

Astronomy 363: Stellar Astronomy and Astrophysics I

University of Montana
Autumn 2019
MWF 10:10 – 11:00 am
CHCB 231
Course Number 74828

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Office: 122 CH Clapp Building

Office Hours: MW 2-3 pm, F 1-2 pm and by appointment

Course website: *see Moodle*

Course Description

The star is the fundamental unit of astronomy. In this course, we will establish a basis for studying the Universe through a physical understanding of the nature of individual stars. We will begin with the observables: stellar properties we can ascertain through direct measurement. From there we will apply physical principles from mechanics, thermodynamics, statistical mechanics, electromagnetism and quantum, atomic and nuclear physics to develop a physical understanding of the nature of stellar interiors. The unifying theme of the course will be to understand the observed Hertzsprung-Russell diagram via basic principles of physics. The first semester, Astr 363, will focus on the internal structure of an individual main sequence star. In the second semester, Astr 365, we will investigate the time evolution of stars (their birth, death, and remnants) and their atmospheres.

Course Objectives

My goals in Astronomy 363 are to...

1. Familiarize students with basic stellar observations.
2. Develop the fundamental physics that govern stars.
3. Apply physics to determine the internal structure of a solar-type star.

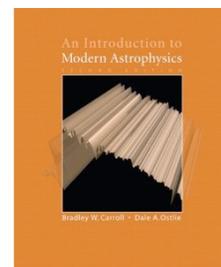
Required Materials

An Introduction to Modern Astrophysics, 2nd Ed.

by Carroll and Ostlie

Available from amazon.com and elsewhere for ~\$95.

(The same textbook will be used for Astr 365.)



Expectations of the Professor

This upper-division course is intended for physics majors with a concentration in astrophysics. I expect that you will have completed the designated pre- and co-requisite courses: Astronomy 132 or 142 (introductory astronomy), Physics 217 (physics with calculus) and Physics 343 (Modern physics). Integral and differential calculus are essential in this course, and you should have a working understanding of the co-requisite course Math 273 (multivariable

calculus). You should also be comfortable working with logarithms, scientific notation and the Greek alphabet! Time in the classroom is an essential part of this course, and it will be to your benefit to attend lectures. Exams and homework will be based primarily on material presented in class. The readings from the textbook will help you prepare for class meetings. This syllabus includes the assigned readings. *I expect students to read the material in advance of the class on the topic, and to be prepared to discuss the material in class.*

This course is a collaborative effort – please ask questions, offer your ideas and be prepared to participate in the discussion. Written work submitted in this course must be expressed in your own words. I specifically encourage students to work together, but each student must write up her or his own response to problems. This step is essential to your learning – writing up the answer to a question requires you to understand the conclusion of your group, whereas transcription of the work of another does not. When in doubt, please ask me what is acceptable.

Pedagogical Philosophy of the Professor

My primary goal in teaching upper-division majors is to help you develop physical intuition and apply principles of fundamental physics learned in introductory coursework. This class in particular is an advanced course in astrophysics, a field of applied physics. As with any applied field, there is a significant amount of vocabulary specific to the discipline. This course will help develop your fluency in the language of astrophysics.

Research in how people learn indicates that the knowledge of an expert in a topic is organized around core concepts. In order to help you develop expertise in stellar astrophysics, I have organized this course around several core concepts. These are listed on the class schedule in this syllabus. Each concept is associated with a number of specific learning goals, a complete list of which I will provide for your use as a study guide. Each learning goal is stated from the student's perspective. If you can achieve these specific goals, you will succeed in this course – and be well on your way towards expertise in stellar astrophysics!

Grading Policy

This course will be graded on the University's traditional letter grade system. Your grade will be based on three midterm exams (13% each), a cumulative final exam (26%), and weekly homework sets (35% total). I have not determined in advance how many As, Bs, etc will be assigned – I'm happy to give every student an A if they demonstrate mastery of the material. Regular grade updates will be available on the course Moodle page.

