Midterm 2 Review Worksheet

Radiation and Stellar Atmospheres

1. At visible wavelengths the extinction (absorption + scattering) cross-section of the average interstellar dust grain is $\sigma_d = 6 \times 10^{-10}$ cm^2. Also, the ratio of the number densities of dust and gas in the ISM is $\left\langle \frac{n_d}{n_g} \right\rangle = 8 \times 10^{-13}$. The density of gas in the ISM (atomic hydrogen mostly) is ~ 1.0 cm^{-3}.

   (a) Write out the expression for the optical depth of the ISM at visible wavelengths given this information and a path length l.

   (b) What is l for $\tau = 1$?

   (c) The number density of gas in this room is about $n_g = 2 \times 10^{19}$ cm^{-3}. If the dust-to-gas ratio in this room were the same as in the ISM, what would l befor $\tau = 1$?

2. A slab of ionized hydrogen gas is placed 0.5 AU from the sun. The slab has a thickness $h = 1$ km and has a circular cross-sectional area with radius $b = 100$ km. The opacity κ is due to electron scattering. Recall that $\kappa_{es} = 0.2$ cm^2 g^{-1}.

   (a) How much energy per second does the slab of gas receive from the Sun?

   (b) What is the electron density if the flux of *scattered* light is 7.3×10^4 erg cm^{-2} s^{-1}? ($m_e = 9.11 \times 10^{-28}$ g and $m_H = 1.67 \times 10^{-24}$ g)

   (c) Assuming the gas in the slab is entirely ionized, what is the mass of the slab?

3. Using optical depth, explain why the Ring Nebula looks like a ring (it's a spherical shell of gas).

4. Now consider a star at the center of the Ring nebula. Assume the shell isn't moving. Do you see absorption or emission lines at the center? What about towards the edge? Draw the spectrum in each case.

5. Repeat the above but allow the shell to expand outwards with velocity V. What changes occur in the spectrum for the above cases?

Stellar Structure

1. What keeps a star from collapsing under its own weight? What equations describe this support?

2. Estimate the central temperature of the Sun.

3. In Astro 10 we teach the students that $L \sim M^3$ for solar-like main sequence stars and they have to take it on faith. You don't. Derive this.

4. How does the main sequence lifetime of stars scale with mass?

5. How does the lifetime of a 0.5 solar mass star compare to the Sun? A 5 solar mass star?

6. When I took a stellar structure class, the professor said, "Stars are perfect thermostats." What do you think he meant? What if a star gets too hot in the core? What if it gets too cold?

7. What would happen to a star if you somehow compressed it to half it's original radius?

8. Why is there a well-defined line of stars on an H-R diagram?

9. At a fixed temperature, which has a higher gas pressure: a gas of neutral hydrogen or a gas of ionized hydrogen?

10. Why does fusion only happen in the cores of stars?

11. Fill in the blanks:

    (a) ${}^{7}_{?}\mathrm{Be} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{8}_{5}\mathrm{B} + \gamma$

    (b) ${}^{15}_{8}\mathrm{O} \rightarrow {}^{15}_{7}\mathrm{N} + ? + \nu_e$

12. Why does CNO dominate over PP in massive stars?

13. Why doesn't helium fusion take place in main sequence stars?