PHY 517 / AST 443 - Observational Techniques

Fall 2016

ESS 450, Mondays and Wednesdays 6:00pm - 9:00pm.

Usually only Mondays for lectures. Labs need to be scheduled with the TAs and/or instructor; expect to schedule 2 - 6 night-time observing sessions, and 1-3 day-time sessions. You need to be flexible for the weather!

General Information | **Course Description** | **Course Schedule** | **Lectures** | **Experiments** | **Proposals** | **Observing Calendar** | **Equipment** | **Computing Resources** | **Grading** | **Course Policies**

General Information

- Credits: 3 (PHY 517) or 4 (AST 443)
- Instructor: Anja von der Linden (anja.vonderlinden 'at' stony brook.edu, ESS)
- Suggested texts:
  - Measuring the Universe, G. Rieke (Cambridge University Press, 2012)
  - Data Reduction and Error Analysis for the Physical Sciences, P.R. Bevington & D. K. Robinson (McGraw-Hill Higher Education, 2003)
  - Practical Statistics for Astronomers, J.V. Wall & C.R. Jenkins (Cambridge University Press, 2008)
- Prerequisites: AST 203 ; some programming experience

Course Description

Astronomers explore the universe by detecting and analyzing light from all over the elecromagnetic spectrum. We concentrate on a subset of techniques for detection of photons at visible and at radio wavelengths.

This is a three-quarters lab and one-quarter lecture course. The laboratory component entails obtaining and analyzing astronomical data with optical and radio telescopes. Three distinct observational experiments will be conducted, focussing on optical photometry/time-series analysis, optical spectroscopy, and radio interferometry. The students will be responsible for setting up and calibrating their telescope equipment, obtaining their own data, and analyzing the data.

The lecture component is intimately intertwined with the experimental aspects of the course. The students will learn the basics of practical observational astronomy, such as determining the observability of select targets, telescope and detector technology, the use of photometric, spectroscopic, and interferometric techniques, and methods of error, statistical, and time-series analysis.

For one of the projects, the students will write a telescope observing proposal, and conduct a peer-review of all proposals. The observing proposal will emphasize the need for generating a testable hypothesis and justifying it through expected signal-to-noise or other appropriate statistical arguments. The peer evaluations will serve to assess the evaluator's ability to critically assess the quality of the other proposals.

The students will prepare journal-style written reports on each of their observational projects and a final oral or poster presentation on one of the projects.

Lectures

Experiments

- General guidelines:
  - The guidelines are mostly identical to those laid out in the course notes for PHY 515 / 445. **This is mandatory reading**.
  - The following notes are specific to PHY 517 / AST 443. (Also mandatory.)

- Experiment 1: Imaging and Photometry
  - **Transiting extrasolar planets.** Perform time-series photometry of stars with known transitng planets. Multiple measurements are needed to attain precision at the 0.1% level, needed for detecting planet transits. This is an exercise in obtaining high-precision measurements and in time-series analysis.
    - Experiment description
    - Catalog of known transiting planets at exoplanet.eu
    - Finding chart service from the STScI Digital Sky Survey (use images from POSS2/UKSTU Red plates)

- Experiment 2: Spectroscopy
  - **Elemental abundances in gaseous nebulae.** The determination of heavy element abundances in emission-line nebulae provides an opportunity to study the gaseous environment in star-forming regions. Measure emission line strengths for different species. Infer gas temperatures and electron densities.
    - Draft experiment description
    - Read also the relevant parts of sections 2-4 of The Spectrum of Earthshine experiment, for guidelines on spectroscopic data acquisition and reduction.
    - Osterbrock "Astrophysics of Gaseous Nebulae and Active Galactic Nuclei" tables:
      - Table 4.4
      - Table 5.1
      - Table 5.7

  Spectroscopy resources:
    - Instructions on how to use ATV, including for spectroscopic extraction.
    - NIST Atomic Spectra Database
    - Neon 5800-7500A spectrum with strongest transitions labeled

