally to report each group’s answers to the professor. The purpose of Concept Questions is to give feedback to the professor, to provide students with an environment for active learning, and to gain insight from discussions with your fellow students.

Laboratory exercises: We will use the Laboratory for Adaptive Optics for lab experiments. In these labs, students will have the opportunity for hands-on experience with the hardware and software components that make up an adaptive optics system. We will arrange alternative activities for those students not located in Santa Cruz.

Homework: Written assignments will be given every other week.

Project: Part way through the quarter, students will begin to work on class projects. These will be actively coached and facilitated. Students will choose a topic they are interested in, and will present their results to the rest of the class towards the end of the quarter.

Exams: There will be a take-home final exam. This exam will consist of both conceptual essay questions and quantitative problems.

Grading: Grades will be based on homeworks, the final exam, lab exercises, and projects.

Supplementary Reference Materials: (available in library of UCSC CfAO)

Optics by Eugene Hecht (Addison Wesley, 2002)

Adaptive Optics in Astronomy, edited by Francois Roddier (Cambridge University Press, 1999)


Introduction to Image Stabilization, by Scott Teare and Sergio Restaino (SPIE Press, 2006)
Wavefront Sensing for Adaptive Optics in Astronomy, by Marcos van Dam (VDM Verlag, 2008)

Topics covered in Astro 289 (not necessarily in the order of their respective lectures):


9. How to analyze and optimize adaptive optics system performance: basic principles of systems analysis and error budgets. Effect of AO design parameters on PSF, encircled energy, energy through a spectrograph slit. Balancing bandwidth error against measurement error. Balancing subaperture size against measurement error.


13. Detectors, signal to noise ratio. Techniques for astronomical observations with current adaptive optics systems. How do you know what to believe about your data? Choice of system parameters such as AO gain and bandwidth, issues in measuring the adaptive optics point spread function, limitations of adaptive optics for imaging and for spectroscopy.


15. Control systems and wavefront reconstruction. Principles of feedback control. Introduction to the basics of control systems, practical implementation of control systems for adaptive optics applications. Gain, bandwidth error.


Academic Honesty and Plagiarism: Academic dishonesty and plagiarism undermine the efforts of honest students, the value of a UC Santa Cruz degree, and the integrity of the university as an institution. Cheating or plagiarism in any part of the course may lead to failing the course and suspension or dismissal from the University. What is plagiarism? In short, it is presenting someone else’s work as your own. Examples include using text from a published source or from the web without attribution, copying another student’s written homework assignment, or allowing your own work to be copied. You are encouraged to discuss homework problems with fellow students, but your collaboration must be at the level of ideas and concepts only. Your homework, project reports, etc. must be written in your own words. Legitimate collaboration ends when you "lend", "borrow", or "trade" written solutions to problems, or in any way share in the act of writing your answers.

The official UCSC policy concerning academic integrity can be found at [http://www.ucsc.edu/academics/academic_integrity/index.html](http://www.ucsc.edu/academics/academic_integrity/index.html)

The American Astronomical Society Code of Ethics makes for thoughtful and interesting reading. It can be found at [https://aas.org/policies/ethics](https://aas.org/policies/ethics)