STELLAR ASTROPHYSICS (Astronomy 310)

Basic information

- **Instructor:** Dr. Ben Brown & Professor Ellen Zweibel

- **Contact information:**
  
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<td>Office hours</td>
<td>Monday 2:30–3:30</td>
<td>Tuesday 4–5</td>
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Either of us can be met in our offices outside of office hours by appointment, arrangement, or by dropping in at any time.

- **Class room and time:** 3425 Sterling, MWF 1:20–2:10pm

- **Mailbox:** 2nd floor of Sterling (Astronomy mailboxes, in department office 2535 Sterling Hall). Please don’t put anything in our Physics mailboxes.

- **Web materials:** Handouts (including this syllabus) are posted at our library reserve website (http://astronomy.library.wisc.edu/reserves/fall12/310/310.html). We will also have links to relevant articles posted there.

Important Dates

See below for explanation.

- September 12: Homework 1 assigned
- September 19: Homework 2 assigned; Homework 1 due
- September 21: First computer lab - class meets in 3517 Sterling
- September 26: Homework 3 assigned; Homework 2 due
- October 3: Homework 4 assigned; Homework 3 due
- October 5: Projects introduced
- October 10: Homework 5 assigned; Homework 4 due
October 17: Midterm review sheet handed out; Homework 5 due

October 24: **Midterm exam**

October 29: Second computer lab - class meets in 3517 Sterling

October 31: Homework 6 assigned

November 7: no homework; work on project. Homework 6 due

November 14: First project milestone due; Homework 7 assigned

November 21: no homework; Homework 7 due

November 22-25: **Thanksgiving recess**

November 28: Homework 8 assigned

November 30: Second project milestone due; Homework 8 due

December 10: **Projects due**

December 21: **Final Exam (5–7pm)**

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**Assignments and exams**

**Homework** The homework assignments will be short. We encourage you to work with other people in the class, and to come see us if you have questions, but the writeups should be your own. When writing up homeworks, indicate at the top of the first sheet all people you collaborated with. Homeworks will be assigned on Wednesdays and will be due one week later (the next Wednesday). We will grade the homework and return it, with solutions, a week after the due date. Because we try to be prompt about handing back the assignments, you should be prompt about turning them in. To encourage this, we will deduct a small number of points from late assignments unless you have a valid personal or professional excuse, preferably arranged in advance. **However, it is always to your advantage to turn in the homework, even late.**

**Exams** The midterm and final exams will be held in class and will be open book, open notes, but closed to electronic media. The midterm will test on the first part of the course; the final will be comprehensive.
Projects  In addition to homeworks, there will be one research project during the semester. We will provide a selection of three projects to choose between: one based on observational data, one based on stellar structure simulations, and one based on stellar population modelling. These projects will require that you learn to program in Python and will involve ongoing stellar research. We expect you to work collaboratively together to learn how to code and build these research tools, and we will hold two classes in the astronomy computer lab (Sterling 3517), and during November Ben will hold all of his office hours in the computer lab to help with coding questions during the project. There will be two milestones along the way for each project, as well as a final report. You yourself must write all code used in the project and you must individually write your own reports; all code will be submitted along with the final report.

Grading policy

About half your grade will come from work done outside the classroom (homework 25%, project 25%) and half from work done inside (midterm 25%, final 25%). The about enables us to recognize exceptionally good contributions to class discussion by slightly raising your grade.

Why study stellar astrophysics?

Most of the mass in the Universe is dark matter of unknown composition, but most of the visible light is starlight. Stellar energy and stellar nucleosynthesis drive the evolution of galaxies with time, and determine many aspects of their current state. Observations of so-called Type I supernovae - the explosive deaths of low mass stars - led to the revolutionary claim that the expansion of the Universe is controlled by dark energy. In lower mass stars, stellar variability significantly complicates the search for extrasolar planets, and the magnetic activity and winds of the host star may strongly determine which planets are habitable. Lastly, without stars there would be no planets, and probably no life.

Stellar astrophysics is one of the big success stories of modern physical science. Although there remains much to explore, thanks to observations, theory, numerical modeling, and advances in many different subfields of physics, we think we have quite a good idea of what stars are, and how they interact with their environment. The purpose of this course is to introduce the subject at a level appropriate to junior and senior majors in Astronomy or a related area.
This course has three aspects:

1. Stellar observations: how we learn the fundamental properties of stars.

2. Stellar structure and evolution: basic equations of stellar structure, energy sources, models, how stars evolve over time, stellar birth and death.

3. Stars in the Universe: how stars enrich the universe with heavy elements, add energy and momentum to their surroundings, and drive galactic evolution.

In this course we have two additional subagendas. First, you will learn the lore and history of stellar astronomy, and have a sense of how we have arrived at our current scientific understanding of stellar interiors and also how this may change in the future. Second, you will learn some scientific computing skills through our homeworks and research project. Both will serve you well as you continue in astronomy.

Reading

- The textbook for this course is “An introduction to the Sun and Stars”, by S. Green and M. Jones. We chose this book because it is new and has a lot of current material. We will supplement some of the material with our own notes. These will be scanned and posted on our library reserve website: http://astronomy.library.wisc.edu/reserves/fall12/310/310.html

- Additional books on reserve in the Astronomy Library:
  - “Introduction to Stellar Astrophysics”, by E. Bohm-Vitense. Three paperback volumes, each self-contained, at the undergraduate level. Sometimes used for the course.
  - “Principles of stellar evolution & nucleosynthesis”, by D. Clayton. Remains the best graduate level introduction to the microphysics - thermodynamics, statistical mechanics, and nuclear physics - of stellar structure. More comprehensive and advanced than the material presented in class. Some of the astronomy is out of date.
  - “Stellar Interiors”, by C. Hansen, S. Kawaler, & V. Trimble. Modern graduate level textbook. Chapter 2 is an especially good overview of stars and stellar evolution.
“Modern Stellar Astrophysics”, by D.A. Ostlie & B.W. Carroll. The first part is a good introduction to history, general astronomical lore, telescopes, and some of the important underlying physics. The second part is stellar astrophysics.

- NASA ADS: Most of the literature in astronomy, going back to the 19th century, is now online. So are many important databases. The URL that unlocks all of this is http://adsabs.harvard.edu/.

The research project

The research project is designed to involve you in real current stellar research. There will be three projects to choose between. One deals with stellar structure models and the numerical simulations we use to solve the stellar structure equations and understand the properties of stellar interiors. One deals with stellar spectra and how we use those observational data to measure the properties of stellar surfaces at great distance. One deals with population modelling, and how we use stellar structure models to understand populations of stars ranging from clusters to galaxies. More details on all three will be provided at a later date.

Learning accommodations

We will make every effort to accommodate students with learning disabilities. To do this however, we need an official letter from the McBurney Disability Resource Center. This is very important and cannot wait until right before the midterm/final/etc. Please talk to us within the first three weeks so we can help you connect with McBurney and the available university resources.