Astronomy 505: Homework #10 (Spectra)

1. **Carroll & Ostlie, Problem 9.25**:
Derive Eq. (9.60) for the uncertainty in the wavelength of a spectral line due to Heisenberg's uncertainty principle. (5 pts)

$$\Delta\lambda \approx \frac{\lambda^2}{2\pi c}\left(\frac{1}{\Delta t_i} + \frac{1}{\Delta t_f}\right)$$

where Δt_i is the lifetime of the electron in its initial state and Δt_f is the lifetime in its final state.

2. **Carroll & Ostlie, Problem 9.27**:
Pressure broadening (due to the presence of the electric fields of nearby ions) is unusually effective for the spectral lines of hydrogen. Using the general curve of growth for the Sun with these broad hydrogen absorption lines will result in an overestimate of the amount of hydrogen present. The following calculation nevertheless demonstrates just how abundant hydrogen is in the Sun.

   The two solar absorption lines given in Table 9.4 belong to the Paschen series, produced when an electron makes an upward transition from the $n = 3$ orbit of the hydrogen atom.

   (a) Using the general curve of growth for the Sun shown in Figure 9.22, repeat the procedure of Example 9.5.5 to find N_a, the number of absorbing hydrogen atoms per unit area (in cm^2) of the photosphere (those with electrons originally in the $n = 3$ orbit). (5 pts)

   (b) Use the Boltzmann and Saha equations to calculate the total number of hydrogen atoms above each square centimeter of the Sun's photosphere. (5 pts)

   (c) Calcuate the column density of hydrogen atoms, and compare your result with a measured value of 1.1 g cm^{-2}. (3 pts)

3. The absolute B magnitude of a K5 giant is 0.95.

   (a) What are the distinguishing features of the optical spectrum for this type of star? (5 pts)

   (b) Calculate the apparent magnitude for this star, at a distance of 20 A.U. from the Earth. Could it be seen with the naked eye? (3 pts)

   (c) Calculate the B-band flux density received by the Earth from this star, given that the zero-point B-band flux density is 4×10^{-20} ergs s^{-1} cm^{-2} Hz^{-1}. (5 pts)

   (d) How much total B-band flux would the Earth receive from this star, ignoring atmospheric effects, in ergs s^{-1}? (You may assume B-band extends from 3900Å to 4900Å.) (3 pts)

4. (a) You take a spectrum of the galaxy IC4198, which lies within 2 h^{-1} Mpc on the sky of the center of the Coma cluster, and find that the radial velocity is 8990 km s^{-1}. If the central velocity of the cluster is 6930 km s^{-1}, and the velocity dispersion of the cluster is 997 km s^{-1}, what is the probability that this galaxy is an actual member of the cluster? Express your answer both as a percentage and in units of σ, assuming a Gaussian distribution of velocities (i.e., $1\sigma = 997$ km s^{-1}). (5 pts)

   (b) What type of galaxy is IC4198? *This will require some online searching, at* http://ned.ipac.caltech.edu *or a similar site.* (3 pts)