SYLLABUS
ASTR 460/560
Stellar Evolution Seminar
Spring 2020

LECTURES: Tuesday/Thursday: 11:00 a.m. - 11:50 a.m. (2 credits)
Steward Observatory, Room 208
(Last regular lecture May 5)

INSTRUCTOR:
Dr. Nathan Smith
Steward Observatory, N512
(520) 621-4513
profsmith170@gmail.com

OFFICE HOURS:
Monday 1:00 p.m. - 2:00 p.m.

EXAMS: None.

OVERVIEW:

The current graduate astronomy curriculum includes a course called Astrophysics of Stars and Accretion (ASTR545), but this course has a focus mainly on the standard theory of stellar interiors and the physics of accretion disks. The undergraduate curriculum includes a basic introduction to astrophysics in 400A. This seminar is designed to be complementary to these core courses, and will connect the equations of stellar structure and evolution to the observed properties of a wide variety of stars, including spectral types, luminosity and temperature evolution on the Hertzsprung-Russell diagram, uncertainties in stellar evolution models, the inferred influence of composition, mass loss, binary star evolution, different types of stellar death, dependence on environment, and influence on the galactic environment (feedback). We will also explore some key observational diagnostics of stellar properties along the way. The course will examine both the historical origin of several key ideas in the field, as well as current frontier topics in the literature. The course will benefit students who intend to specialize in research on stars, but will also cover key topics relevant to interpreting observations of galaxies and the role of stars in galaxy evolution and cosmic evolution.

GRADES: Your final grade for the course will be determined based on the assignments and class participation in the following proportion:

In-class Presentations	40%
In class Participation	40%
Observing proposal	20%

We reserve the right to change or curve the course grading, but a guideline for percentage vs. grade cutoffs is: **A = 90% and up, B = 80% and up, C = 70% and up, D = 60% and up, E < 60%.**

TOPIC SCHEDULE:

Week	Topic
Jan 16	Overview, logistics, pre-main-sequence
Jan21/**23**	Stellar structure, convection, nuclear burning
Jan **28**/**30**	The Sun, solar wind, low-mass main-sequence stars and brown dwarfs
Feb 4/6	The HR Diagram and stellar evolution models
Feb 11/13	Stellar atmospheres, spectral types, observational diagnostics
Feb 18/20	Low-mass post-MS stars, blue stragglers, globular clusters, low metallicity
Feb 25/27	Low-mass late phases; AGB, carbon stars, planetary nebulae, role of binaries
Mar 3/5	Low-mass binary endpoints, white dwarfs, novae, Type Ia supernovae
Mar 10/12	**Spring Break**
Mar 17/19	Intermediate-mass stars and the transition to massive stars
Mar 24/26	Massive main-sequence stars, winds, upper mass limit
Mar 31/Apr 2	Massive stars: rotation, binaries, mass loss
Apr 7/9	Massive evolved star zoo: red/blue supergiants, LBVs, Wolf-Rayet stars
Apr 14/16	Core collapse supernovae, SN remnants, GRBs
Apr 21/23	Exotica (compact object binaries, GW sources) ** **Observing proposal due 4/23.**
Apr 28/30	Feedback/population synthesis / Low-metallicity, Pop III
May 5	First stars and reionization

COURSE OBJECTIVES and LEARNING OUTCOMES:

- During this course, students will read and discuss influential historical papers that were critical for the early development of each topic, and they will also study modern papers from the professional literature that show progress in the field and illustrate the driving questions of current research.

- During this course, students will take turns presenting topics, in addition to participating in discussion. For these topics, presenting students will develop a deeper understanding necessary to present the material to the class, they will discuss relevant physics and professional terminology, and they will facilitate a discussion.

- Upon completion of this course, students will have gained a clear understanding of how the theory of stellar structure and evolution taught in their previous course connects to real research in the field.

- Upon completion of this course, students will have gained an understanding of the historical origins and initial questions associated with each topic, and they will understand how research progress in the field has led to the current driving questions in astrophysics research.

- For a subset of topics for which they present and lead discussions, all students will have probed deeper in order to understand that topic at a professional level and will be able to answer advanced questions about that topic.

- Upon completion of this course, graduate students will have led advanced discussions (more independently than expected for undergraduates), they will have developed a deep understanding of the physics and state of research in the field, and through the observing proposal project, will have applied this expertise to a research program of their own design that may contribute to that field.

HOMEWORK: There are no weekly problem sets. The weekly homework will center on reading relevant papers from the literature (see below), or in some cases excerpts from monographs, for discussion each week. Students are expected to have read the papers when not presenting, and to be intimately familiar with papers (as well as related literature and concepts) when they are presenting.

