Astrophysics. Exam I Review

Chapter 1

- Ancient civilizations and their understanding
- Celestial Sphere
- Coordinates systems
- Ptolemaic system (epicycle, deferent, etc)
- Heliocentric system
- Copernicus, Tycho, Kepler, Galileo, Newton
- Planetary configurations (opposition, etc)
- Precession (what is it, period, consequences)
- Proper motion, radial motion

Chapter 2

- Ellipses
- Kepler's Laws
- Newton's Laws
- Law of Universal Gravitation
- Coordinate conventions for 2-body problem
- Reduced mass: $\mu = \frac{m_1 m_2}{m_1+m_2}$
- Total energy in terms of reduced mass:

$$E_{tot} = \frac{1}{2}\mu v^2 - G\frac{M\mu}{r}$$

- Total orbital angular momentum

$$\vec{L}_{tot} = \mu \vec{r} \times \vec{v}$$

- Results from the derivation of Kepler's 2nd law

  1. $\frac{d\vec{L}}{dt} = 0$ (angular momentum is constant in 2-body problem)
  2. $\frac{dA}{dt} = \frac{L}{2\mu}$
  3. $L = \mu\sqrt{GMa(1-e^2)}$

- The total energy of a 2-body system is 1/2 of the time-average potential energy: $E_{tot} = \frac{1}{2}\langle U \rangle$

- Kepler's 3rd law (modified)

$$P^2 = \frac{4\pi^2}{G(m_1 + m_2)} a^3$$

- Virial Theorem: for a multi-body system in equilibrium, the time-averaged kinetic energy and potential energy are related by:

$$-2\langle K \rangle = \langle U \rangle$$

- Also, for both multi-body systems and 2-body systems, total energy is:

$$\langle E \rangle = \frac{1}{2}\langle U \rangle$$

Chapter 3

- Parallax and distance. $d(pc) = \frac{1}{p''}$ (for baseline = 1 AU)

- Specific intensity I_λ (or I_ν) in erg $s^{-1} cm^{-2}$ $\mathring{A}^{-1}$ sr^{-1}

- Flux (emergent or incident), $F = \frac{L}{4\pi r^2}$ in erg $s^{-1} cm^{-2}$

- Luminosity: total energy leaving an object in all directions over all wavelengths

- Monochromatic luminosity: $L_\lambda d\lambda$ = a luminosity only within the wavelength range λ to $\lambda + d\lambda$.

- Luminosity (blackbody) = $L = A\sigma T^4$.

- Luminosity (not quite perfect blackbody) = $L = \epsilon A\sigma T^4$.

- Magnitude System
  - 5 magnitudes difference correspondes to a flux ratio of 100X.
  - smaller numbers means brighter
  - apparent magnitude: $m = -2.5log_{10}\frac{F}{F_{ref}}$
  - absolute magnitude, M: the apparent magnitude of a star at the standard reference distance (10 pc = 32.6 ly).
  - absolute magnitude, $M = -2.5log_{10}\frac{L}{L_{ref}}$ (L_{ref} is about $80 \times L_{\odot}$.)
  - absolute magnitude is a measure of luminosity, apparent is a measure of brightness.
  - Example: $M_{\odot} = 4.76$, $m_{\odot} = -26.7$, $L_{\odot} = 3.826 \times 10^{33} ergs^{-1}$
  - Distance modulus, (m-M),: $(m - M) = 5log_{10}\frac{d}{10pc}$
  - Distance modulus: an alternative measure of distance that directly tells you how the brightness of the object differs from its brightness at 10 pc.
- Wave nature of light
  - Light has wave properties: interference pattern formed by double-slit
  - $c = \lambda\nu$
  - Time-averaged Poynting Vector: a measure of monochromatic flux
  - Time-averaged Poynting Vector: $\langle S\rangle = \frac{c}{8\pi}E_0B_0$
  - Radiation pressure is greater when light is completely reflected than when light is absorbed - transfer of momentum.
- Blackbody radiation
  - Blackbody: an ideal emitter and absorber.
  - Blackbody absorption: 100%
  - Blackbody emission: spectrum obeys Planck function, Wien's Law, and the Stefan-Boltmann Law.
  - Wien's Law: $\lambda_{max}T = 0.29cmK = 2.9 \times 10^7 AK$
  - Stefan-Boltzmann law: $F_{surf} = \sigma T^4$
  - Planck's Law: $B_\lambda(T) = \frac{2h\nu^2/\lambda^5}{e^{hc/\lambda kT} - 1}$