ASTRON 0088: Stonehenge to Hubble
Course Syllabus

Revised August 30, 2016

Basic Course Information

Term: 2171 (Fall 2016)
Credits: 3
Prerequisites: Basic mathematics (any MATH course)
Meeting Time: Tuesdays and Thursdays 1:00 to 2:15 PM, Alumni Hall room 343

Instructor: Prof. Carles Badenes

Office: 309 Allen Hall (3rd floor)
Office Hours: Tuesdays 2:30-3:30 PM, Thursdays 3:30-4:30 PM (or by appointment)
Email: badenes@pitt.edu (email is generally the best way to contact me)
Office Phone: (412) 624-9039

Background I am a member of the Department of Physics and Astronomy at the University of Pittsburgh. I hold a Ph D in astrophysics, and my research specialty is stellar evolution, in particular supernova explosions.

Goals My main goal is to work with students to make this course engaging, interesting, and fun. Do not hesitate to contact me with **any** questions or concerns, either by email or by coming to office hours. I need your feedback in order to improve your learning experience! Please let me know if you have issues with the course material, or you would like me to cover some topic that you are particularly interested in. Of course, I have to abide by University and Department rules and I have to work within the Physics and Astronomy curriculum, so I cannot accommodate all requests, but I will do my best. I am looking forward to a great semester!

Logistics I will hold regular office hours on Tuesdays between 2:30 and 3:30 PM and on Thursdays between 3:30 and 4:30 PM in 309 Allen Hall. If you cannot make these times, try to use the teaching assistant's office hours or recitation sections to have your questions answered. Otherwise, please contact me and we can arrange to meet at another time. If you need further help or would prefer to seek help from a tutor, the Department of Physics and Astronomy maintains a Physics Resource Room in 312 Thaw Hall that is staffed by tutors between 9 AM and 5 PM on weekdays throughout the semester. Please take advantage of this service.

Teaching Assistant: Brian L. Flores

Office: 300 Allen Hall, Desk 1
Office Hours: Mondays 1-2 PM and Tuesdays 5-6 PM
Email: blf40@pitt.edu

Brian is a 3rd year graduate student in our Department. He studies stellar atmospheres and winds. Currently he is working with Prof. John Hillier to build models for the atmosphere of the most massive hydrogen-burning stars, called 'O Type' stars. They are looking at how to better model clumpy winds from these stars using a technique called radiative transfer.

Course Description

This course is a self-contained historical introduction to astronomy for students not majoring in the physical sciences. Astronomy is a vast field of study, and it is impossible to even mention all of its major areas in a single course, so ASTRON 0088 is very general and mostly descriptive in nature. Some of the lectures will make use of simple arithmetic and geometry because astronomy is a *quantitative* science. My primary goals are to cultivate an understanding of the scientific method and an appreciation for critical thought that students can apply well beyond this course, to develop an interest in astronomy, and to have fun! The course aims to give an historical perspective of astronomy, beginning with a discussion of the earliest views of the Universe and the role of astronomy in primitive civilizations. The course proceeds with the development of our current understanding that we live on a planet in one of many solar systems, on the edge of a galaxy that contains billions of stars, and is but one of a hundred billion galaxies in the observable Universe. The underlying theme will be the process of scientific discovery and advancement. Understanding the nature of scientific discovery remains critically important in the world of today, especially because science is often misrepresented or described incorrectly in the media, popular literature, and public debate.

Course Outline

The material will be roughly divided in three major sections. The first section will describe the evolution of humankind's early belief in an Earth-centered Universe to a cosmic view of a Sun-centered Universe developed during the 16th and 17th centuries by Copernicus, Galileo and others. From this, we continue through the time of Isaac Newton, the development of the modern scientific method, and its application to astronomy. This marks the beginning of modern, empirical science and the closely-related fields of physics and astronomy.

We will continue with a brief study of some simple practical topics in astronomy, including phenomena that can be readily observed with the unaided eye or a small telescope: seasons, tides, phases of the moon, eclipses, the motions of the planets, other solar system objects, constellations, stars, nebulae, and galaxies. We will briefly discuss the use of small telescopes for astronomical observations.

