

## Astrophysics I: Stellar Evolution

Dr. Tom Maccarone

This course will meet MWF at 11 AM.

**Course goals:** This course will cover all the basics and a few advanced topics in stellar evolution. It will be based on the textbook by Dina Prialnik, “An Introduction to the Theory of Stellar Structure and Evolution”. I will supplement this with a bit more material on a few topics. For the topics which are well covered in the textbook, I will provide some notes to help you to understand what I have emphasized, and for the topics which are not covered well in the textbook, I will provide notes at a similar level of detail to what is normally seen in a textbook.

**Learning goals:**

1. Understand key methods for measuring the key parameters of stars
2. Understand the basic equations of stellar structure and the physical principles on which they are based
3. Understand the key radiative transport processes in stars
4. Understand the key nuclear reaction networks in stars
5. Have a phenomenological understanding of the different stages in the lifetimes of stars, and how the life cycle of a star depends on its mass

**Assessment:** Students’ understanding of the learning goals will be evaluated from selected questions on homework assignments and exams.

“Week” will refer here to a set of three lectures, and because there are some holidays in the semester, this will not always refer to a calendar week.

**Week 1 (January 16-23):** General course introduction – motivation for understanding stars, and a discussion of how measurements of stellar properties are made. Significant review of some general astronomy

**Week 2 (January 25 - February 6):** Key equations of stellar evolution – conservation of mass, energy and conservation laws in nuclear physics

**Week 3 (February 8-13):** Physics of gas and radiation – this will essentially be a review of some key results in thermodynamics that are most important for understanding stellar structure and evolution

**Week 4 (February 15-20):** Nuclear physics relevant to stars – specific fusion reactions, and an understanding of why certain reactions take place in certain stars

**Week 5 (February 22-27):** Simple equilibrium configurations for stars – polytropic models, the Chandrasekhar limit, etc.

**Week 6: (March 1- March 6)** Stability and instability in stars – understanding why instabilities develop and some of the consequences of instabilities

*Test 1 on the first 5 weeks of the course: March 8 in class*

**Spring Break: March 9-17: Have fun!**

**Week 7 (March 18-22):** A schematic picture of stellar evolution – getting a qualitative feel for what happens after stars exhaust their hydrogen

**Week 8 (March 25-29):** Mass loss from stars – stellar winds, and an understanding of the consequences of stars' losing mass for their end stages of evolution

**Week 9 (April 3-8):** A more detailed picture of stellar evolution, with a focus on the end stages of life as a star

**Week 10 (April 10-15):** End points of stellar evolution – supernovae, and the production of neutron stars and black holes

*Review Day: April 17, Test 2 April 19 (will cover weeks 6-10 of the course)*

**Week 11 (April 22-26):** Binary stellar evolution – a brief look at how binary stars evolve when the two stars can interact with one another

**Week 12 (April 29-May 3):** The stellar life cycle - star formation, and feedback of stars onto the interstellar medium, a bit on extrasolar planets, how they form and how they are detected

**Week 13:** May 6 – final review session

Final exam: to be determined by exam office - will cover the entire course

**Grading:**

There will be four homework assignments given. Each homework assignment will count for 5% of your final grade. The first two tests will count for 20% of your grade, and the final exam will count for 40%.

I plan to make a certain fraction of each exam very challenging to give the very top students an opportunity to demonstrate their abilities, and I also plan to make a certain fraction of each exam very easy to make sure that any students on the pass/fail border have a chance to demonstrate that they have learned enough to justify passing. An average of at least 75 will get you at least an A-, an average of at least 65 will be at least a B-, an average of 55 will be at least a

C- and an average of 45 will be passing. If I decide after the fact that the tests have been too difficult, then I may give a more generous grade distribution. I want to make sure that you are aware of this upfront so that if you are not accustomed to this sort of exam, you do not become discouraged if you get what you think is a low score on the first test.

You are encouraged to discuss the homework assignments with one another, but you are required to write up your own solution set. You should make sure that when you turn in an assignment that you have understood it well enough that if your assignment were lost, you would be able to reproduce the answers you gave with a high level of accuracy in a fairly short amount of time.

I will give you at least 10 days to do each homework assignment from the time I pass it around.

#### **Cross registration by graduate students**

If you are a graduate student taking this course, you will need to do two additional assignments. These will both be due at the end of the semester. You will have to do either two literature review papers, in which you read scientific papers on an advanced topic and write a coherent summary about the topic, or one review paper and one computational assignment. I will get a feel for how many of you there are, and who wishes to do which assignments and issue these assignments by the end of week 4 of the semester. I will count give you a grade that is composed 50% of the material also assigned to the undergraduates, with the same weighting as for the undergraduates, and 25% each for the two additional assignments.

**Office Hours:** MWF @ noon (i.e. right after class), T $\theta$  @ 11 AM, Science Building Room 113.

Do please feel free to drop by with questions any time *except* the hour before class, which I will be using for going over my notes to make sure that I know what I plan to teach you that day.