C/P 740 Winter Quarter 2008
Dr. Herbst

HOMEWORK ASSIGNMENT # 2
Due: Tuesday, 22 January

1. Estimate the concentration ratio of dust particles to H atoms assuming the standard size for the particles. Then, assuming dust particles to have a density of 2.5 gm cm^{-3}, estimate the mass ratio of dust to gas. Assuming the dust particles to be composed of carbon, is the cosmic abundance of this element (C/H = 2 x 10^{-4}) sufficient to account for the dust-to-gas mass ratio?

2. Estimate how many atoms there are in a dust particle of standard size, and how many of these are on the surface of the particle. Use chemical ideas of bond length and remember that crude approximations are common in astronomy.

3. If the optical depth for visible wavelengths in the red is 10, what would you expect the optical depth to be for radiation of 30 microns wavelength? What percentage of the radiation at this wavelength would get through the cloud?

4. Determine the frequencies of the lowest three rotational transitions of the common interstellar molecule CO. You may assume that the inter-nuclear distance is a fixed 1.12819 A. At a temperature of 10 K, what is the most populated rotational level *J* for this molecule?

5. It is known that the dominant form of hydrogen in dense interstellar clouds is molecular. Molecular hydrogen is also important in diffuse clouds. Since H_2 does not have a dipole moment, how can astronomers study this species?

6. Using the rigid rotor-harmonic oscillator model, determine the wave numbers (cm^{-1}) of the first three P-branch and R-branch transitions for the v = 1-0 transition of CO. Look up the frequency of the rotationless transition. What high overtone would be needed for CO to absorb in the visible via excitation of a vibrational level?

7. Suppose a star forms inside an interstellar cloud with a surface temperature of 5000 K and heats the dust in its immediate vicinity to 300 K. Radiation is seen from both the star and the dust. Describe the radiation as quantitatively as possible.