Midterm exams take place during regular class time on the scheduled days unless a longer evening time is selected by agreement of the class. If you cannot be present, tell me *before* the exam and we can discuss arrangements. For *well-documented* compulsory absences, we will arrange a time for you to take the exam *early*.

Homework must be turned in by 5pm on the due date (generally Fridays). Late homework will be penalized by 10% per weekday to a minimum of 50% (no work will be accepted after December 6). Homework must be legible! If your first attempt is messy, use it as a draft to rewrite a final version for submission. If I can't read it easily, you'll get no credit!

Course Schedule & Reading Assignments

			Readings
STELLAR OBSERVATIONS			
M	Aug 26	Flux and magnitude	3.2
W	Aug 28	Distance, absolute magnitude & luminosity	3.1
F	Aug 30	Filters, color and photometry	3.6
M	Sept 2	<i>Labor Day Holiday</i>	
W	Sept 4	Thermal radiation & the Planck function	3.4, 3.5
F	Sept 6	Stellar spectra	5.1
M	Sept 9	Stefan-Boltzmann law & stellar radii	pp 69-70, pp 144-148
W	Sept 11	Binary stars and stellar mass	Ch. 7
F	Sept 13	Solar measurements & radioactive dating	pp 756-759
M	Sept 16	Hertzsprung-Russell diagram	8.2
W	Sept 18	Mass-luminosity relation and MS lifetimes	p 189
F	Sept 20	Midterm 1	
PHYSICS OF STELLAR STRUCTURE			
M	Sept 23	Gravity & hydrostatic equilibrium	10.1
W	Sept 25	Statistical mechanics and PDFs	
F	Sept 27	Pressure integral and the ideal gas law	10.2
M	Sept 30	Stellar interiors & ionization	pp 213-219
W	Oct 2	Radiation pressure	pp 236-237, p. 295
F	Oct 4	LTE and radiative transfer	pp 251-261
M	Oct 7	Opacity and mean free path	9.2
W	Oct 9	Radiative energy transport	pp 315-316
F	Oct 11	Convective energy transport	pp 316-325
M	Oct 14	Equations of stellar structure	pp 329-332
W	Oct 16	Mass-luminosity relation, revisited	
F	Oct 18	Midterm 2	
STELLAR NUCLEOSYNTHESIS			
M	Oct 21	Four fundamental forces	
W	Oct 23	Nuclear reactions & binding energy	pp 298-302
F	Oct 25	Wave/particle duality & quantum tunneling	pp 127-132
M	Oct 28	Nuclear reaction rates & cross sections	pp 302-308
W	Oct 30	Hydrogen fusion	pp 308-312
F	Nov 1	Helium fusion	pp 312-313

M	Nov 4	Heavies fusion STELLAR MODELING	pp 313-315
W	Nov 6	Boundary conditions and integrations	pp. 332-334
F	Nov 8	Computer modeling with MESA code	
M	Nov 11	<i>Veterans Day Holiday</i>	
W	Nov 13	Solar internal structure models	pp 349-356
F	Nov 15	What determines the mass range for stars?	
M	Nov 18	Midterm 3 THE SUN AS A STAR	
W	Nov 20	Solar elemental abundances and luminosity	pp 356-360
F	Nov 22	Solar neutrinos	
M	Nov 25	Helioseismology	pp 509-512
W	Nov 27	<i>Thanksgiving Break</i>	
F	Nov 29	<i>Thanksgiving Break</i>	
M	Dec 2	Solar magnetic field and the sunspot cycle	11.3
W	Dec 4	Solar wind & the corona	11.2
F	Dec 6	Review	
Th	Dec 12	Final Exam, 8:00 – 10:00 am	

Additional Reading

There are several excellent texts on the subject of stellar astrophysics, many of which were used to prepare course material. The texts marked with stars are classics in the field.

The Physics of Stars, 2nd Ed., A.C. Phillips, 1999

Principles of Stellar Evolution and Nucleosynthesis, D. C. Clayton, 1983 ★

Stellar Structure and Evolution, R. Kippenhahn & A. Weigert, 1990

An Introduction to the Study of Stellar Structure, S. Chandrasekhar, 1967 ★