Phy 151 – Stellar Structure and Evolution FALL 2011

INSTRUCTOR: Prof. Pat Boeshaar boeshaar@physics.ucdavis.edu
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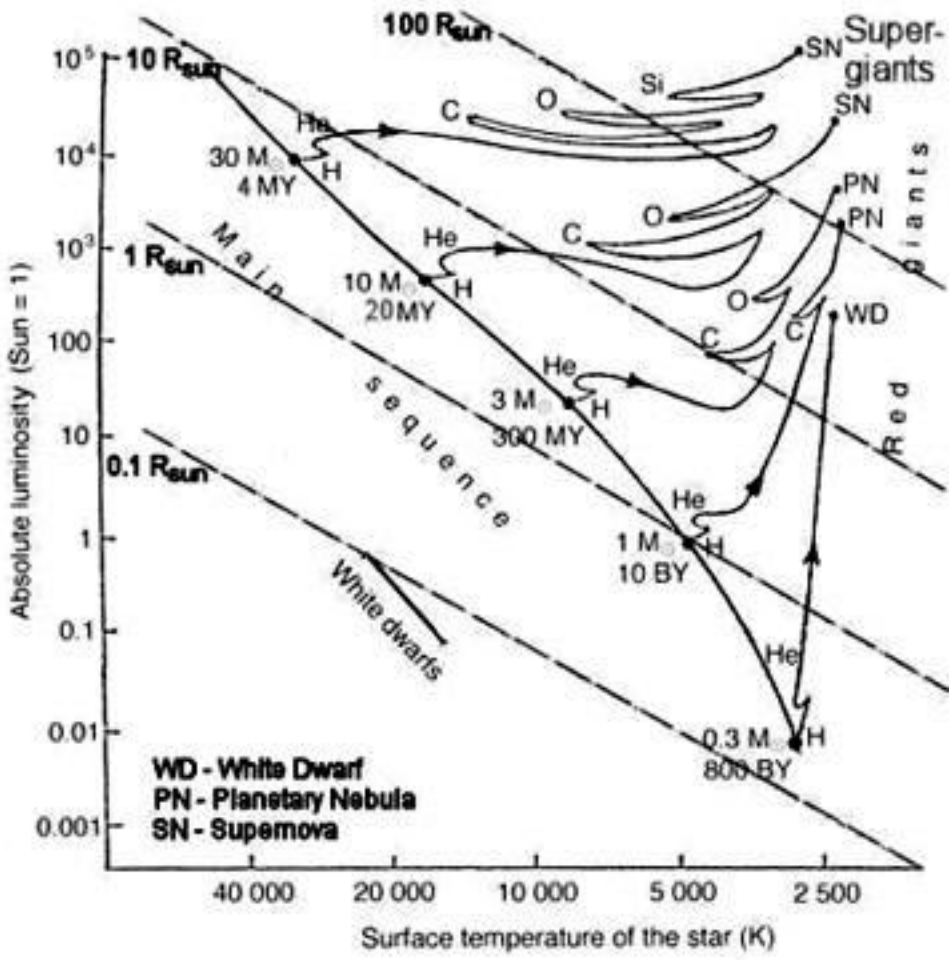
OFFICE HOURS: 12:30 p.m. – 1:30 p.m. MTW or by appointment

TEXT: ***An Introduction to Modern Astrophysics*** (2nd Edition) by Bradley W. Carroll & Dale A. Ostlie
ISBN: 0-8053-0402-9

PLUS: additional handouts accompanied by my notes posted on Smartsite before the class to supplement the basic material in the text. **Bring these to class!**

GRADES: Homework – 30%
Midterm - 20%
Wiki & Presentation – 25%
Final Exam – 25%



Stellar Evolutionary Tracks in a Hertzsprung-Russell Diagram

COMMENT: **Do not be intimidated by all of the equations in the text. There will be less emphasis on the mathematics as we will be explaining the physical processes by which stars evolve in this class: from the observational as well as the theoretical viewpoints, along with all related uncertainties. We will not be covering all details of the chapters or sections listed. Understanding the material in the Physics 9 sequence is the only prerequisite for this course.**

