Physics 590 – Astrophysics – Fall 2005
Natural Science 313 – MWF 12:00-12:50
John Kielkopf

Objectives

In this course we will review the fundamental concepts, methods, and technology of modern astrophysics, and use these to understand new discoveries at the forefront of astrophysical research. Since physics enables the technology used for astronomical observations, and since it is the underpinning science for interpretation and modeling of the universe, students with a background in physics have the preparation for work in astronomy and astrophysics. However, *astro*physics is different from physics in that it is an observational, rather than experimental, science. Astronomers cannot, for example, adjust the mass of a star to see the effect that has on the star's luminosity. Instead, they must observe selected stars and deduce this effect from their measurements and models that depend on basic physics. The language and methods of astronomy may seem arcane and specialized to the physicist, and this course is intended to be a gateway from physics to astronomy and astrophysics. Its goals are both to provide an overview of current work, and to develop the skills needed to understand it and to pursue independent research.

Schedule

The schedule and course requirements may be adjusted as needed to meet our learning objectives.

Aug 22-26 First light

- No class on Monday – schedule conflict.
- Through the Earth's atmosphere [1-12]
- Optical astronomy [13-29]

Aug 29-2 Innovations in instrumentation

- Large telescope design [30-46]
- Ray tracing [Oslo]
- Active/adaptive optics and interferometry [Supplement]

Sep 5-9 Analyzing "star" light

- No class on Monday because of Labor Day holiday.
- CCD detectors [47-64]
- Spectrographs [65-76]

Sep 12-16 Observational astronomy

- Hubble Space Telescope and its archives [Supplement]
- X-Rays to Infrared: Spitzer and Chandra [126-145, Supplement]
- Ground-based observatories: KPNO to LSST [Supplement]

Sep 19-23 Cataloging the sky

- Photometry [84-92,182-185]
- Celestial coordinates and reference systems [163-172]
- Time [172-181]

Sep 26-30 Distances and 3-D visualization

- Parallax [358-361]
- Hipparcos and Tycho catalogs [Supplement]
- Partiview [Supplement]

Oct 3-7 Properties of stars

- Stellar spectra [182-198]
- Binary and eclipsing stars [198-211, Supplement]
- Stars in clusters [211-224]

Oct 10-14 Evolving stars

- No class on Monday because of Fall Break.
- Novae and Supernovae [224-235, Supplement]
- First test

Oct 17-21 Stellar structure

- Equilibrium [236-245]
- Energy generation and transport [245-254]
- Structure of main sequence stars [254-260]

Oct 24-28 Stellar evolution

- Models of evolving stars [260-273]
- White dwarf stars [273-275, Supplement]
- Supernova models [275-294]

Oct 31-4 Galaxies

- Galaxy types and a close look at M51 [295-307, Supplement]
- Dark matter [309-311, Supplement]
- Active galaxies [312-326]

Nov 7-11 The Local Group

- Milky Way [327-345]
- Magellanic Clouds [302-303, Supplement]
- Virgo Cluster [346-356, Partiview]

Nov 14-18 Large Scale Structure

- Distance measurements and lookback time [357-373, Supplement]
- Hubble Constant [374-388]
- Sloan Survey [Supplement]

Nov 21-25 Early Universe

- Cosmic Background Radiation [388-396]
- No class because of Thanksgiving
- No class because of Thanksgiving

Nov 28-2 Project reports and discussion

- Reports
- Reports
- Reports

Dec 5 Last day

- Second test

Textbook and Content

Although the prerequisites for this class are Physics 307, Introductory Astrophysics, and Physics 455, Introductory Computational Physics, in practice you will need only basic undergraduate physics and mathematics, and no detailed prior knowledge of astronomy (although that will help). The expectation is that you now have the background to apply classical and basic quantum physics to understanding the structure and evolution of galaxies and the universe.

The textbook for this course is *Observational Astrophysics*, by Robert C. Smith (Cambridge UP, Cambridge, 1995), ISBN 0-521-27834-1. The book may be obtained by ordering through local bookstores or through Amazon `http://www.amazon.com`

Each week will cover a topical area with material selected from the textbook and with supplementary resources. The level of the text is appropriate for undergraduate students with a background in the physical sciences. Supplementary material will build on your developing skills and go to a greater depth in some interesting aspect of that topic. There will be a few problem assignments (usually made the previous Friday) to be handed in *on Friday* that match the classwork and reading for the week.

Projects

Everyone will be required to do a small independent project on a topic in astrophysics related to the course, but selected for their own interests and skills. The project should use at least one of these three resources:

- Sloan Digital Sky Survey
  (`http://www.sdss.org`)
- Digital Universe and Partiview
  (`http://www.haydenplanetarium.org/hp/vo/du/partiview.html`)
- Nature
  (`http://www.nature.com/`)

Sloan Digital Sky Survey is the most ambitious astronomical survey project ever undertaken. The survey is mapping in detail one-quarter of the entire sky, determining the positions and absolute brightnesses of more than 100 million celestial objects. Much of the survey is available through a web-based resource. There will be assignments for everyone to use the Sloan Survey as a class exercise too.

Partiview is a three-dimensional visualization program. Free software originally designed for Linux, it is also available in a Windows version. The Hayden Planetarium and the American Museum of Natural History use Partiview to plan public shows that explore the universe in depth, based on the best catalogs of position and distance we have for stars in our own galaxy (Hipparcos) and for other galaxies (Sloan Survey).

Nature is a pre-eminent rapid publication journal. It often contains articles describing the very latest discoveries in astronomy and astrophysics. We will routinely point out its table of contents in class and occasionally distribute articles. The journal is accessible through the University's electronic subscription with your university computer account and a web-browser from any computer on campus, and remotely through a portal on the University Library's webpage.

At the end of the semester each student will present the results of their project to the class in a short (25 minute) talk that uses OpenOffice presentation software, Powerpoint, or Adobe Acrobat (pdf) technology. The quality of the project work, the presentation, and the student discussion will be used to assign a grade to the project.

Grading

Since this is a senior-graduate course, the projects will be more advanced for students enrolled for graduate credit. In addition to the project and the homework, there will be two in-class exams as noted on the schedule. Regular attendance for class is expected.

The grade will be based on the homework assignments that are to be returned each Friday (30%), the projects presented at the end of the term (30%), and the two in-class exams (20% each).

Contact

The homepage linking our astronomy courses is

`http://www.physics.louisville.edu/astro`

will have an updated schedule and resource links for the course. The best way to contact me is through email to `kielkopf@louisville.edu`. Messages left on my lab office answering machine (502-852-5990) may not be answered until the next day, or if I am traveling, until I return. Office hours are 3-4 Wednesday afternoon if you want to come by to discuss something, or you can make an appointment. However, I usually will not be available Tuesday and Thursday.

I may have to travel this fall for research and contract obligations including work on our remote telescope in Australia. If I am away for more than a few days, the class will have alternative web-based assignments and we will maintain contact through our website and email. We expect that it will be possible to have classes by teleconference from Australia, if needed, in our facility in the Gheens Science Hall.