ASTR406: Stellar Structure and Evolution (Fall 2020)

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Prof. office hours: TBD or by appointment (on zoom)

Lectures: Tuesday and Thursday, 12:30am-13.45pm in room ATL 2324/zoom

Course description

The goal of this course is to give students a "physical understanding" of stellar structure, star formation and evolution. We will try to explain basic concepts in simple, sometimes intuitive, physical terms. In the lectures, we will cover many topics about stars in general (not on "solar physics"), including:

- global properties (energetics and timescales)
- micro-physics (EOS, nuclear reactions, energy transport and opacity)
- equations of internal structure
- evolution as a function of stellar mass
- end states (white dwarfs, neutron stars, and black holes)
- binary interactions

This course is designed for Astronomy and Physics majors. You must have completed ASTR320 (Theoretical Astrophysics) or obtained permission from the Astronomy Department. The course website is
http://www.astro.umd.edu/~ricotti/NEWWEB/teaching/ASTR406_20.html

Textbook

Required textbook:

Understanding Stellar Evolution
by Lamers & Levesque

IOP Astronomy ebook https://iopscience.iop.org/book/978-0-7503-1278-3 [must log-in from UMd network to get free access]

This is a free book available in pdf, ePub and Kindle formats. Slides and exercises are also available from the same publisher. I will rely mainly on this ebook and the accompanying slides in addition to other material, mainly from Max Pettini's lectures at IoA Cambridge (that I will make available on ELMS).

Hybrid in-person/online format of the course

Based on the results of a survey of the student in this course (12 students in Fall 2020), the majority of the students either requested or prefer an online format for the course. Hence, I will not enforce in-person class participation and have designed the course to be hybrid in-person (if you wish to attend the lectures) or remote. The first 2 weeks of classes will be online for everyone, as by UMD rules. Classes after Sept 14th will be in-person for those of you wishing to attend. I will present slides and using zoom I will share the presentation for remote access, also recording each lectures. Hence, you are encouraged to attend the class synchronously (keeping the camera on may help give a "class" feel to the lectures) as it is delivered. I prefer maximum class participation in order to make the lectures more engaging, but you have the freedom to review the class at a later time if for some reason cannot make the class time.

It will be difficult for me to deliver the lecture and take questions from zoom participants in real time. Therefore, I encourage to use the chat on zoom to formulate questions on the lecture: periodically I will pause to read and answer the questions.

There may be times when we do in-class exercises, and I encourage you to do them remotely, maybe setting up zoom rooms for group interactions.

In order to evaluate participation, especially for remote students and also to be prepared for the possibility of another lockdown, I will prepare weekly quizzes on ELMS to check your learning and participation to the class (the quizzes will not be graded but will be counted toward your participation grade). For those of you who took ASTR320 with me in Spring 2020, the quizzes will be similar in style to the ones we used for that class.

Other than the weekly quizzes your grade will be based on 5 homework, a midterm exam and a final exam.

Course expectations

Participation: Whether you attend the class online or in-person, I encourage you to be actively involved and participate. I will try to stimulate zoom/in-class discussions … simply getting hold of the lecture notes is likely insufficient to do well in this course.

Preparation: I expect you to be prepared to work. We will be covering several fascinating and challenging concepts - you will understand this material more easily if you preview the recommended reading material ahead of time, as well as giving it a more careful read after the lecture. You also should review your class notes sometime before the next lecture to make sure everything is clear. I encourage you to ask questions in the lectures or during my office hours.

Study Habits: Study wisely and ask for help if you need it. It is better to keep up with the material on a daily basis than cram the night before the exam. I encourage you to chat about

problems with your friends and classmates – you will learn a huge amount from trying to explain confusing issues to each other. ***However, please keep in mind that all graded materials, including class-assignments and home-works, must be your own thoughts in your own words.***

Grading

Grade will be based on homework, class participation, one midterm exam and a final exam according to the following weights:

Participation/Quizzes	15%
Homework	35%
Midterm exam	25%
Final exam	25%

Letter grades will be assigned guided by the following scheme.

A+	100% - 97%
A	96.9% - 93%
A-	92.9% - 90%
B+	89.9% - 87%
B	86.9% - 83%
B-	82.9% - 80%
C+	79.9% - 77%
C	76.9% - 73%
C-	72.9% - 70%
D+	69.9% - 67%
D	66.9% - 63%
D-	62.9% - 60%
F	less than 60%

I may adjust the precise grade boundaries to obtain a fair distribution of final grades, but I will only adjust the above-mentioned grade boundaries downwards (i.e. the above-mentioned grade boundaries are the "guaranteed" boundaries and any curving will only be to your advantage).

Weekly Quizzes

I will post on ELMS weekly quizzes (due by the end of the day on Friday) to check whether you are studying the material and watching the videos. These will count toward the participation grade but will NOT be graded based on the number of correct answers.

