Astronomy 241: Stellar Astrophysics

Stellar Atmospheres, Interiors and Evolution

Spring 2015

Motivation: The importance of stars to developing our physical understanding of the universe, and to the origins and natural sustainability of life on Earth (and perhaps elsewhere) can hardly be overstated. Stars have provided invaluable natural phenomena for understanding and testing the frontiers of physics, from the 17th and 18th century (gravity), to the 19th and 20th centuries (thermal physics, radiation), nuclear/particle physics), and now (dark matter, dark energy). Stars are the primary sources of electromagnetic radiation and heavy elements in the universe, hosts to planetary systems, building blocks of galaxies, and test particles for understanding gravity and the geometry of the universe. Our measurements of the distances, velocities, brightnesses, spectra, and chemical compositions have been critical to piecing together the history of our Galaxy and the universe as a whole. Stars are the spawn of, polluters of, and drivers of the gas and dust that makes up the interstellar medium. The nearest star (the Sun) is the primary source of energy to the Earth's surface - and its fairly steady EM radiation has been essential for sustaining life on Earth over billions of years. Stars are where the four fundamental forces move and transform baryonic matter and energy on a large scale, with combinations of density and temperature unmatched even in the Big Bang. Our observations (measured during comparatively short human lifespans) catch stars at a wide ranges of stages in their lives (being born, shinging stably, and dying). Stellar lifetimes are measured in millions to billions of years (or longer), depending on their initial mass and composition.

For astronomers, this is a course on the physical details of stars; we will derive expressions for the emission by, and internal structure of, stars of various masses and stages of development from first principles, to elucidate the processes that give rise to their observed properties. For non-astronomers, this is a first course in the transport of electromagnetic radiation through matter, and in fluid mechanics, using one of the simplest classes of natural objects (stars) as the venue. For all, this is a physics course that involves application of techniques you have learned, from all four basic parts of the physics curriculum: mechanics, E&M, thermal physics and quantum mechanics. *How do we study stars and what have we learned about how they work?*

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Textbook: *An Introduction to Modern Astrophysics, Second Edition*, by Bradley W. Carroll and Dale A. Ostlie (Addison-Wesley, 2007). It is also known as "*BOB*" (Big Orange Book) of "C&O". The book will be used heavily for the course (and often during class).

WWW Site: *http://www.pas.rochester.edu/∼emamajek/AST241*

Software: For some exercises in this class, you will need a means of manipulating data, doing calculations, and plotting your results. You are strongly recommended to use either commercially available software on your favorite operating system (e.g., Mathematica, Excel, Mathcad, etc.) or other options (e.g., Python). We will discuss software options in the coming weeks.

Format: brief lecture/tutorial. Class meetings will be used principally for discussion of the textbook readings – including the performance of derivations and examples – and the homework problems by the whole class. I will provide summaries of the material in the textbook, additional material to illuminate the text, and facilitate discussions. The idea is to get you as much practice and problem-solving experience as possible. The emphasis on student involvement obviously has the potential to make the course a much richer and more worthwhile experience than the standard lecture-recitation-examination format usually used in larger courses. However, it will be hard to realize much of the potential unless *everyone in class keeps up with the reading and homework.*

Class meetings: Class is Wed/Fri 11:50am-1:05pm in Chart Room 480 B&L.

Homework assignments: ∼10 problem sets, to be assigned weekly during the semester. Assignments will be graded and returned for error correction by you (see below) within 1 or 2 class periods. Electronic submission of homeworks may be preferable in some instances. When a descriptive answer is called for, I expect to see sufficient narrative, in the form of complete sentences and properly constructed paragraphs (if needed). Homework must be *neat, legible, using correct units, and quoting your answers to a proper number of significant figures.*

Team homework: Most of the problems on each set will be designated as solo problems, on which students are required to work independently. There will also be some group assignments. The team problems will generally be the more challenging ones. Solo problems will of course be written up and handed in separately by each student, but each team will turn in only one writeup of their solutions, and each team member will receive the same grade for this work. I remind you that, as an educational technique, learning from fellow students is second in effectiveness only to figuring it out yourself: the "student" gets an explanation at the appropriate level, from someone who learned it recently enough to remember the pitfalls; the "teacher" has to resolve issues about the problem that may get glossed over if an explanation to someone else is never attempted; and in a good group, everyone gets many opportunities to be "student" and "teacher."

Homework error correction: Every Wed or Fri, homework sets will be due. They will be returned within 1-2 class periods, with points deducted for errors and with occasional comments and clues. If you correct the errors and resubmit the homework set by an agreed upon date (usually within week after the original due date), 50% of the originally-deducted points will be restored. This second chance to get it right applies both to solo and team homework assignments.

Late homework policy: Homeworks are due *at the beginning of class* on the deadline date. Late homeworks will be assigned zero points. Exceptions will be made if you have an excuse from a doctor (illness) or a coach (university athletic event), or can provide an obituary (attending funeral). Extraordinary exceptions will be handled at my discretion on a case-by-case basis. If you do not have an official excuse, *it is better to turn in an incomplete homework (where you can get half of the deducted points back with corrections) rather than a late one (zero credit).*

Examinations: none. The homework is intended to be debilitating enough.

Grades: based completely on the homework assignments. Homework scores, expressed as a percentage, will be determined for each problem set either from adding the scores from the solo and team problems. Each homework will be worth $1/n$ of the final grade, where n will be the number of assignments turned in. Final grades will be set by an absolute scale, rather than "by the curve." In terms of the maximum possible percentage score, the grading scale will be as follows:

% Score	>85	>80	>75	>70	>65	>60	>55	>50	>40	>40
Grade	A	A-	B+	B	B-	C+	C	C-	D	E

Extra help: I am obviously most accessible during office hours, but you are welcome to stop by and talk with me whenever you want. I will be happy enough to answer any questions you have concerning the course, but even happier to help those who find the material or presentation sufficiently confusing that they're not even sure what to ask. Use of the class email listserver is encouraged.

Course Outline: The schedule showing dates, subjects, and reading assignments is posted on the web at: https://www.pas.rochester.edu/∼emamajek/AST241/index.html