AST 840, Spring 2014
Stellar Astrophysics

Edward Brown

This graduate-level course covers the physics of stars and stellar-like objects: their births, lives, and deaths.

Course goals

This course emphasizes both stellar phenomenology and the physical processes that determine the evolution of stellar objects. The goal is a mastery of stellar "microphysics" at a chalkboard level, and the ability to integrate the disparate physical components into a physical model of stellar evolution. At the conclusion of this course, you should be able to

- describe the evolution of stars and stellar-like objects from birth to death;
- explain stellar behavior in terms of simple physical models;
- perform simple back-of-the-envelope calculations of a wide variety of physical processes that occur in stars; and
- evaluate critically the output of numerical models.

Contact information

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Class meetings and office hours

The class meets Tuesdays and Thursdays from 12:40 to 14:00 in 1300 BPS. Office hours are informal: if my door is open, you are welcome to drop in; alternatively, you may contact me for an appointment.

Text

The primary text is Hansen et al. (2004). My course notes will additionally draw on the sources listed in the references. You are welcome to borrow these books, or any others, from me for a limited time. In addition, my complete set of notes is available from a course Dropbox™ folder located at `https://www.dropbox.com/sh/85ix6075bvkuic1/OUxi8c3tHX`.

Assignments

The coursework consists of a combination of short reading assignments and longer weekly problem sets. As you know, solving problems is critical for mastering a subject, so this component comprises the majority of the final grade. We'll discuss the problems in class, so come ready to present your solution to the class—you will be evaluated on your in-class participation. Presenting your solutions to the class is good practice for "thinking on your feet," an invaluable skill for a practicing scientist. Because we discuss the problems in class, it is important to have your assignment done on time. If you are unable to finish an assignment on time, you must notify me in writing at least 24 hours in advance.

No rule of scholarly activity is more important than giving proper credit to the contributions of others. Although you are free to consult with classmates while working on assignments, you must explicitly acknowledge them by name and indicate their contributions in the write-up.

Use of the MESA code

We will be using the open-source stellar evolution code `MESA` (Modules for Experiments in Stellar Astrophysics) in this course. During the first week of the course we'll ensure that everyone has access to a working installation of the code, either on a personal laptop or via an account on `starmaker.pa.msu.edu`. The weekly homework assignments will include problems that require the use of `MESA`.

Project

In the latter part of the course, you will complete a longer project in which you'll explore a current problem in stellar astrophysics. You will decide on a topic in consultation with me, perform numerical analysis using `MESA`, and write, in a professional style, a report on your work. The reports will be circulated in the class for peer-review: that is, you will review a subset of your classmates' reports, and part of your grade for this project will be based on your reviews.

Final exam

The final exam consists of a 30-minute individual oral examination in which each student will individually answer questions and work problems on a whiteboard. Appointments for the exam will occur during finals week; I will contact you during the last week of courses to schedule the exam.

Grading policy

The weights for the course grade are as follows.

Homework	45%
In-class participation	10%
Project (incl. feedback)	25%
Final	20%

For many of the homework problem sets, the grading will be on a three-point scale: $\{-, \checkmark, +\}$ meaning, respectively, "needs improvement", "satisfactory", and "outstanding." For selected problem sets I will grade the write-up in detail and assign a numerical grade.

Outline of topics

We will follow the outline given in the course notes.

References—stellar astrophysics

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Clayton, D. D. 1983, Principles of Stellar Evolution and Nucleosynthesis (University of Chicago Press)

Cox, J. P. 1980, Theory of Stellar Pulsation (Princeton University Press)

Hansen, C. J., Kawaler, S. D., & Trimble, V. 2004, Stellar Interiors, 2nd edn. (Springer-Verlag)

Kippenhahn, R., & Weigert, A. 1994, Stellar Structure and Evolution (Springer-Verlag)

Mihalas, D. 1978, Stellar Atmospheres, 2nd edn. (W. H. Freeman)

Paxton, B., Bildsten, L., Dotter, A., Herwig, F., Lesaffre, P., & Timmes, F. 2011, ApJS, 192, 3

Paxton, B., et al. 2013, ApJS, 208, 4

Shapiro, S. L., & Teukolsky, S. A. 1983, Black Holes, White Dwarfs, and Neutron Stars (Wiley)

Zel'dovich, Y. B., & Novikov, I. D. 1971, Relativistic Astrophysics, Vol. 1, Stars and Relativity (University of Chicago Press)

References—general physics and astrophysics

Baym, G. 1990, Lectures on Quantum Mechanics (Addison-Wesley)

Bethe, H. A., & Salpeter, E. E. 2008, Quantum Mechanics of One- and Two-Electron Atoms (Dover)

Feynman, R. P., Leighton, R. B., & Sands, M. 1989, The Feynman Lectures on Physics (Addison-Wesley)

Landau, L. D., & Lifshitz, E. M. 1980, Course of Theoretical Physics, Vol. 5, Statistical Physics, Part 1, 3rd edn. (Pergamon)

—. 1987, Course of Theoretical Physics, Vol. 6, Fluid Mechanics, 2nd edn. (Pergamon)

Pathria, R. K. 1996, Statistical Mechanics, 2nd edn. (Butterworth-Heinemann)

Rybicki, G. B., & Lightman, A. P. 1979, Radiative Processes in Astrophysics (Wiley)

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—. 1991b, The Physics of Astrophysics, Vol. I, Radiation (University Science Books)

Spitzer, L. 1990, Physics of Fully Ionized Gases, 2nd edn. (Dover)