- Experiment 3: Radio astronomy
  - **Angular diameter of the Sun.** Michelson interferometry is a technique with broad applications in both physics and astronomy, and is used to date to directly measure stellar diameters. The Sun is a marginally resolved source for our home-built Stony Brook radio telescope when viewed in single-dish mode, but is well resolved when observed inteferometrically. Compare an intensity scan of the Sun to that of a known point source (a geostationary TV satellite) in single-dish mode and infer the Sun's angular diameter. Then repeat the experiment with the interferometer, recording the Sun's and the satellite's visibility amplitudes as a function of baseline for several different interferometer baselines. Your interferometrix measurents should yield a much more accurate solar diameter.
    - Experiment description
    - Michelson-Type Radio Interferometer for University Education (Koda et al. , 2016)
    - Locus of geosynchronous satellites as seen from Stony Brook

    - Solar positions: US Naval Observatory

- Test data:
    - Photometric sequence on WASP-36b
    - Spectra of Betelgeuse with three different slit widths, covering the entire free spectral range

- Log sheets for: imaging, spectroscopy, and radio observations.

Proposals

- Write a telescope observing proposal for one of the laboratory experiments, or a research topic of your own choosing
- 4 pages maximum, including 2 pages for figures, tables, and object list. Use a 12-pt font, 1-inch margins, and single spacing.
- Mandatory proposal cover sheet
- LaTeX proposal template
- Example proposal
- Proposal review instructions and grade sheet

Observing Calendar

Mt. Stony Brook

Today | **August 2016** | Print | Week | **Month** | Agenda

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	Aug 1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	Sep 1	2	3

Events shown in time zone: Eastern Time

Calendar

Equipment

- Mt. Stony Brook 14-inch telescope. Our Department operates the Mt. Stony Brook observatory, housing a 14-inch Meade LX200-ACF telescope. This will be the workhorse telescope for the imaging and spectroscopic components of the course. Telescope manual and step-by-step instructions. Note that the current telescope manual refers to using the CCDOps software for CCD imaging observations, while you will be using CCDSoft, which allows more flexibility with guiding.

- Visible-light CCD camera. Imaging observations with the 14-inch telescope will be taken with the SBIG STL-1001E CCD camera. The CCD camera is mounted on the back end of the telescope and is controlled through a laptop computer. A set of standard broad-band BVRI and a narrow-band H-alpha filters are available. Summary information sheet; specifications; operations manual, CCDSoft quick-start guide, or CCDSoft v.5 manual.

- Visible-light spectrograph. Spectroscopic observations will be obtained with a spectrograph that offers moderate (500-5000) resolution between 3500 - 9500 angstroms. Manual and specifications; manufacturer's website (in German) with a sketch of the optical path, step-by-step instructions.

- Radio telescope and interferometer. Our two-element radio interferometer employs 1-meter aluminum mirrors to combine light onto a single 1 meter commercial satellite dish. The interferometer has an adjustable 2-10 meter baseline and the reflective elements are well suited for observations at centimeter wavelengths. Single-dish radio observations can also be taken by flipping the satellite dish by 180 degrees and pointing it away from the aluminum mirrors. Step-by-step instructions.

Computing Resources

- Math/Physics SINC site computers:
  - These will be available to you during open SINC site hours. Make sure that you have an account on them.
  - If you need to login remotely, make sure that you have an Xserver installed on your computer.
    - On Mac OS X, you will need X11, which can be downloaded freely from the Apple site or you can use the open-source variant XQuartz. Once you have X11 installed, create an X11 window, and from the command line type
      ssh -Y *your_username*@mathlab.sunysb.edu
    - On Windows, you will need an Xserver like X-Win32, a licensed version of which can be found on the Stony Brook DoIT site. When configuring a new connection, make sure that you specify 'ssh' as Type and click on 'Linux' for the Command entry.
  - If you need extra disk storage space (as you will for the transit planet lab), log in specifically to compute.mathlab.sunysb.edu and use one of the two local storage disks linked specifically to this computer: /space1 or /space2. Make a subdirectory for yourself on one of the two disks and transfer your files to your subdirectory. The local storage disks are not backed up, so make sure to have all important information saved in your home directory.
- Setup and initialization of IDL under Unix (for bash shell):
  - Add the following lines to the .bashrc file in your home directory:

```
if [ -f ~/.idlstartup ]; then
    export IDL_STARTUP="~/.idlstartup"
fi
```

  - Copy the file .idlstartup in your home directory
- Unix tutorials:
  - A detailed intro at the University of Surrey, UK.
  - Paul Twohey's guide for beginners. Note that some information is specific to UC Berkeley.