We will end with a discussion of our modern view of the Universe. Much of this will require an attempt to understand the scales involved in astronomical investigations. For example, the distance between the Earth and the Sun, though vast compared to distances encountered in our everyday lives, is sixty billion times smaller than the distance across our galaxy. From the realization that the Sun is not the center of the Universe, we have successively discovered that the Sun is not at the center of our Milky Way galaxy, that the Milky Way is not at the center of the Universe, and that in fact the Universe has no discernible center. Instead, we live in an expanding Universe of more than one thousand billion galaxies that originated 13.8 billion years ago in an event we refer to as the Big Bang. We will review how we have pieced together the evidence for the Big Bang, and how successive generations of stars formed since then have synthesized the chemical elements that make up our bodies and all living things found on Earth. We will also discuss some topics of active current research by professional astronomers like the evidence for the existence of unfamiliar forms of matter called dark matter and dark energy; black holes at the centers of galaxies; planets around other stars; space exploration; and the search for life elsewhere in the Universe.

If there is a particular subject related to astronomical science that you find interesting, please let me know and I will try to cover it as part of the course if there is sufficient interest. In the past, students have requested lectures on black holes, supernovae, planets around stars other than the Sun, searches for extraterrestrial intelligence, space flight, global warming, solar power, and many other subjects. Remember, I want you to have fun and be interested in this course.

Textbook

The official textbook for his course is *Discovering the Cosmos, 2 nd edition* by Robert Bless, which captures the philosophy of ASTRON 0088 quite well. However, the book is not required and should be regarded only as a useful reference if you want to have the lecture material reinforced by another source. A book I highly recommend is *Coming of Age in the Milky Way*, by Timothy Ferris. This is a book for popular audiences, not a textbook, but

it covers a great deal of the material for the course in a clear and engaging way. Finally, a basic level astronomy textbook that I like is *21st Century Astronomy* by Hester, Smith, Blumenthal, Kay, and Voss. This book provides a careful and accurate description of the logic of the scientific method.

The lecture slides, homework sets, and recitation materials will cover all of the content you are responsible for in this class, so it will be important to attend the lectures and recitations and take notes. I will post all these materials on CourseWeb site at http://courseweb.pitt.edu. Please check it often for updates, and let me know if you have any problems downloading the files.

Grading Policy

The final letter grades for this course will be determined using a curve, as specified for courses that fulfill the general education requirements of the College of Arts and Sciences at the University of Pittsburgh. Because of this, your absolute grade will not necessarily be your final letter grade, but it will reflect your relative standing within the class. The final grade will be computed from the different components of the course according to the following percentages:

- **5%** for a trip to the Allegheny Observatory.
- **15%** for lecture participation as measured by your answers to clicker questions.
- **20%** for the recitation part of the course.
- **60%** for the sum of grades on three exams. Each exam is worth 20% of your final grade.

Each of these items is explained in more detail below. The curve will be such that **at least 50% of students** will receive a letter grade of **B- or better**. The following grades will be *guaranteed*:

- 90% of all available points earns a grade of A or better.
- 80% of all available points earns a grade of B or better.
- 70% of all available points earns a grade of C or better.
- 60% of all available points earns a grade of D or better.

Due to the curve, you will often be able to earn a given grade with a point percentage lower than those quoted above. The curve will only be used to help your grade, never to reduce your grade.

Allegheny Observatory Visit

The University of Pittsburgh's own Allegheny Observatory is a facility with a rich history that has been used in a number of important astronomical discoveries. The Allegheny Observatory continues to be used for research today, primarily to observe planets around nearby stars (other than the Sun). As part of ASTRON 0088, you will have the opportunity to visit the observatory on an evening during the course, and, if the weather is clear, to make observations of celestial objects. **At least one trip to Allegheny Observatory is mandatory**. Students should schedule their trips with the TA, Brian Flores. Buses depart from Allen Hall in the evening and return to campus about three hours later. Detailed information about the available visit dates and bus schedules can be found in this website: http://www.physicsandastronomy.pitt.edu/content/ao-bus-schedule.

Lectures

Fifteen percent of your final grade will be based upon your participation in lectures. Beginning the second week of class, all lectures will contain a series of clicker questions. Answering these questions correctly should not be a source of stress. You will receive 1 point for each correct answer and 0.8 points for each incorrect answer. During the semester, there will be between two and four clicker questions in each lecture. You can earn 15% toward your final grade by getting 80% of the possible clicker points. For example, you can earn the full 15% by answering all of the questions incorrectly! Alternatively, you can earn the full 15% by answering 80% of the questions correctly and not answering the remaining 20% at all. Of course, there are a number of different combinations that get you to 80%. If you earn less than 80% of the total points, credit will be allocated in proportion to the number of points you have earned.

