Stellar Astrophysics

ASTRON 325/425

Vicky Kalogera

The physical conditions in stellar interiors will be discussed and the evolution of stars from the stellar nursery in star forming regions to the stellar graveyard of white dwarfs, neutron stars and black holes will be presented. Emphasis will be given on the physical processes of energy generation and transport in stars as well as the evolution of single and binary stars.

Location and Hours: Dearborn 23 — MW 2:00-3:20 PM

Textbook:

Stellar Interiors: Physical Principles, Structure, and Evolution
Hansen & Kawaler
Springer (ISBN 0-387-94138-X)

Course activities:

- Set of homeworks (6) due approximately every Monday
  > some of the problems will be optional for undergraduate students (extra credit)
  > homeworks will be due at the beginning of Monday's lectures and most often solutions will be given at that lecture
  > late homeworks will not be accepted once solutions are distributed
- Test #1 tentatively on April 30 during class time.
- Test #2 tentatively a take-home exam distributed on May 28

Grading: Homeworks (40%), Test 1 (30%), Test 2 (30%)

Office Hour: Thu 3:45 – 4:45 PM
Course Web Site:
http://www.astro.northwestern.edu/Vicky/
Click on <Teaching> and follow links
E-mail Contact: vicky@northwestern.edu
Office and Phone: Tech F317 and 1-5669

Course Outline

Lecture 1 (March 29):
Stars: general introduction - H-R Diagram - Magnitudes and Colors

Lecture 2 (March 31):
Dynamical Timescale - Hydrostatic Equilibrium - Virial Theorem - Total Stellar Energy - Thermal Timescale - Temperature Estimates

Lecture 3 (April 5):
Mean Molecular Weights - Energy Generation and Transport - Dimensional Analysis and Stellar Scaling Laws - (Model of Constant Density) - Nuclear Time Scale

Lecture 4 (April 7):
Equations of State (Non-Degenerate): - Distribution Functions - Chemical Potentials - Chemical Equilibrium - Blackbody Radiation - Ideal Monatomic Gas - Ionization Equilibrium and Saha Equations - Adiabatic Exponents

Lecture 5 (April 12):
Radiation Transport: - Intro - Specific Intensity and Higher-order Moments - Transfer Equation

Lecture 6 (April 14):
Radiation Transport: Optical Depth - Solutions of the Transfer Equation - Stellar Interiors - Diffusion Approximation

Lecture 7 (April 19):
Radiation Transport: Diffusion Equation - Stellar Atmospheres - Eddington factors

Lecture 8 (April 21):
Opacity sources: - Intro - Electron Scattering - Free-Free Absorption - Bound-Free and Bound-Bound opacities - Electron Conduction - Convection

Lecture 9 (April 26):
Nuclear Energy Generation: Nuclear Energetics - Cross Sections and Reaction Rates - p-p Chains and CNO Cycle - Heavier Element Burning

Lecture 10 (May 3):
Stellar Models: Basic Equations - Polytropic Models

Lecture 11 (May 5):
Stellar Models: Eddington Standard Model - Evolution: Pre-MS Evolution - Fully Convective Stars and the Hayashi Track

Lecture 12 (May 10):
Pre-MS Evolution: Post-Hayashi Track - Main Sequence: Min and Max Mass, Radial Expansion - Low-, Intermediate-, and High-Mass Stars

Lecture 13 (May 12):
Off-MS Evolution: Chandrasekhar-Schonberg limit - H-shell burning - Hertzsprung gap - Red Giant Branch - He-Flash

Lecture 14 (May 17):
Off-MS Evolution: Horizontal Branch - AGB Evolution - Planetary Nebulae - Onion-Skin Model - Supernovae - Degenerate Matter

Lecture 15 (May 19):
Degenerate Matter: White Dwarfs and Neutron Stars

Lecture 16 (May 24):
Binary Stars - Roche Potential - Mass Transfer - Solar Neutrino Problem

Lecture 17 (May 26):
Star-Formation Topics