Astrophysics I: Stars and Stellar Evolution

AST 4001

Alexander Heger[1,2,3]

[1]School of Physics and Astronomy
University of Minnesota

[2]Theoretical Astrophysics Group, T-6
Los Alamos National Laboratory

[3]Department of Astronomy and Astrophysics
University of California at Santa Cruz

Stars and Stellar Evolution, Fall 2008

Agenda

1. Welcome
   - Overview
   - Course Administration
   - Topics
   - Build Your Own Star
2. Introduction
   - About You

Overview

Target Audience and Class Content

- This is a survey course on the astrophysics of stars, stellar evolution, and stellar populations. The students will learn about the formation, evolution, and deaths of stars, their interiors and observable atmospheres, their formation environments, remnants, and classifications. They will learn about the origin of the elements and their synthesis in stars, chemical evolution, stellar populations in the Milky Way, and the galactic distribution of stars. Both observational and theoretical perspectives will be included.
- The course will show how the know physics principles, in conjunction with astronomical observations, can be used to extract information about the structure and evolution of stars.

Textbook

- **Diana Prialnik:**
  An Introduction to the Theory of Stellar Structure and Evolution,
  Cambridge University Press, Paperback, 2000,
  2007 reprint: ISBN 978-0-521-65937-6

Course requirements

- **2 mid-term quiz** (Oct 2, Nov 6; drop one) (25%)
- **1 final** (December 13) (25%)
- **6 homework problems**
  due every second Tuesday **before class** starting September 23. (25%)
- **stellar evolution project**
  different problems/projects, usually due along with homework assignments. (25%)

Contact

- **Location & Dates:**
  Physics 236A, MTWTh 10:10-11:00 AM
- **Office hours:**
  Wednesdays, 13:00-14:30, 342F Tate
- **email:**
  I cannot guarantee that I will receive all emails due to SPAM filters, or answer them in time.
  I will try to reply to email within 24 h, on class days.
- **Web site:**
  `http://stellarevolution.org/AST-4001`
  I will post updates, problem sets, etc.
- **Google course calendar** (on Web site):
  `o86pe6r5paic30h4qv6acm9ej0%40group.calendar.google.com`

Topics

1. General introduction to astrophysical quantities
2. Observational determination of basic stellar properties
   - Solar data
   - Magnitudes, distances, parallaxes of stars
   - Stellar luminosities, colors, temperatures
   - Line spectra, spectral types
   - Color-magnitude diagrams, clusters, ages
   - Chemical composition

Topics (continued)

3. Stellar Interiors and Evolution
   - Equations of stellar structure
   - Physics of stellar interior, equation of state
   - Degenerate stellar configurations
   - Stability, energy transport, and mixing
   - Thermonuclear burning and nuclear reaction rates
   - Phases of stellar evolution

Topics (continued)

4. Final stages of stellar evolution
   - red giants
   - asymptotic giant branch (AGB) stars
   - red supergiants
   - supernovae
   - gamma-ray bursts
5. Stellar remnants
   - white dwarfs
   - neutron stars
   - black holes

Topics (continued)

6. Stellar Atmospheres
   - Radiative transfer, equilibrium conditions, absorption coefficient
   - Structure of a stellar atmosphere and formation of spectral lines
7. Beyond stars
   - Circumstellar matter
   - Stellar populations and Galactic structure
   - The first stars in the universe
   - Galactochemical evolution

Topics (continued)

8. Advanced Topics of Stellar Evolution
   - Circumstellar matter
   - Formation of stars
   - Stellar rotation
   - Stability
   - Binary star evolution
   - Supernovae and Explosive Nucleosynthesis
   - Recycled stars:
     - Novae
     - X-ray bursts
     - Pulsars
     - Micro-quasars
     - X-ray binaries
     - Soft gamma-ray repeaters

Stellar Evolution Project

- Bill Paxton's **EZ Stellar Evolution** code
  `http://www.kitp.ucsb.edu/~paxton/EZ-intro.html`
- Uses Linux `gfortran`
- g95 FORTRAN compiler can be downloaded for most platforms.
  `http://www.g95.org`

Overview

Who Are You?

You are the stars of this class.

Please let me know who you are!

Quick writeup:

- Why are you in this class?
- What do you expect from this class?

(not graded)

Hand in at end of class or during office hours (most welcome).
Please include your name.