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Syllabi

Course Syllabi

1-2014

ASTR 365.01: Stellar Astronomy and Astrophysics II

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Astronomy 365: Stellar Astronomy and Astrophysics II

University of Montana
Spring 2014
MWF 10:10 – 11:00 am
CHCB 231
Course Number 34891

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Office Hours: Tue/Thur 3-4pm, Fri 1-2pm, and by appointment
Course website: http://cas.umt.edu/physics/astr365/

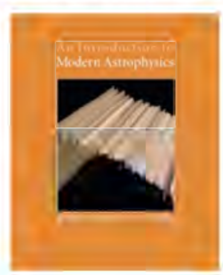
Course Description

Stars in the night sky appear fixed and unchanging, eternal. In this course, we will apply our physical understanding of the structure and composition of stars to discover that they are in fact ever-changing objects locked in a constant struggle against gravity. We will begin with the relatively benign life cycle of low-mass stars like our Sun. Next, we will investigate the violent life cycle of high-mass stars. From there we will apply physical principles from mechanics, thermodynamics, statistical mechanics, relativity, and quantum, atomic and nuclear physics to develop a physical understanding of the nature of stellar remnants, stellar atmospheres and spectroscopy, and the formation of stars. The unifying theme of the course will be to understand the Hertzsprung-Russell diagram via basic principles of physics. The first semester, ASTR 363, focused on the internal structure of individual main sequence stars. In the second semester, ASTR 365, we will investigate the time evolution of stars, their birth and end states.

Course Objectives

My goals in this course are to…

1. Apply physics to understand the life cycle and end states of stars.
2. Introduce the physics and phenomena of star formation and the interstellar medium.
3. Develop a physical understanding of stellar spectra.



Required Materials

An Introduction to Modern Astrophysics, 2nd Ed.
By B.W. Carroll and D.A. Ostlie
available from amazon.com (and elsewhere) for ~ $120

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-requisite courses: Astronomy 363 (the first half of this course), Astronomy 132 or 142 (introductory astronomy) and Physics 217 (physics with calculus). It is advantageous if you have also taken Physics 343 (modern physics), but we will study the necessary quantum, atomic and nuclear physics within this course. Integral and differential calculus are essential in this course, and you should have a strong understanding of the pre-requisite Math 273 (multi-variable 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. No single textbook completely covers the full range of topics presented in this course, but the readings will help you prepare for class meetings. This syllabus includes assigned readings and a brief summary of what you should learn from each reading. *I expect students to read the material in advance of the class on a 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.

And of course, while in class, please turn off your phones and other electronic gadgets. Laptops are acceptable for note-taking, if you so desire.

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 outlined 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 you for use as a study aid. 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 weekly homework sets (40% total), three midterm exams (12% each), and a cumulative final exam (24%). I have not determined in advance how many As, Bs, etc will be assigned – I'm happy to give every student an A if s/he demonstrates mastery of the material. Along the way I will provide regualr updates regarding your grade in the course.

Midterm exams take place during regular class time on the scheduled days. 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 <u>by 5pm on the due date</u> (generally Fridays). Late homework will be penalized 10% per weekday. Homework must be legible! If your first attempt is messy, use it as a draft and rewrite a final version for submission. If I can't read it, you'll get no credit!

Course Schedule & Reading Assignments

			Readings
		STELLAR EVOLUTION	
M	Jan 27	M.S. evolution and the Virial theorem	2.4, 446-452
W	Jan 29	Core hydrogen exhaustion	452-457
F	Jan 31	Shell fusion and ascent of the RGB	457-461
M	Feb 3	Helium fusing stars	461-463
W	Feb 5	AGB stars and planetary nebulae	463-474
F	Feb 7	Post-MS evolution of high mass stars	518-521
M	Feb 10	Approach to the iron catastrophe	313-315
W	Feb 12	Supernova observations, SN 1987A	15.2
F	Feb 14	Supernovae: collapse, explosive nucleosynthesis	15.3
M	Feb 17	*Washington-Lincoln Holiday*	
W	Feb 19	Wolf-Rayet stars and gamma ray bursts	521-523, 15.4
F	Feb 21	**Midterm 1**	
M	Feb 24	Variable stars and the instability strip	14.1
W	Feb 26	Interacting binaries and Type Ia supernovae	18.1, 18.5
		STELLAR REMNANTS	
F	Feb 28	White dwarfs	16.1-16.2
M	Mar 3	Degeneracy pressure, Chandrasekhar mass	16.3-16.4
W	Mar 5	Neutron stars	16.6
F	Mar 7	Pulsars	16.7
M	Mar 10	Gravity and the equivalence principle	17.1
W	Mar 12	General relativity and spacetime curvature	622-626
F	Mar 14	Schwarzschild metric	626-633
M	Mar 17	Collapse to a black hole	633-639
W	Mar 19	Astrophysical black holes	639-646
F	Mar 21	**Midterm 2**	
		STAR FORMATION AND THE ISM	
M	Mar 24	Gas phases in the interstellar medium	398-399, 431-432
W	Mar 26	Interstellar dust and extinction	399-404
F	Mar 28	Atomic gas	404-406
M	Apr 7	Radio astronomy	
W	Apr 9	Molecular clouds	406-411
F	Apr 11	Pre-MS evolution: protostars and disks	12.2
M	Apr 14	Pre-MS evolution: the Hayashi track and birthline	425-429
W	Apr 16	T Tauri stars and Herbig Ae/Be stars	434-441
F	Apr 18	Star clusters and the initial mass function	430, 474-477

M	Apr 21	Brown dwarfs	Supplement
W	Apr 23	**Midterm 3**	
		STELLAR ATMOSPHERES	
F	Apr 25	Radiative transfer and the source function	255-258
M	Apr 28	Plane parallel atmosphere	258-263
W	Apr 30	Detailed balance and Einstein coefficients	Supplement
F	May 2	Line broadening and equivalent width	267-271
M	Apr 30	Theory of spectral line formation	271-273
W	May 2	Curve of growth	273-276
F	May 4	Review	
F	May 16	**Final Exam, 10:10am – 12:10pm**	

Additional Reading

There are many excellent texts on the subjects of stellar astrophysics and the interstellar medium, many of which will be 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

Supernovae and Nucleosynthesis, D. Arnett, 1996

Black Holes and Time Warps, K.S. Thorne, 1995

Black Holes, White Dwarfs and Neutron Stars: The Physics of Compact Objects, S.L. Shapiro and S.A. Teukolsky, 1983 ★

Gravitation, C.W. Misner, K.S. Thorne and J.A. Wheeler, 1970 ★

Gravity: An Introduction to Einstein's General Relativity, 2003

The Formation of Stars, S.W. Stahler and F. Palla, 2004

Physics and Chemistry of the Interstellar Medium, S. Kwok, 2007

The Observation and Analysis of Stellar Photospheres, D.F. Gray, 1983 ★

Introduction to Stellar Astrophysics, Vol. 2: Stellar Atmospheres, E. Böhm-Vitense, 1989

Astronomical Masers, M. Elitzur, 1992