Stars

PHSC 12700 / ASTR 12700

Fall 2019 at UChicago
Lectures M/W/F 10:30-11:20am; Kent 120
Labs as scheduled with the registrar.

Prof. Daniel Fabrycky (fabrycky@uchicago.edu,
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Website: https://canvas.uchicago.edu/courses/24170

Elements such as carbon and oxygen are created in fusion reactions at high temperatures and pressures in the deep interiors of stars, conditions that naturally arise in stars like the Sun. This course will outline the physical principles at work and the history of the development of the key ideas: how nuclear physics and the theory of stellar interiors account for how stars shine, why they live for such long times, and how the heavy elements in their cores are dispersed to form a new generation of stars. Gravity assembles stars out of more diffuse material, a process that includes the formation of planetary systems. The course shows how, taken together, these physical processes naturally lead to the ingredients necessary for the emergence of life, namely elements like carbon, nitrogen, and oxygen, and planets in stable orbits around long-lived stars. The course features quantitative analysis of data; any tools needed beyond pre-calculus algebra will be taught as part of the course.

Required Text: Searching for the Oldest Stars, by Anna Frebel.
ISBN 976-0-691-16506-6 available in the Bookstore and Seminary Co-op

TAs:
Abby Lee abbyl@uchicago.edu
Jazmine Jefferson jjefferson1111@uchicago.edu
Andrew Neil aneil@uchicago.edu
See also Lab Syllabus by: Brent Barker, teaching support manager for labs

Office hours: ERC 576, Thursday 3:30-5:00pm (Andrew, Abby, & Jazmine),
ERC 539, Tuesdays 2pm-3pm (Prof Fabrycky)

Goals – as in the course catalog:
1. To instill the confidence to be a life-long learner in areas involving numbers, scientific concepts, and technology;
2. To develop an ability to evaluate strengths and weaknesses of arguments based on the use of data, technical claims, and scientific theories;
3. To gain an understanding of the intellectual beauty of the subject, that is, understanding why some people devote their lives to the field;
4. To master at least one area in real depth.

Lecture / Reading / Exam Schedule (powerpoints available at canvas.uchicago.edu)
Week 1: (1) overview, astronomical objects, **(2)** stars in the Milky Way (Reading: chapters 1 and 6.1-6.3)
Week 2: (3) distance and motion of stars within the Milky Way, **(4)** physics that powers sunlight, pp-chain, **(5)** confirming the idea: neutrinos - **HW 1 due** (Reading: Bahcall article, and ch. 2)
Week 3: (6) photons from the Sun's surface, **(7)** stellar spectral types, **(8)** organization into the Hertzsprung-Russell diagram - **HW 2 due** (Reading: chapters 2.3, 7.1-7.2, 4.1)
Week 4: (9) physics powering other stars, CNO cycle, **(10)** fusing helium to carbon, and on up to iron. (Reading: chapter 3) **(11)** stellar structure - **HW 3 due** (Reading: chapter 3, 4.3, 4.4)
Week 5: **(12)** stellar evolution, **(13)** supernovae (chapter 4.5),
November 1: MIDTERM in class, 10:30-11:20am.
Week 6: (14) Neutron Stars, White Dwarfs, Telescopes (catch-up with all of chapter 3)
(15) Binaries and Stellar collisions **(16)** Heavy-Element Nucleosynthesis, slowly and rapidly - **HW 4 due** (Reading: ch. 4.6-5.2)
Week 7: (17) Metal-poor stars, differential enrichment **(18)** Cosmochronometry **(19)** Universe at Low Metallicity, first stars & planets - **HW 5 due** (chapter 4.6, 5.3, 7.2-7.3, 9.2-9.4)
Week 8: **(20)** Formation of stars **(21)** Star formation and Disk stage (Reading: section 6.4-6.5, 4.2, 9.1, handout from Schulz); **(22)** Stellar cluster dynamics - **HW 6 due**
Week 9: (23) Variable stars, **(24)** Stellar activity: winds and magnetism (Read: web articles linked in ppt), **Friday** class off for Thanksgiving holiday.
Week 10: (25) Stellar rotation, **(review)** Final review - **HW 7 due Wednesday**.
Friday, Dec 13: 10:30am-12:30pm, Kent 120, FINAL exam.

Assignments: except where noted above, due Friday 5 PM, to a box on the 5th floor of ERC. (They can also be turned in at the morning lecture on Friday.)

Policy on Group Work – Group work on the assignments and labs is encouraged. Collaboration is sharing of ideas, as you teach one another. Each person must use their own words in each submission, and give credit to those who collaborated on the work. Only *data* (e.g., spreadsheets of numbers) may be shared electronically, and it may only be passed among collaborators who were active in data collection. Phrases that appear on multiple students' work will result in no credit and proportional disciplinary action.

Grades – The assignments (7 total) are worth 40% of the grade. The labs are worth 30% - see rubrics. Late material will be graded for half as much credit, if it is turned in within one week of the due date. The lowest assignment or lab score will be factored out of the grade. The exams are an in-class midterm (10%) and a 2-hour final (20%).

Attendance – Please mark your attendance as you enter lecture. If you miss a lecture, please get any related material from the website and follow up with your TA about the key points.