Astrophysics. Final Exam Review

- See Exam I review for Ch 1-4 material.
- Expect table of constants as on Exam I.
- Look over the boldface terms in texbook, especially Ch.24.
- Look over notes on the presentations - I'll invent questions that don't favor any one person.

Chapter 5 Interaction of Light and Matter

- Kirchoff's Laws: a description of how continuous, absorption line, and emission line spectra can form.
- Redshift, $z = \frac{\Delta\lambda}{\lambda_0}$
  where λ_0 is the rest wavelength.
- Recession speed, non-relativistic: $v_r = cz$
  where c is the speed of light
- Recession speed, relativistic:

$$\frac{v_r}{c} = \frac{(z+1)^2 - 1}{(z+1)^2 + 1} \qquad \text{which comes from} \qquad z = \sqrt{\frac{1 + v_r/c}{1 - v_r/c}} - 1$$

- Speed of star: $v = \sqrt{v_r^2 + v_\theta^2}$ where v_r is the radial velocity and v_θ is the tangential velocity or *proper motion*.
- $E_{photon} = h\nu = \frac{hc}{\lambda}$
- Photoelectric Effect
  - Work function $= \phi =$ the minimum binding energy of an electron in a metal.
  - Maximum KE of ejected electron: $K_{max} = \frac{hc}{\lambda} - \phi$
- Compton Effect
  - Change in wavelength of scattered photon: $\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$
  - Compton wavelength, $\lambda_C = \frac{h}{m_e c} = 0.0243\mathring{A}$

- Bohr Model
  - Rydberg formula for wavelengths of H: $\frac{1}{\lambda} = R_H(\frac{1}{m^2} - \frac{1}{n^2})$ where $m < n$, and m and n represent energy levels.
  - $R_H = 1.09677.585 \times 10^5$ cm^{-1}
  - Bohr's orbital angular momentum: $L = n\hbar = \mu v r$
  - Bohr's orbital radii: $r_n = a_0 n^2$ where $a_0 = 0.529\mathring{A}$
  - Bohr's energy levels: $E_n = -13.6\text{eV}\frac{1}{n^2}$
  - Energy of photon released: $E_{phot} = \frac{hc}{\lambda} = -13.6\text{eV}(\frac{1}{n_{high}^2} - \frac{1}{n_{low}^2})$
- de Broglie wavelength for matter particles: $\lambda = \frac{h}{p}$
- quantum numbers for electron orbits: n, l, m_l, m_s
- orbital angular momentum: $L = \sqrt{l(l+1)}\hbar$ where $l = 0, 1, 2, ..., (n-1)$
- z-component of orbital angular momentum: $L_z = m_l\hbar$ where $m_l = 0, \pm 1, \pm 2, ... \pm l$
- Spin quantum number: $S_z = m_s\hbar$ with $m_s = \pm 1/2$.

Chapter 8 Spectal lines and stars

- Boltzmann Equation for relative populations of atomic states:

$$\frac{N_b}{N_a} = \frac{g_b}{g_a} e^{-(E_b - E_a)/kT}$$

- Partition function, Z, is a weighted sum of the number of ways an atom can arrange its electrons. Each j indexes a different energy level.

$$Z = g_1 + \sum_{j=2}^{\infty} g_j e^{-(E_j - E_1)/kT}$$

- Saha equation for relative numbers of atoms in different ionization stages.

$$\frac{N_{i+1}}{N_i} = \frac{2kTZ_{i+1}}{P_e Z_i} \left(\frac{2\pi m_e kT}{h^2}\right)^{3/2} e^{-\chi_i/kT}$$

- Radius of star from its effective temperature and luminosity:

$$R = \frac{1}{T_e^2}\sqrt{\frac{L}{4\pi\sigma}}$$

- Stellar Types: OBAFGKM(RNS) or (LT)
- Luminosity classes (from MK classification): Ia,Ib,II,III,IV,V,(wd)
- H-R Diagram (y-axis=L or M; x-axis=color, T, or spectral type)
- Physical star properties from spectra (T,R,rotation, B-field, etc.)