Homework and Reading Assignments

Homework assignments will be posted on CourseWeb approximately every other week, beginning the first week of class, and might be accompanied by reading assignments. These homework assignments are designed to emphasize the points being discussed during the lectures and serve as practice for the course exams and quizzes. The homework assignments are not mandatory. However, if you do not practice the homework problems, you will probably not do well on the quizzes given in the recitation section (see below) or the in-class exams. The teaching assistant, Brian Flores, will go over a selection of homework problems during the recitation sections. Make sure to ask the TA for help with any problems that you have trouble with if you want to be well prepared for quizzes and exams. If you like, you may hand in the homework **only at the beginning of each recitation section**. If you choose to do this, you may have your cumulative homework grade (based on all of the homework assignments throughout the semester) replace your two lowest quiz grades as part of your recitation grade. This is intended to offer students an opportunity to earn points and alleviate the pressure of taking quizzes. Notice that if you fail to complete a homework assignment on time, there will be no opportunity for a make-up assignment and you will receive a grade of zero for that homework assignment. Such a grade will significantly lower your cumulative homework score. Finally, if you hand in your homework and do not stay for the remainder of the recitation period, you will be given a grade of zero on that homework assignment.

Recitation

Attendance of the recitation sections is mandatory. Recitation sections will be used to review material, including homework assignments, and to administer quizzes. Throughout the semester, there will be between 6 and 10 quizzes given during recitation. Your recitation grade will constitute 20% of your final grade, and it will be calculated as the average of your quiz grades after dropping the two lowest grades. In addition, if you choose to turn in the homework assignments for a grade each week, you may use your homework grade to replace two more quiz grades. Finally, the TA will be able to give an additional 5% boost to your recitation grade based on participation. Because attendance is mandatory and you can have up to four quizzes dropped if you are handing in homework, **there will be no make-up quizzes**, except under extremely exceptional circumstances.

Exams

There will be three exams in this course, including the final exam, which will be given during finals week. Students must bring their Pitt ID cards to all exams. The use of books, notes or other written materials, computers, cellular phones, and all devices that can render documents, graphics, or connect to the internet are absolutely prohibited. Each exam will cover approximately one third of the course material. However, the material covered later in the course will often rely on the material covered earlier in the course, so it is difficult to do well on the later exams if you allow your understanding of the early material to deteriorate significantly. Each exam be comprised of approximately 40 to 60 multiple choice or true/false questions. The focus of this course will be on a qualitative understanding of astronomical subjects and sound reasoning in addressing scientific questions. Each exam will constitute 20% of your final course grade. The three exams taken together will constitute 60% of your final grade. Make-up exams will

only be given under extremely special circumstances, such as illness or University-approved travel, and will require a written confirmation from, for example, a medical doctor. The exam dates are:

- **First exam: Thursday, September 29 (in class).**
- **Second exam: Thursday, October 27 (in class).**
- **Third (final) exam: Friday, December 16 (finals week, 12 PM, 343 Alumni Hall).**

Course Topics in Detail

Here is a rough outline of what will be covered in ASTRON 0088. This plan may be modified according to student interests, to accomodate questions that may arise during the course, and to adapt to the pace at which we proceed.