Format of the Midterm and Final Exams

I will create an exam in pdf (not a Quiz, something similar to a Homework). Samples of previous exams will be available on ELMS (from Suvi Gezari: this is the first time I teach this class). On **October 6th**, with some time limit (1:30 hours to allow extra time to upload the solution), you will work on the Midterm exam, you will scan it or take a picture of it, and upload it on ELMS or send me the pdf. This will be a traditional exam on which you will work individually, but consultation of books and notes is allowed.

The midterm exam is a "**major scheduled grading event**" and is covered by the relevant rules for excused absence. If you are not able to take an exam due to illness or other legitimate reasons, you must make every reasonable attempt to contact me on or before the day of the exam either by email or voice mail. In addition, you must provide documentation detailing the reason for your absence. *A self-signed note is insufficient*.

As per the University schedule, the final exam for this course will be held on December 21-2020 from 1:30pm to 3:30pm (given that this is a small class, it may be possible to reschedule depending on the student's needs). I will allow an extra 15min for scanning and uploading the exam to ELMS. The final exam will cover all material not covered in the Midterm exam (roughly the material discussed in class after the Midterm exam). Again, the final exam is a "**major scheduled grading event**" and is covered by the relevant rules for excused absence (see above).

Homework

Homework will be posted on ELMS approximately once every two weeks and will generally be due the following week. The due date will be clearly stated on the homework. On the due date, homework should be submitted electronically on ELMS. Late homework will be accepted for a week after the due-date and will be subjected to a penalty of up to 30%. Once the solution sets are handed out, late homework cannot be accepted. If you have a valid emergency that prevents you from making a homework deadline, you should make all reasonable efforts to contact me before the due date telling me the nature of the emergency. Please document all such emergencies; *a self-signed note is sufficient provided that it contains a statement that (1) the information is true and correct and (2) providing false information is prohibited under the Code of Student Conduct.*

Academic Integrity

The University's policies and rules on academic integrity are laid out in this document: http://www.president.umd.edu/policies/docs/III-100A.pdf. In essence, you must never engage in acts of academic dishonesty at any time. Acts of academic dishonest include cheating, fabrication, plagiarism, or helping any other person to do any of these things.

These rules apply to homework and quizzes as well as exams. As a part of these rules, you must give credit to any published article or webpage that you have used to help you with a particular assignment. The University takes these issues extremely seriously, as do I.

Preliminary course outline

Lec #	Date	Lecture topic	Book chapters/slides	Homework
		Basic Principles		
#1	Sep 1	Course Introduction; observations of stellar parameters, H-R diagram	Ch1-2; Slides1	
#2	Sep 3	Hydrostatic equilibrium and virial theorem	Ch3; Slides1	
#3	Sep 8	Gas physics: EOS	Ch4; Slides 2	HW1
#4	Sep 10	Opacities in stars	Ch5; Slides 2	
#5	Sep 15	Radiative transport	Ch6; Slides 2	
#6	Sep 17	Convective transport	Ch7; Slides 3	HW1 due
#7	Sep 22	Nuclear fusion; the s- and r-processes	Ch8; Slides 3	HW2
#8	Sep 24	Summary: stellar timescales	Ch9; Slides 3	
#9	Sep 29	Equations of stellar structure, polytrophs, Lane-Emden equation	Ch10-11; Slides 4	
#10	Oct 1	Calculating stellar evolution, the MESA code	Ch10; Slides 4	HW2 due
	Oct 6	**MIDTERM EXAM**		
		Star Formation and Stellar Evolution		
#11	Oct 8	Star formation	Ch12; Slides 4	
#12	Oct 15	The main sequence	Ch13; Slides 5	HW3
#13	Oct 20	Post main sequence evolution	Ch14; Slides 5	
#14	Oct 22	Stellar winds mass loss	Ch15; Slides 5	
#15	Oct 27	Red giant phase	Ch16; Slides 6	HW3 due
#16	Oct 29	Horizontal branch stars	Ch17; Slides 6	HW4
#17	Nov 3	Asymptotic giant branch stars	Ch18; Slides 6	(election day)
		Late evolution and stellar remnants		
#18	Nov 5	Post-AGB and Planetary nebulae	Ch19; Slides 7	
#19	Nov 10	White dwarfs and neutron stars	Ch20; Slides 7	HW4 due
#20	Nov 12	Pulsating stars (Cepheid strip)	Ch21; Slides 7	HW5
#21	Nov 17	Observational evidence of mass loss	Ch22; Slides 8	
#22	Nov 19	Evolution of massive stars 8-25 Msun	Ch23; Slides 8	
#23	Nov 24	Evolution of massive stars >25 Msun	Ch24; Slides 8	HW5 due
	Nov 26	**Thanksgiving (no class)**		
#24	Dec 1	Supernovae	Ch26-27; Slides 9	
#25	Dec 3	Close binaries and mass transfer (X-ray binaries, novae, CVs)	Ch28-29; Slides 10	
#26	Dec 8	Chemical yields	Ch30; Slides 10	
#27	Dec 10	Review session		
	Dec 21	Final exam (official date/time: 1:30pm-3:30pm)	Date and time TBD	