Astronomy 310
Fall 2001

Final Review

The final Exam (**5:05 PM Sunday, 16 Dec in 2327 Sterling**) will be 2 hours long, closed notes. It will be weighted 1/4 each on Stellar Data and Stellar Spectra and 1/2 on Stellar Interiors and Evolution. For the first two sections, review especially the previous exams and problem sets. For Interiors and Evolution, emphasize qualitative understanding of physics, with simple estimations based on scaling.

Observations

- Magnitudes and distances and how to calculate with them
- Spectral Types
- Stellar Masses from visual and spectroscopic binaries

Atmospheres

- Thermodynamic equilibrium distributions
- Radiation transfer and different intensity moments
- Limb darkening, grey atmospheres, $T(\tau)$, Eddington-Barbier relation
- Opacity Mechanisms and the atomic physics behind them
- How the continuous opacity affects the shape of a spectrum
- Line Formation: depth, profile, what determines line strength

Interiors

- Equations of stellar structure: memorize and understand physical basis
- The virial theorem; dynamical (hydrostatic) and thermal timescales
- Convection: stability criterion; adiabatic temperature gradient
- Ideal Gas equation of state; mean molecular weight; X, Y, and Z
- Degenerate equation of state: non-relativistic and relativistic degeneracy
- Nuclear Energy Generation: energy available ($E=\Delta mc^2$); coulomb barrier; tunneling; "Gamov peak"; proton-proton chain (memorize); CNO cycle, triple-α; energy generation rates
- Opacity: Kramer's opacity, electron scattering
- Main Sequence: Mass-Luminosity relation, lifetimes; $T_c(M_*)$, $\rho_c(M_*)$; energy generation and convective regions as function of mass
- Post-Main Sequence Evolution: know the evolutionary history of a 1 $M_\odot$ and a 5 $M_\odot$ star in some detail, including evolution of composition, sites of energy generation, convection. Understand Herztsprung Gap, Hayashi track, Helium Flash, the Horizontal and Asymptotic Giant Branches; the Fe Catastrophe and Type II supernovae
- White Dwarfs and Neutron Stars: Mass-radius relation, Chandrasekhar Limit, white dwarf cooling track in H-R diagram
- Nucleosynthesis: equilibrium abundances from energy generation processes. Generally which elements are produced and in which stars for r- and s-processes.

Formula Sheet

Speed of light	$c=3\text{x}10^{10}$ cm/s
Gravitation constant	$G=6.7\text{x}10^{-8}$ dyn cm^2/gm^2
Boltzmann constant	$k=1.4\text{x}10^{-16}$ erg/deg
Stefan-Boltzmann constant	$\sigma=5.7\text{x}10^{-5}$ ergs/cm^2 deg^4 s
Electron Mass	$m_e=9.1\times10^{-28}$ gm
Hydrogen Mass	$m_H=1.7\times10^{-24}$ gm
Solar Mass	$M_\odot=2\times10^{33}$ gm
Solar Radius	$R_\odot=7\times10^{10}$ cm
Astronomical Unit	1 AU$=1.5\times10^{13}$ cm
Parsec	1 pc$=3.1\times10^{18}$ cm

For small θ in arcsec, $\tan\theta = \sin\theta = \theta/206625$

$L = 4\pi R^2\, \sigma T_{\text{eff}}^4$

$m - M = 5 \log D(\text{pc}) - 5$

$(M_1 + M_2)/M_\odot = a^3(\text{AU})/P^2(\text{yr})$

$K_1 = 2\pi a_1 \sin i/\ P(1-e^2)^{1/2}$

$= 30\ \text{km/sec}\ a_1(\text{AU}) \sin i/P(\text{yr})\ (1-e^2)^{1/2}$

$B_\lambda = 2hc^2/\lambda^5\ 1/(\exp(hc/\lambda kT) - 1)$

$\Delta\lambda/\lambda = v/c$

$N_n/N_m = g_n/g_m \exp-(\Delta E_{1n} - \Delta E_{1m})/kT$

$N^i N_e/N^{i-1} = (2\pi m_e kT/h^3)^{3/2}\ 2\ u_i/u_{i-1} \exp(-\chi_{\text{ion}}/kT)$

$d\tau_\lambda = \kappa_\lambda\, ds$

$v_{th} = (2kT/\mu m_H)^{1/2}$

$F_\lambda(0) \sim \pi B_\lambda(\tau_\lambda = 2/3)$

$T(\tau)^4 = 3/4\ T_{\text{eff}}^4\ (\tau + 2/3)$

$g_n(\text{Hyd}) = 2n^2$

$R_\lambda = (F_c - F_\lambda)/F_c$

$W_\lambda = \int R_\lambda\, d\lambda$

$\mu = 1/(2X + 3/4\ Y + 1/2\ Z)$

$\kappa(\text{Atomic}) \sim \rho\ T^{-3.5}$

$\epsilon \sim \rho\ T^\nu$, (PP: ~4; CNO: ν~20; 3α: ν~30)

$M_e = 1.4\ M_\odot/(\mu_e/2)^2$