

# A575 HW #9

Handed out: April 1, 2009

Due (at the beginning of class): April 8, 2009

1. [15 pts] Suppose you are doing a survey to find objects of luminosity  $L$  with an imaging array that covers solid angle  $\Omega$  on the sky (with many pixels). The imaging array has a flux limit given by

$$f_l = f_o(t/t_o)^{-1/2} \quad (1)$$

where  $t$  is the array exposure time on a given field, and  $f_o$  and  $t_o$  are a reference flux and exposure time, respectively. Suppose that the space density of sources is  $n_s$  and space is Euclidean. Let  $N$  be the total number of sources found in a total survey time,  $t_{survey}$ . The total survey time is fixed. You desire to find as many sources as possible in your allocated time.

(a) Derive an expression for the total number of sources you expect given the parameters above. Make sure you cast this in a form that lets you see how the number of sources detected varies with integration time.

(b) What is better for your survey, breadth or depth?

(c) What might happen if you make your exposure time too short?

2. [25 pts] Suppose we consider an ionizing source surrounded by gas. In equilibrium, the number of photoionizations balances the number of recombinations in the nebula. For a uniform density gas, this relationship is:

$$N_{Ly\alpha} = \frac{4}{3}\pi r_s^3 N_H^2 \alpha_B \quad (2)$$

where  $N_{Ly\alpha}$  is the number of Lyman continuum photons coming from the central source;  $r_s$  is the radius of the ionized region (called the Strömngren radius),  $N_H$  is the hydrogen density of the nebula, and  $\alpha_B \sim 2.6 \times 10^{-13} \text{ cm}^3 \text{ s}^{-1}$  is the recombination coefficient to all levels but  $n=1$  in hydrogen (recombinations to  $n=1$  simply re-ionize the hydrogen again).

Suppose we have a quasar with  $L=10^{46} \text{ erg s}^{-1}$  and  $L_\nu = C_o \nu^{-n}$  with  $n=1$  over the region from  $0.1 \text{ \AA}$  to  $100 \mu$ .

(a) Compute the number of Lyman continuum photons (shortward of  $912 \text{ \AA}$ ) coming from the quasar.

(b) Suppose  $N_H = 10^4 \text{ cm}^{-3}$ , what is the radius of the ionized region?

(c) An O5 star has  $N_{Ly\alpha} \sim 5 \times 10^{49} \text{ s}^{-1}$ . What would be the size of the ionized region around this star?

(d) Suppose  $N_H = 1 \text{ cm}^{-3}$ , what are the radii of the ionized regions for the O-star and quasar?

(e) Based on these estimates, what do you think would happen if a quasar were sitting at the center of our galaxy which has an average interstellar medium density of  $N_H = 1 \text{ cm}^{-3}$ ?

3. [10 pts] Consider an AGN located a distance,  $d$ , from us that has an observed bolometric flux  $F_{obs}$  and an effective temperature  $T_{eff}$ .

(a) Assuming a Euclidean universe, derive a rough expression for the angular size,  $\theta$  of the source as a function of  $F_{obs}$ ,  $T_{eff}$  and  $d$ .

(b) Suppose  $F_{obs} = 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$  and  $T_{eff} = 10^3 \text{ K}$ , and  $d=15 \text{ Mpc}$ . Estimate the angular size of the source in milliarcseconds.