Astrophysics. Final Exam Review

See Exam I review for Ch 1-3 material.

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:

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

- 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: $E_{phot} = \frac{hc}{\lambda} = -13.6\text{eV}(\frac{1}{n^2_{high}} - \frac{1}{n^2_{low}})$

- de Broglie wavelength for matter particles: $\lambda = \frac{h}{p}$
- Heisenberg's uncertainty principle:
  - $\Delta x \Delta p \gtrsim \hbar$
  - $\Delta E \Delta t \gtrsim \hbar$
- Schrödinger's orbital angular momentum: $L = \sqrt{l(l+1)}\hbar$ where $l = 0, 1, 2, ..., (n-1)$
- Schrödinger's z-component of orbital angular momentum: (SKIP) $L_z = m_l \hbar$ where $m_l = 0, \pm1, \pm2, ... \pm l$
- Schrödinger's equation (3D, time-independent):

$$\frac{-\hbar^2}{2m}\nabla^2\psi + U(r,\theta,\phi)\psi(r,\theta,\phi) = E\psi(r,\theta,\phi)$$

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
- Physical star properties from spectra (T,R,rotation, B-field, etc.)

Chapter 7 Binary Systems

- Classification (eclipsing, astrometric, spectroscopic, etc.)
- Determining masses from.
- Mass ratios: $\frac{m_1}{m_2} = \frac{r_2}{r_1} = \frac{\alpha_2}{\alpha_1}$

Chapter 24 Galactic Astronomy

- Stellar Mass-Luminosity relationship: $L \propto M^{3.5}$.
- Stellar lifetime: $\tau_L \sim \frac{M}{\dot{M}} \propto \frac{1}{M^3}$
- Hertzsprung-Russell Diagram or "color-luminosity diagram" is a plot of star luminosity versus spectral type (or color or temperature).
- 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.
- $n_M(M, S, \Omega, r)$ = 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,

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

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

- 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:

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

- Look over the boldface terms, especially from sections discussed in class.

- Look over notes on the presentations - I'll invent questions that don't favor any one person.