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

TAs:  
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Office hours: Thursday 3pm-4pm  
location Eckhardt Research Center (ERC) room 576  
by appointment: Prof Fabrycky, 5640 S. Ellis Ave., ERC 539

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 chalk.uchicago.edu)  
Week 1: (1) overview, astronomical objects, (2) stars in the Milky Way, (3) distance and motion of stars within the Milky Way. (Reading: chapters 1 and 6.1-6.3)  
Week 2: (4) physics that powers sunlight, pp-chain, (5) confirming the idea: neutrinos, (6) photons from the Sun’s surface. (Reading: Bahcall article, and chapter 2)  
Week 3: (7) stellar spectral types, (8) organization into the Hertzsprung-Russell diagram, (9) stellar structure. (Reading: chapters 2.3, 7.1-7.2, 4.1)
Week 4: (10) physics powering other stars, CNO cycle, (11) fusing helium to carbon, and on up to iron. (Reading: chapter 3) (12) stellar evolution. (Reading: chapter 4.3, 4.4) Week 5: (13) basics of telescopes, supernovae (review) Midterm review.

November: MIDTERM in class, 10:30-11:20.

Week 6: (14) Neutron Stars, White Dwarfs, and Binaries, (15) Stellar collisions (16) Heavy-Element Nucleosynthesis, slowly and rapidly. (Reading: ch. 3.1-3.3, 4.5, 5)

Week 7: (17) Metal-poor stars, differential enrichment (18) Cosmochronometry (19) Universe at Low Metallicity, first stars & planets (chapter 4.6, 5.3, 7.2-7.3, 9.2-9.4)

Week 8: (20) Star formation and Disk stage (Reading: section 6.4-6.5, 4.2, 9.1, handout from Schulz); Friday class off for Thanksgiving holiday

Week 9: (22) Stellar cluster dynamics, (23) Variable stars, (24) Stellar activity: winds and magnetism. (Read: web articles linked in ppt)

Week 10: (25) Stellar rotation, (review) Final review.

Monday, December 10: FINAL – 2 hours. 10:30am-12:30pm, Hinds 101

Assignments: due 5 PM Friday. Turn them in to your TA’s mailbox on the 5th floor of Eckhardt Research Center (5640 S. Ellis Ave.)

Policy on Group Work – Group work on the assignments and labs is encouraged, but each person must submit a complete report in their own words, and the report must say who else collaborated on the work.

Grades – The assignments (8 total) are worth 40% of the grade; the lab participation and reports are 30%; the tests are an in-class midterm (10%) and a 2-hour final (20%). Late assignments and reports get 10% off per day, rounded up.

Attendance – Important! If you miss a lecture, please get any related material from the website and follow up with your TA about the key points. Lab attendance is mandatory.

Laboratory –
At your assigned lab time, starting week 2, report to KPTC 312.
L01 Mon 3:00-4:50 pm TA: Meng-Xiang
L02 Mon 5:30-7:20 pm TA: Mandy
L03 Tue 11:00a-12:50p TA: Cory
L04 Tue 6:30-8:20 pm TA: Mandy
L05 Thu 1:30-3:20 pm TA: Meng-Xiang
L08 Thu 6:30-8:20 pm TA: Cory

Your TA will teach you the material and guide you through the lab. The lab instructions will be available on the webpage (Canvas) ahead of time to introduce you to the ideas.

Week Days Name
2 Oct. 8, 9, 11 Intro to Measurement
3 Oct. 15, 16, 18 Spectroscopy (emission lines)
4 Oct. 22, 23, 25 HR Diagram
5 Oct. 29, 31, Nov. 1 Binary Orbit / 61 Cyg AB
6 Nov. 5, 7, 8 Radioactivity Part 1 (Intro, Shielding)
7 Nov. 12, 14, 15 Radioactivity Part 2 (Half-Life)