Week 1: Aug 30, Sep 1	Introductory material: our place in the Universe, the scientific method
Week 2: Sep 6, 8	The first astronomers: Archaeoastronomy, the Greeks, the Middle Ages *Add/drop period ends Sep 9*
Week 3: Sep 13, 15	The Renaissance: Copernicus, Tycho Brahe, Johannes Kepler
Week 4: Sep 20, 22	The Renaissance II: Kepler's Laws of Planetary Motion, Galileo Galilei
Week 5: Sep 27, 29	The Enlightenment: Isaac Newton **First Exam: Thursday, September 29**
Week 6: Oct 4, 6	The basics of astronomy: the night sky, matter and radiation
Week 7: Oct 11, 13	The basics of astronomy II: flux and luminosity, distances, and telescopes *Fall break is Oct 17; Tuesday classes do not meet on Oct 18*
Week 8: Oct 20	Stellar astronomy I: the Sun *On Oct 20, the class will meet in Scaife Auditorium 6*
Week 9: Oct 25, 27	Stellar astronomy II: the life cycles of stars **Second Exam: Thursday, October 27** *Monitored withdrawal deadline is Oct 28*
Week 10: Nov 1, 3	Stellar astronomy III: white dwarfs, neutron stars, and supernovae; the origin of the chemical elements
Week 11: Nov 8, 10	Galactic astronomy: William Herschel, the Milky Way, other galaxies
Week 12: Nov 15, 17	Relativity: black holes and time warps
Week 13: Nov 22	Modern cosmology I: the expanding Universe and the Big Bang *Thanksgiving Recess: Nov 23-27*
Week 14: Nov 29, Dec 1	Modern cosmology II: the cosmic Microwave Background, the large scale structure of the Universe
Week 15: Dec 6, 8	Cosmic evolution in perspective, and back to Earth
Finals Week:	**Final Exam: Friday, December 16**

CourseWeb

The University of Pittsburgh provides a web based resource called Courseweb, which is a portal to web sites for individual courses. A Courseweb site for this course has been created and there you can view announcements, send email to the instructor or the TAs, and download course material such as the syllabus and lecture slides. Reading and homework assignments will all be announced on Courseweb. To access Courseweb go to http://courseweb.pitt.edu. Use your Pitt email username and password to login to Courseweb. If you have forgotten your username and password or need to set up an account, contact the help desk at 412-624-4357, or 4-HELP. Once you have logged into the system simply click on the link for this course to access the available material.

The Department of Physics and Astronomy

As students at the University of Pittsburgh, you have access to a Physics and Astronomy Department that is highly recognized and is performing world-class research. The Department of Physics and Astronomy wants you to feel welcome. If you are interested in further study of or research in physics or astronomy please talk to me or any other faculty member.

The Department of Physics and Astronomy provides free assistance for all students. The **Physics Exploration Center** allows students to operate some simple experiments and demonstrations. Within the Exploration Center is the **Physics Help Room**, staffed with TAs who can answer homework related questions, explain basic concepts and help you with the math. This is a free service and you are encouraged to use it. The Physics Exploration Center and the Physics Help Room are both located in Thaw 312, and a detailed schedule is posted here. In addition, tutoring is available through the Academic Support Center (WPU 311). You may also make use of the undergraduate lounge off of the mail room on the second floor of the Old Engineering Hall. This is a good place to meet with classmates to discuss problem sets and course material. You might also meet physics and astronomy majors here that can help you, discuss other classes with you, or inform you about the major program. The Department hosts a doughnut and coffee hour every Wednesday at 4PM, which is designed to encourage discussion. The Astrophysics group within the Department hosts seminars on topics of current interest in astronomy and astrophysics every other Friday at noon. The talks are typically at an advanced level, but eager students can learn a great deal about contemporary astronomy and astrophysics by attending. You can find the talk schedule in the Department web site, www.physicsandastronomy.pitt.edu. We also hold bi-weekly coffee discussions on several astronomy-related topics that are regularly attended by faculty, graduate students, and undergraduate students who are completing guided research projects in the astronomy group. Please ask me to provide you with updated information about these events if you want to attend.

Academic Integrity

The integrity of the academic process requires fair and impartial evaluation on the part of faculty and honest academic conduct on the part of students. To this end, students are expected to conduct themselves at a high level of responsibility in the fulfillment of the course of their study. It is the corresponding responsibility of faculty to make clear to students those standards by which students will be evaluated and the resources permissible for use by students during the course of their study and evaluation. The educational process is perceived as a joint faculty-student enterprise which will perforce involve professional judgment by faculty and may involve - without penalty - reasoned exception by students to the data or views offered by faculty.

Cheating/plagiarism will not be tolerated. Students suspected of violating the University of Pittsburgh Policy on Academic Integrity, from the February 1974 Senate Committee on Tenure and Academic Freedom reported to the Senate Council, will be required to participate in the outlined procedural process as initiated by the instructor. A minimum sanction of a zero score for the quiz or exam will be imposed. For details, refer to the University Guidelines on Academic Integrity.

Disabilities

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412)228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.