Text Sections

TOPICS:

A. Observational Motivation

1) **Determination of Stellar Observational Parameters That Are Necessary for Theoretical Modeling** Chapter 3, 5, 7

Mass – Binary Star Systems
Astrometric, Eclipsing, Spectroscopic
Radius – Lunar Occultations & Stellar Interferometry
Surface Temperature – Effective, Color, Ionization, Excitation
Photometric Systems – fluxes vs. magnitudes
Distance – Parallaxes
Luminosity – Need Effective Temperature and Size

2) **Stellar Spectroscopy – Atomic & Molecular Line Depths & Shapes** Chapter 5, 8.1, 9.5

Temperature and Luminosity Effects Fig. 11.3
Chemical Composition
Also:
Pressure Broadening – Gravitational Effects
Zeeman Effect – Magnetic Fields
Rotational Broadening
Doppler Broadening

3) **Hertzsprung-Russell (H-R) Diagrams** Chapter 8.2, 13.3

Solar Neighborhood
Stellar Clusters – Associations, Galactic, Globular
Stellar Populations vs. Metallicity (chemical abundance)
Evidence for Stellar Evolution
Role of Mass and Chemical Composition
Positions of Different Types of Stars in Cluster HR Diagrams

B. Overview of Stellar Structure

1) **Equations of Stellar Structure** Chapter 2.4, 10..1, 10.2, 10.4, 10.5
See p. 330 for summary

Boundary Conditions – hydrostatic equilibrium, spherical symmetry, etc.
Virial Theorem
Russell-Vogt Theorem