Chapter 24 Galactic Astronomy

- Stellar Mass-Luminosity relationship: $L \propto M^4$.
- Stellar lifetime: $\tau_L \sim \frac{M}{\dot{M}} \propto \frac{1}{M^3}$
- Distance to star from magnitudes: $d = 10^{(m-M+5)/5}$
- Distance to star including extinction: $d = 10^{(m-M+5-A)/5}$, where A is absorption measured in magnitudes.
- Absorption (or extinction): $A = kd$ with $k \sim 1$ mag/kpc.
- Optical depth, τ: $A_\lambda = 1.086\tau_\lambda$
- $n_M(M, S, \Omega, r)$ = number density of stars of absolute magnitude $M \pm 1/2$, of spectral type S, in some direction, in solid angle Ω, and at the distance r.
- $N_M(M, S, \Omega, d)dM = \int_0^d n_M(M, S, \Omega, r)\Omega r^2 dr$ = integrated star count of stars with type S, etc., out to a distance d.
- $\bar{N}_M(M, S, \Omega, m)dM = \int_0^{m_{max}} n_M(M, S, \Omega, m)\Omega 10^{2(m-M-a+5)/5} dm$ = integrated star count of stars with type S, etc., to a limiting magnitude m_{max}.
- $A_M(M, S, \Omega, m) = dN_M(M, S, \Omega, m)/dm$ = differential star count
- Special case: $n_M(M, S)$ = constant, and no extinction. Then,

$$\bar{N}_M(M, S, \Omega, m) = \frac{\Omega}{3} n_M(M, S) 10^{[3(m-M+5)/5]}$$

$$\text{and } A_M(M, S, \Omega, m) = \frac{3\ln 10}{5}\bar{N}_M(M, S, \Omega, m)$$

- Model for stellar density distribution in the Milky Way:

$$n(z,R) = n_0(e^{-z/z_{thin}} + 0.02e^{-z/z_{thick}})e^{-R/h_R}$$

- Mass enclosed within a circular orbit for a particle with circular speed V_c:

$$M_r = \frac{rV_c^2}{G}$$

- Circular velocity, $V_c = \sqrt{\frac{GM_r}{r}}$
- Mass enclosed from a spherically symmetric density distribution:

$$M_r = 4\pi \int_0^r \rho(r) r^2 dr$$

- Density from circular velocity profile:

$$\rho(r) = \frac{V^2(r)}{4\pi G r^2}$$

These are the equations that will be provided on the Final exam:

Selected Equations	
$P = \frac{<S>}{c}\cos\theta$	$P = \frac{2<S>}{c}\cos^2\theta$
$\Delta\lambda = \frac{h}{m_e c}(1-\cos\theta)$	$K_{max} = \frac{hc}{\lambda} - \phi$
$v_{space} = \sqrt{v_r^2 + v_\theta^2}$	$E_n = -13.6\text{eV}\frac{1}{n^2}$
$L = \mu\sqrt{GM_a(1-\epsilon^2)}$	$\frac{N_b}{N_a} = \frac{g_b}{g_a}e^{(-E_b-E_a)/kT}$
$\frac{N_{i+1}}{N_i} = \frac{2kTZ_{i+1}}{P_e Z_i}\left(\frac{2\pi m_e kT}{h^2}\right)^{3/2} e^{-\chi_i/kT}$	$R = \frac{1}{T_e^2}\sqrt{\frac{L}{4\pi\sigma}}$
$d = 10^{(m-M+5-a)/5}$	$N_M(M,S,\Omega,d) = \int_0^d n_M(M,S,\Omega,r)\Omega r^2 dr$
$\bar{N}_M(M,S,\Omega,m) = \frac{\Omega}{3}n_M(M,S)10^{[3(m-M+5)/5]}$	$M_r = 4\pi\int_0^r \rho(r)r^2 dr$
$< U >= -2 < K >$	$E_{tot} =< U > + < K >$