Astronomy 241: stellar astrophysics

Spring 2024

This is a course intended for junior and seniors, in the physical details of stars and circumstellar disks. 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. This involves application of techniques from all five parts of the basic physics curriculum: mechanics, fluids, E&M, thermal physics and quantum mechanics. It also involves use of computation, as many of the equation networks which describe stars and disks cannot be solved analytically.

Prerequisites: PHYS 121-123 or PHYS 141-143, MATH 281, PHYS 237, PHYS 217; PHYS 227 (or concurrent enrollment). Also recommended: ASTR 111, ASTR 142, PHYS 218 (or concurrent enrollment).

Professor: Dan Watson. Office: 418 Bausch and Lomb. Email: dmw@pas.rochester.edu. Web: http://www.pas.rochester.edu/~dmw.

Required textbook: Brad Carroll and Dale Ostlie, *Introduction to modern astrophysics*, second edition (Cambridge University Press, 2017). Downside: expensive in hardcover form. Upside: A good book, which you will use as a textbook or reference in multiple ASTR courses. It is available as a Kindle e-book, $20 cheaper than the hardcover, and as a paperback which is only $0.40 cheaper than the hardcover. I recommend the Kindle version, which I use on a tablet running Windows 11. It should work well in the (free) Kindle apps on iOS and Android too. Oddly, though, the Kindle edition is not supported on actual Kindle e-readers.

We will mainly cover **chapters 7-18** in C&O, supplemented by readings in professional astrophysics journals. The material in chapter 17 – black holes – is covered in ASTR 231.

Brad Carroll was a UR theoretical astrophysics postdoc long time ago, thereby becoming familiar with the scope and pace of our ASTR 200-level courses. That's one reason why the book is a great match for ASTR 241.

Required software: MATLAB **or** Mathematica. Both are site licensed and free for use by UR students in arts, science and engineering. Also recommended: python and its libraries `numpy` and `astropy`; **or** IDL and its library `astrolib`. Python is free and open source; IDL – expensive but much more powerful than python – is site licensed and free for use by UR students in physics and astronomy.

Web site: http://www.pas.rochester.edu/~dmw/astr241. Contains complete class-meeting presentations, homework assignments and solutions, and additional reference material which we will be using on homework and/or during class meetings.

Format: Oxford tutorial. Class meetings will be used principally for small-group discussion of the textbook readings and the homework problems, and for derivations and examples worked out by the whole class. I will provide summaries of the material in the textbook, additional material to illuminate the text, facilitation of the discussions, and a great deal of personal attention to each student, but will not deliver full-length lectures. The idea is to put students through as much practice and problem-solving as possible. The emphasis on student involvement has the obvious potential to make the course a much richer and more intensive experience than the standard lecture-recitation-examination format usually used in larger or less specialized courses. But it requires that **everyone** in class keeps up with the reading and homework.

Class meetings: The main meetings are Tuesdays and Thursdays, except 3/12/2024 and 3/14/2024), 1105-1220, in 407 B&L. One additional meeting per week, primarily for the facilitation of team homework

assignments (see below), takes place Fridays, except for 3/08/2024 and 3/15/2024, 1000-1050, also in 407 B&L.

Homework assignments: Twelve problem sets, to be assigned weekly during the semester. Problems will originate in part from the textbook, and in part from inspiration by the current and classic stellar-astrophysics professional literature. Normally the assignments will seem unusually long and/or challenging by the standards of math and physics homework. **Typically** each problem set will be assigned on a Tuesday, be due the following Tuesday, and be returned for error correction (see below) a couple days after submission.

Use of MATLAB or Mathematica for preparation of homework is required, as is the electronic submission of homework. All homework solutions, however mathematical or graphical, must include sufficient narrative, in the form of complete sentences and properly constructed paragraphs, to approach the style and detail of a journal paper.

Each student will be provided a personal folder on Box for homework submission, and for the return of graded work.

Solo and team homework: Most of the problems on each set will be designated as **solo problems**, on which students are required to work independently. The others, designated **team problems**, will be solved by groups of 2-3 students, working together, and hopefully contributing equally to the team's work. The team problems will generally be the more challenging ones. Solo problems will of course be written and submitted separately by each student; each team will turn in only one writeup of their solutions – also submitted via Box – and each team member will receive the same grade for this work.

Homework error correction: Normally, each Tuesday, a homework set is due. It will be returned via Box the following Thursday, with points deducted for errors, and with occasional comments and clues. Correct the errors and resubmit the homework set by the following Tuesday – a week after the original due date – and 50% of the originally-deducted points will be restored. This second chance to get it right applies both to solo and team homework assignments.

Examinations: none.

Extra help: Office hours are posted on the class website's front page. I'm also accessible whenever I can be found in B&L or on line; I make extra efforts to be electronically accessible late on nights before homework is due.

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 set is worth 8.33% (1/12) of the total score for the course. Final grades will be set by an absolute scale, rather than by a curve. In terms of the maximum possible percentage score, the grading scale will be as follows:

Percentage score	≥ 85	≥ 80	≥ 75	≥ 70	≥ 65	≥ 60	≥ 55	≥ 50	≥ 40	< 40
Final grade	A	A-	B+	B	B-	C+	C	C-	D	E

Last time I taught this class, shortly after the beginning of time (Spring 2005!), the average percentage score was 89.6, for an A.

Academic honesty disclaimers: You are free to collaborate in class, and in general on the setup of homework problems. However, all solutions to solo homework problems must be your own work, written solely by you. For our purposes, **cheating** consists of submission of homework or exam solutions that are

not your own work, or submission of solutions under someone else's name. According to University rules, any detected act of cheating that is not the result of a simple misunderstanding must be handed over to the Board on Academic Honesty for investigation.

You may **not** use any extra-UR academic-help services, including but not limited to Bartleby, Brainly, Chegg, Course Hero, and Slader. **Any** access to **any** of these sites counts as cheating, and thus is also an academic-honesty violation; it would be handed over for investigation by the Board on Academic Honesty.

Similarly, the sharing of our website's password-protected material – or the credentials for access to this material – with **anyone** outside the membership of the class is an academic-honesty violation; it would lead to investigation by the Board on Academic Honesty.

Statement of inclusion: The University of Rochester and I are committed to inclusion, and welcome to ASTR 241 students of all backgrounds and abilities. Services and reasonable accommodations are available to students with temporary and permanent disabilities, to students with DACA or undocumented status, to students facing mental health issues, other personal situations, and to students with other kinds of learning needs. Please feel free to let me know privately if there are circumstances affecting your ability to participate in class or your full participation in this course. Any such information will be held in strict confidence. Some resources which might be helpful include the Office of Undocumented/DACA Student Support, and the University of Rochester CARE network.

Disability resources: If you encounter any barrier(s) to full participation in this course due to the impact of a disability, please also contact the Office of Disability Resources. The access coordinators in the Office of Disability Resources can meet with you to discuss the barriers that you are experiencing and explain the eligibility process for establishing academic accommodations. You can reach the Office of Disability Resources at disability@rochester.edu or (585) 276-5075.

Mental health services: Managing your mental and physical health while keeping up with all the academic responsibilities may be an overwhelming challenge. The University offers support services in a variety of areas and has adapted to supporting students both in-person and online. I encourage each of you to review the services offered by the University, and to reach out to me should you find yourself struggling. You can find a list of services, with descriptions, here.

