ASTRO 530: Problem Set 1

Problem 1: Two galaxies have identical apparent B-band magnitudes of $m_B = 20.0$, but galaxy 1 is at a distance that is twice as large as that of galaxy 2.

a) What is the apparent magnitude of the two galaxies combined?

b) What is the difference in absolute B-band magnitudes of both galaxies?

Problem 2: By deriving Eq. [2.8], show that the surface brightness in the V-band, μ_V, (in magn arcsec^{-2}) is related to I_V (in $L_\odot$pc^{-2}) according to

$$\mu_X \simeq -2.5 \log(I_V) + 26.40$$

(Hint: Table 2.1 may prove useful)

Problem 3: Consider two identical disk galaxies, 1 and 2, each with a total B-band luminosity (in the absence of any dust extinction) of $L_B = 10^{10} L_\odot$. Now suppose both galaxies have an infinitesimally thin screen of dust in their equatorial plane, with an optical depth $\tau_B = 0.8$.

a) If galaxy 1 is seen face-on and is located at a distance of 10 Mpc, what is its apparent magnitude in the B-band?

b) Suppose that galaxy 2 is located at a distance of 20 Mpc, along exactly the same line-of-sight as galaxy 1, and is also oriented face-on with respect to the observer. What is the apparent magnitude observed along the los to galaxies 1 and 2?

Problem 4: Consider an infinitesimally thin exponential disk, with a surface brightness profile given by $I(R) = I_0 \exp(-R/R_\mathrm{d})$.

a) Express the total luminosity of the disk in I_0 and R_d.

b) What is the effective radius of the disk, in units of R_d.

c) In many disk galaxies, the scale length in the B-band is significantly larger than that in the I-band. Discuss two possible explanations for this.

`Note do not forget problems 5 and 6 on the back!`

Problem 5: In a galaxy at $z = 0.0075$ astronomers detect a Cepheid with an apparent V-band magnitude of $m_V = 29$. Careful monitoring reveals a lightcurve with a period of 3.62 days. What is the peculiar velocity of the galaxy along the line-of-sight if $H_0 = 70 \mathrm{km\,s^{-1}\,Mpcs^{-1}}$? (Hint: read section 2.1.3)

Problem 6: A certain disk galaxy has a surface brightness profile that is truncated at a semi-major axis length of 3.44 arcmin. The semi-minor axis length at truncation is found to be 1.38 arcmin. The galaxy is found to be located at a distance of 10 Mpc, and has an apparent magnitude of $m_B = 12.48$. Long-slit spectroscopy along the major axis has shown that the Hα at the edge is offset by $150 \mathrm{km\,s^{-1}}$ with respect to the Hα at the center of the galaxy. Using a background source whose intrinsic SED is known, astronomers have furthermore established that the V-band extinction in the disk galaxy is $A_V = 1.51$ magn.

a) What is the inclination angle under which this galaxy is observed?

b) What is the extinction corrected B-band luminosity of this galaxy, assuming a Milky-Way extinction curve?

c) Assuming a stellar mass-to-light ratio of $\Upsilon_B = 2.0(M_\odot/L_\odot)$, give an estimate for the mass of the galaxy's dark matter halo inside the truncation radius. (Hint: $G = 4.3 \times 10^{-9}\,(\mathrm{km/s})^2 M_\odot^{-1}\mathrm{Mpc}$, and don't forget to correct the rotation velocity for inclination.)

Deadline: September 25, 2010

Grading:

5 points each for 1a, 1b, 3a, 4a, 4b, 4c, and 6a

10 points each for 3b and 6b

15 points each for 2, 5 and 6c

TOTAL : 100 points