- IDL tutorials and resources:
  - Christophe Morisette's IDL Cookbook for beginners.
  - The IDL FAQ.
  - Coyote's Guide to IDL Programming, which includes a more comprehensive list of IDL-related websites.
  - The IDL Astronomy Users Library. You need to install these procedures, if they have not been installed already. (Check for the existence of an $IDL_DIR/external/astron/ directory, for example.)
  - The JHU APL IDL library.
  - Alphabetical list of IDL routines with on-line descriptions.
- Example IDL code. You will need to tailor these scripts to your files and data, but the programs here can be used as a strating point.
  - Basic CCD image reduction: image_reduce.pro.
  - A full sequence of photometry on a transiting planet field, the coordinates of the individual stars are known. Assumes that images are well-aligned, as would be obtained from guiude exposures: planet_photometry.pro.
  - Simulates and plots single-dish profiles of the Sun and of a satellite: single_dish.pro.
- Astronomical FITS image viewing programs:
  - SAOImage DS9
  - ATV: an interactive display tool for IDL
- Literature search:
  - NASA ADS: virtually all literature of astronomical interest can be found here.
  - astro-ph: the most up-to-date resource (updated daily), but incomplete.
- Typesetting in LaTeX:
  - You are required to typeset your lab write-ups in the format of the American Astronomical Society (AAS) journals. Here is a sample. The LaTeX set of files needed to produce this are archived here. You are welcome to use any text editor to produce this result. Should you choose LaTeX, AASTeX v5.2 (LaTeX 2e) is installed on the Math/Physics SINC computers.
  - Refer to the AASTeX package page for examples and hints on using AASTeX.
  - You are encouraged to use Natbib and AstroNat (a BibTeX package) to manage your citations. A copy of the Natbib style file is included with the AASTeX package, but AstroNat will require your own installation.
- Other tools:
  - Stellarium: a free open source planetarium for Windows/MacOSX/Linux. You may find it useful for finding your targets on the sky.
  - Airmass calculator: for your observation planning

Course Grading

The course grades will be assigned on the basis of the following:

- 75% projects and written reports (25% each)
- 10% observing proposal
- 10% final presentation
- 5% evaluation of peers' proposals and presentations

Course Policies

- Lecture notes: Select slides will be available after each lecture on the course website.
- Late work: Assignments up to one week old will be accepted with a 25% penalty. More than one week overdue assignments will not be accepted.

Stony Brook Policies

ACADEMIC INTEGRITY

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another persons work as your own is always wrong. Any suspected instance of academic dishonesty will be reported to the Academic Judiciary. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/uaa/academicjudiciary/

ELECTRONIC COMMUNICATION

Email to your University email account is an important way of communicating with you for this course. For most students the email address is firstname.lastname@stonybrook.edu, and the account can be accessed here: http://www.stonybrook.edu/mycloud. It is your responsibility to read your email received at this account. For instructions about how to verify your University email address see this: http://it.stonybrook.edu/help/kb/checking-or-changing-your-mail-forwarding-address-in-the-epo. You can set up email forwarding using instructions here: http://it.stonybrook.edu/help/kb/setting-up-mail-forwarding-in-google-mail. If you choose to forward your University email to another account, we are not responsible for any undeliverable messages.

RELIGIOUS OBSERVANCES

See the policy statement regarding religious holidays at http://www.stonybrook.edu/registrar/forms/RelHolPol%20081612%20cr.pdf. Students are expected to notify the course professors by email of their intention to take time out for religious observance. This should be done as soon as possible but definitely before the end of the add/drop period. At that time they can discuss with the instructor(s) how they will be able to make up the work covered.

DISABILITIES

If you have a physical, psychiatric/emotional, medical or learning disability that may impact on your ability to carry out assigned course work, you should contact the staff in the Disability Support Services office (DSS), 632-6748/9. DSS will review your concerns and determine, with you, what accommodations are necessary and appropriate. All information and documentation of disability is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information go to the following website http://www.stonybrook.edu/ehs/fire/disabilities.shtml.

CRITICAL INCIDENT MANAGEMENT

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, and/or inhibits students' ability to learn. See more here: http://www.stonybrook.edu/sb/behavior.shtml.