2) **Types of Models** Chapter 10.5, 10.6

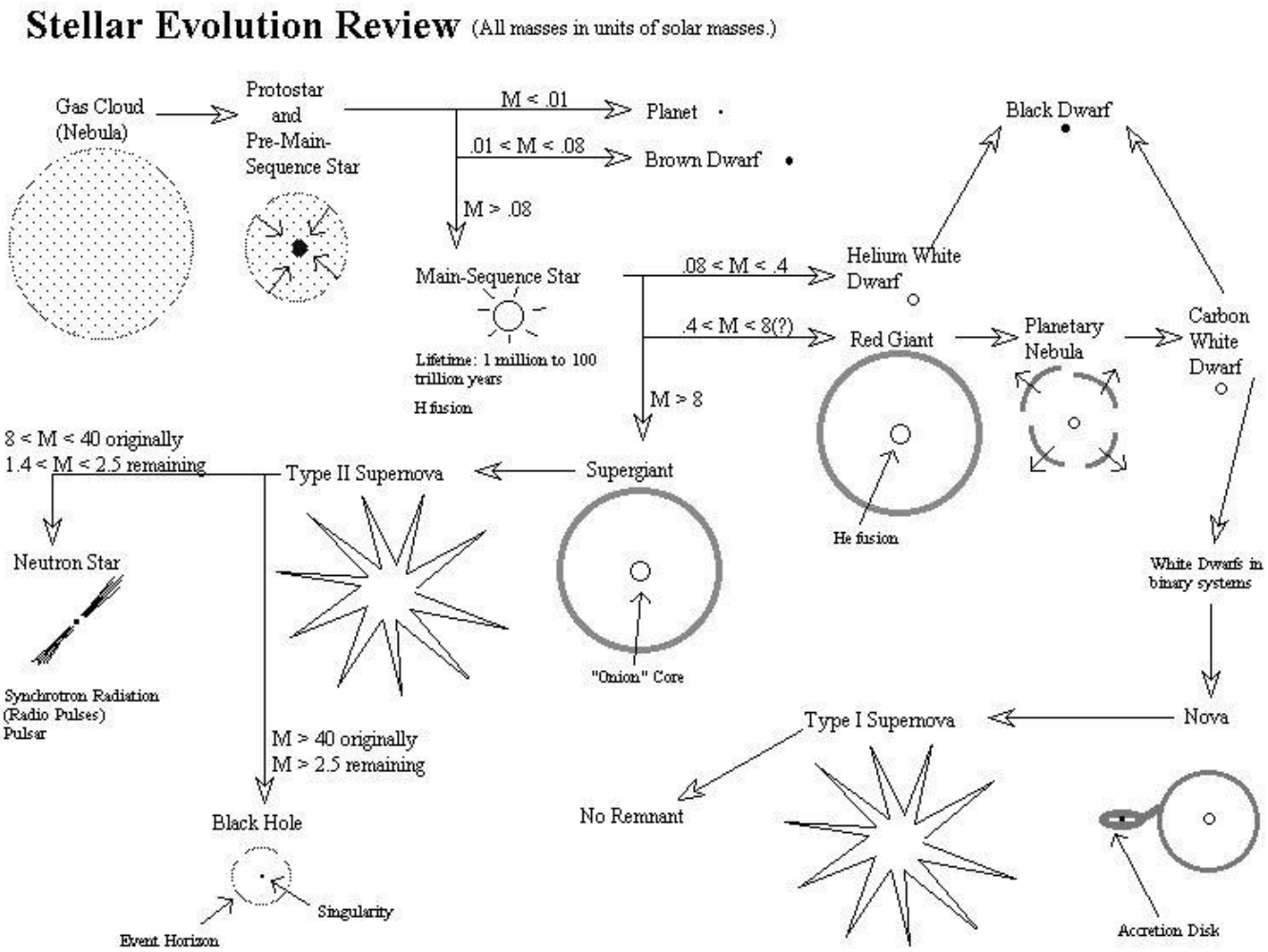
Equation of State - Polytropes

3) **Energy Sources** Chapter 10.3, 10.4

Review – Nuclear Energy Generation
Hydrogen Fusion Reactions, Neutrino Physics
Nuclear Reaction Rates – Dependence on Temperature
Energy Transfer – The Role of Convection (See Fig 11.2)
Limits on Stellar Mass – approx. 100 to 0.07 M_o

4) **Theoretical H-R Diagram** Chapter 12, 13.1, 13.2, 14.1, 15.1

Zero Age Main Sequence
Pre-Main Sequence Hayashi Tracks
Time Scales – Low vs. High Mass Stars
Post Main Sequence Evolution as a Function of Mass
Chemical Evolution
r and s processes (p. 542)
Instability Strip



5.) **Stellar Endpoints** Chapter 15.2, 15.3, 16, 17.3

The Role of Degeneracy
Brown Dwarfs → Black Dwarfs p. 428
Planetary Nebulae → White Dwarfs
Type II Supernovae → Neutron Stars & Black Holes

6) **Dynamics of Close Binary Systems (if time remains)** Chapter 18.4, 18.5

Novae and Type Ia Supernovae

Student Presentations: Last class of the term – Group presentations based on a Wiki using scientific articles which may be supplemented by other sources. Students will choose among topics ranging from Star & Solar System Formation Scenarios through the Observable Evidence for Stellar Mass Black Holes. The emphasis will be on critiquing the observational data. Students will be evaluated based on organization, information content, and clarity of their Wiki presentations.

Final Exam: Monday, December 5 at 3:30 – 5:30 p.m.

Additional Useful References:

Stellar Evolution by Amos Harpaz
(A K Peters, 1994)
The Physical Universe: An Introduction to Astronomy by.Frank H. Shu
(University Science Books 1982)
Introduction to Stellar Astrophysics by Erika Bohm-Vitense
Volume 1 - Basic Stellar Observations and Data
Volume 3 – Stellar Structure and Evolution
(Cambridge, 1989)
Astrophysics in a Nutshell by Dan Maoz (Princeton University Press, 2007)

Also: from the Open University in Britain:

An Introduction to the Sun and Stars by Simon F. Green and Mark H. Jones
(Cambridge 2003, 2004)
Stellar Evolution and Nucleosynthesis by Sean G. Ryan and Andrew J. Norton
(Cambridge 2010)