

A575 HW #3

Handed out: February 2, 2009

Due (at the beginning of class): February 9, 2009

1. [20 pts] Recall that the Schechter function is:

$$\phi(L)dL = n^* (L/L^*)^\alpha \exp(-L/L^*) d(L/L^*)$$

where n^* is the number density per Mpc^3 of L^* galaxies. L^* characterizes the break in the luminosity function, and α is the powerlaw slope for $L \ll L^*$. Further, recall that the absolute magnitude M^* is related to the luminosity L^* by

$$\log(L/L^*) = -0.4(M - M^*)$$

(a) Find the expression for $\phi(M)dM$.

(b) For an apparent magnitude limited sample, the distance to which you can see a galaxy of luminosity L is $d \propto L^{1/2}$, and the volume $V_s \propto d^3$. The luminosity *distribution* of such a sample is $n(L)dL = \phi(L) dL V_s(L)$. Find how $n(L)$ depends on L/L^* and α , and then evaluate the peak luminosity in units of L^* for such a sample if $\alpha = -1.25$.

(c) The mass-to-light ratio of galaxies is approximately $12 (M_\odot/L_\odot)$. Using this and the values for the B band luminosity function $n^* = 0.012 h \text{ Mpc}^{-3}$, $L^* = 10^{10} h^{-2} L_\odot$, and $\alpha = -1.25$, find the mass density of local galaxies in grams per cm^3 for $h = 0.7$.

2. [10 pts] The Sérsic profile is often written as

$$I(R) = I(R_e) \exp(-b[(R/R_e)^{1/n} - 1])$$

where the constant b is chosen so that the effective radius, R_e , includes half the light. For $n > 1$, $b \sim 1.999n - 0.327$.

(a) Show that the $R^{1/4}$ formula yields a total luminosity

$$L = \int_0^\infty 2\pi R I(R) dR = 8! \frac{e^{7.67}}{(7.67)^8} \pi R_e^2 I(R_e) \sim 7.22 \pi R_e^2 I(R_e).$$

(b) Show that half of this light comes from within radius R_e .

3. [20 pts] I Zw 18 is a nearby, extremely metal-poor galaxy. It has an apparent magnitude (blue) of 16.61, a gas-phase metallicity of 1/50th of solar [$12 + \log(\text{O}/\text{H}) = 7.2$], and an observed HI flux density of 2.97 Jy km/s .

(a) Assuming a distance of 10 Mpc, what is its absolute magnitude and total hydrogen mass?

(b) Using the results from the Wilson (1995) paper, calculate the expected $J=1 \rightarrow 0$ CO line intensity for I Zw 18. [Note, eq 4 of the paper is for $\log(\alpha/\alpha_{Gal})$.]

(c) The KPNO 12m has a beam size of $55''$ for observations of the $J=1 \rightarrow 0$ line at 115 GHz. This is sufficiently large that a single pointing will include all of the emission from a tiny galaxy such as I Zw 18. The observed HI line width of I Zw 18 is 50 km/s . If the KPNO 12m has a gain of 34 Jy/K at 115 GHz, what is the expected peak antenna temperature for an observation of I Zw 18?

(d) With a one hour observation, it is possible to achieve rms noise of approximately 6 mK with the 115 GHz receiver and 5.2 km/s velocity resolution. Based on your calculation above, comment on the feasibility of detecting CO in I Zw 18 with the KPNO 12m telescope.