2 Feb 2011 **Ay 126** M. Kamionkowski & W.L.W. Sargent

The Interstellar Medium

Problem Set 5

Due **in class** Wednesday February 9, 2011

Readings: Chapter 5 of Tielens.

Homework Problems:

Interstellar Dust

1. Extinction by dust in our galaxy is very patchy. Here, we will consider a cloud with a size of 5 pc, a hydrogen density of 50 H-atoms cm^{-3} and a dust-to-gas mass fraction of 10^{-2}. We will asssume spherical dust grains with a radius of 0.1 μm and a specifc density of 3 g cm^{-3}. What is the visual extinction through this cloud if these grains absorb with unit efficiency? If clouds are randomly distributed and the mean visual extinction is 1.8 mag kpc^{-1} in the plane of the Milky Way, on average, how many clouds are there per kpc ?

2. Because of radiation pressure, a dust grain at a distance r_o from a star with luminosity L_* will be accelerated to a terminal velocity,

   $v(term) = (3L_* Q_{rp}/8cr_0 a\rho_s)^{1/2}$

   with a the grain size, ρ_s the specific density of the grain material, and Q_{rp} the radiation pressure efficiency.

   (a) Derive this expression, starting from

   $F_{rp} = C_{rp} F/c$

   with C_{rp} the radiation pressure efficiency. (Hint: F = mvdv/dr).

   (b) Calculate the terminal velocity for a grain radius of 0.1μ m, a specific density of 3 g cm^{-3}, a radiation pressure efficiency of 1, and a luminosity of 10^4 $L_\odot$.

3. Calculate the temperature of a silicate grain in the diffuse interstellar medium, adopting the Planck mean efficiencies given in equation (5.35), a UV absorption efficiency of unity, and an integrated interstellar photon radiation field, $4\pi N_{ISRF} = 108$ photons cm^{-2} s^{-1} and a mean photon energy of 10 eV.

4. Compare and contrast the processes that heat and cool interstellar dust to those of interstellar gas. Do you expect dust to be hotter or cooler than gas in HII regions ? And in neutral atomic regions ? And in molecular clouds ? Explain your answer.

5. Compare and contrast the processes that contribute to the charging of interstellar dust and the conditions when they dominate.