Signals & Noise PHY 123/253 Project Instructions

Some history: I first gave this course in an academic setting at UC Berkeley in 1973. It has historically been heavy on homework and demos, with little hands-on experiences for the students. While the students said they got a lot out of it, they did not get much direct experience with experimental techniques. This year I am changing that, lightening up on the homework, but requiring equal out of class time to be spent in the lab working on projects. On many class days the last 20 minutes will be lab. There are two classes of projects: A) Those that every student must complete (the "noise & signal lab" experiments), including an in-lab review of electronics, and B) Elective projects: you chose which of four additional projects to undertake during the term, depending on your interests. A 7-10 page 11pt font project report is required. The lab in Roessler 156/154 will be open 9am to 4:30pm 5 days per week.

NOISE & SIGNALS LAB

After a hands-on practical review of electronics and test equipment, each student will take the "noise & signals lab." This noise lab is actually several short experiments spaced over two weeks which will be set up in Roessler 154. You will have your own setup. Amplifier noise and boxcar integration (synchronous detection) of weak signals will be explored.

ELECTIVE EXPERIMENT

Based on your preference, you will be assigned one of four main experiments to undertake during the term 1) the Balmer series of hydrogen/deuterium, 2) CCD imaging observations of an emission nebula using the campus observatory, 3) shot noise exploration, or 4) Johnson (thermal) noise exploration + 1/f noise. This experiment will require about 1 week of work (part your out-of-class work associated with the course). Read about these four exciting experiments by clicking the appropriate icon on
http://123.physics.ucdavis.edu/projects.html
Depending on demand, pairs of students or groups of up to 4 will undertake the measurements. A signup sheet with options for 1st, 2nd, and 3rd choice for your main experiment will be handed out in the first week, and assignments made on that basis The experiment and writeup are yours: you own your experiment. You must figure out where the errors are and design fixes. In this course you will learn techniques for extracting faint signals from noise and correcting for systematic error.

1. The Balmer series experiment uses a high resolution optical spectrograph. The light from a HD plasma tube is chopped and sent through the spectrograph to a photo-diode, preamp, and phase-sensitive detector. You will learn how to extract a known signal buried in noise.

2. The astronomical observing will use a CCD camera on a research telescope. You will help design and do the observing and undertake your own data reduction and analysis using Python. Faint signals will be extracted from the noise due to sky and instrument backgrounds.

3. Physics of shot noise. FFT spectral analysis and photon shot noise.

4. Physics of thermal and 1/f noise. Johnson noise and the nature of "1/f" noise (from biophysics to speech to music to transistors), and theoretical aspects of the fluctuation-dissipation theorem in the quantum limit.