OBSERVING PROPOSAL: A required assignment for graduate students is to write a fake but realistic observing proposal appropriate for one of the topics discussed in class – preferably one for which you are the presenter. The goal is to develop a deep enough understanding of the current state of research in that subfield to write a concise and relevant research proposal at a professional level, applying your new knowledge to an observational test of an idea. The observing project you design should utilize one or more facilities available through Steward Observatory (e.g., LBT, MMT, Magellan, Bok, Kuiper, VATT, UKIRT, or ARO facilities), and you should use the Steward proposal template (or ARO form if appropriate). Even if you are a graduate student inclined toward theoretical projects, you must write an observing proposal to connect theoretical concepts of stars discussed in class to empirical tests. Follow the appropriate proposal template (including page limits) as if this were a real proposal. This should contain a professional-quality scientific justification and experimental design appropriate for peer review by the Steward TAC (although you are not required to actually submit the proposal). The proposal does not need to be realistic in terms of how you think Steward politics might apply to time allocation (for example, you could request all of Arizona's allocation of LBT time to monitor eclipsing binaries, even though in reality this might be unlikely to get accepted), but it should be well justified scientifically. Due date is April 23, hardcopy in class.

This observing proposal should not resemble any previous observing proposal you have already written for actual observing time or for another class. You are also discouraged from writing a proposal that you would have written anyway for your thesis work. The purpose here is to develop and apply expertise in a new area.

PARTICIPATION IN CLASS: This seminar course is conducted as a discussion requiring active participation by all students enrolled. This is especially true in a small class. We will conduct interactive discussions in class; this will improve your understanding of the material and will count toward your grade. In fact, class participation is a major component of your grade. Students are expected to ask questions often. If you are persistently silent in class discussions, or it seems like you have not read the material before class, this will detract from your grade.

LITERATURE PRESENTATIONS: Starting on week 2 we will begin a regular pattern where every class is spent by students giving in-class presentations accompanied by discussion. We will alternate from one student to the next each day/week. The focus is on work in the literature relevant to the topic that week. There will be some flexibility in format from one topic to the next, but a typical sequence will be (1) a review of important historical work in the literature that set the stage for the topic, (2) discussion of a the basic theoretical ideas relevant to the topic and the most common current observational approaches, and (3) discussion of a modern review article or other seminal paper to give the updated current state of the field. Each of these could be roughly 10 minutes, although it is up to you, and should allow ample time for engaging discussion.

These do not need to be polished power-point presentations as one might do in a Journal Club. Instead, the emphasis is on giving background, ***instigating discussion***, engaging the other class members, and answering their questions – the aim should be a presentation more akin to the style of an arXiv coffee discussion, except that you have actually read the paper ahead of time and studied it in detail. You might also concentrate more on the history/background and relevant theory. All students in the class will read the papers before class and participate actively in discussions, but the discussion will be led by one student (or two) who prepares the presentation that day. It is the responsibility of the presenter to focus the discussion and plan for the appropriate amount of time. Many of the papers contain too much material to cover everything in two 50-min class periods, so a selection of some subset of the material will often be appropriate. The number of presentations will depend on enrollment. Grades will be awarded based on effort, preparation, and mastery of the topic, as well as partly on an individual's facilitating of the discussion. Graduate students will be expected to present a more comprehensive and thorough discussion of the topic than undergraduates, and will be expected to be less reliant on input from the instructor to guide the discussion than an undergraduate presenter. Graduate students may also present a larger number of times, or may choose more difficult topics.

Important: When it is your turn to present, you must choose a "New" paper (or papers) in advance. A good choice is usually a modern ARAA article, but that is not always the case. If you are leading the discussion for a given Tuesday and/or Thursday some week, be sure to send an email to the class ***by Friday of the week before***, at the latest, so that they have time over the weekend to read the paper(s). The degree to which your classmates will get frustrated and annoyed with you will be proportional to t^{-x}, where t is the amount of time you have given them to read the paper(s) and x is a big number.

ACADEMIC AFFAIRS: Please see **https://academicaffairs.arizona.edu/syllabus-policies** regarding standard UA policies concerning Absence and Class Participation, Threatening Behavior, Accessibility and Accommodations, the Code of Academic Integrity, and the Nondiscrimination and Anti-harassment policy.

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor; see **http://policy.arizona.edu/faculty-affairs-and-academics/course-syllabus-policy-undergraduate-template**.