Astronomy 421 – Problem set 4

Due Thursday, Oct 6

1. For some point P in space, show that for any arbitrary closed surface surrounding P, the integral over the solid angle about P gives:

$$\Omega_{\text{tot}} = \oint d\Omega \quad = 4\pi \text{ steradians}$$

2. Using the Rayleigh criterion, estimate the angular resolution limit of the human eye at 550 nm. Assume that the diameter of the pupil is 5mm.
3. Compare the answer in problem 2 to the angular diameters of the Moon and Jupiter (you can find data on the Moon and Jupiter in Appendix C of C&O). What can you conclude about the ability to resolve the Moon and Jupiter with the naked eye?
4. What would be the diameter of a single dish telescope with the equivalent collecting area as the 27 VLA antennas?
5. The two full LWA stations in New Mexico each have 256 dipoles. How many unique baselines does this provide for each station?
6. For a gas of neutral hydrogen atoms, at what temperature is the number of atoms in the first excited state only 1% of the number of atoms in the ground state? At what temperature is the number of atoms in the first excited state equal to 10% of the number of atoms in the ground state?
7. The blue-white star Fomalhaut ("the fish's mouth" in Arabic) is in the southern constellation of Pisces Austrinus. Fomalhaut has an apparent visual magnitude V = 1.19. Use the H-R diagram in Fig 8.16 to determine the distance to this star.
8. Find:
    a. An expression for n_λ dλ, the number density of blackbody photons (in photons/m^3) with a wavelength between λ and λ + dλ.
    b. The total number of photons inside a kitchen oven set at 400 F (477 K), assuming a volume of 0.5/m^3.
9. Calculate how far you could see through Earth's atmosphere if it had the opacity of the solar photosphere. Use the value for the Sun's opacity from Example 9.2.2 in C&O and 1.2 kg/m^3 for the density of the Earth's atmosphere.
10. Suppose ETs on a planet 10 pc from Earth use a 200 Megawatt transmitter to broadcast a signal at 21 cm with a 10 kHz bandwidth. What will be the flux density that we receive in Jy? How many Watts would be collected by a 100 m diameter antenna?