AST 358 /EXAM 1 SOLUTION SET

Q1

B-R= m_B - m_R = -2.5 log (f_B/f_R)
where
f_B, f_R are flux received at B and R wavelengths
Initial B-R color = 0.2
New B-R color = -2.5 log(100) + 0.8 = -4.2

Q2.

In the Hubble classification system, we assume that the bulge to disk (B/D) ratio correlates with the gas content of a galaxy, such that spiral galaxies with a high B/D ratio are assumed to also have disks with smooth spiral arms. As galaxies wiith a low B/D ratio and clumpy gas-rich spiral arms fall into the cluster, they will be converted into spirals, which have a low B/D and whose disks host smooth spiral arms or no spiral arms. Such systems do not fit readily within the the Hubble classification system.

Q3.

3a. See exam1-sol-part2.pdf

3b. A magnitude-limited survey only detects galaxies whose apparent magnitude or flux is brighter than some minimum value, say f_min
So a galaxy of luminosity L is only detected out to a distance d
where

d^2 = (L/4 pi F_min)
d prop to sqrt(L)

Thus, as a magnitude-limited survey samples increasingly large distances, it preferentially only detects increasingly bright galaxies, while fainter galaxies 'drop out' of the survey.

3c. See exam1-sol-part2.pdf

Q4

4a. The rotation curve of spiral galaxies stays flat out to large radii R.
The application of Newtonian dynamics to the observed circular speed

Vc(R) via the equation Vc(R) = sqrt(G*M(R)/R) for a spherically symmetric mass distribution shows that the implied total mass M(R) inside radius R is much larger than the known mass of visible matter (gas, stars, dust). This implies that a large fraction of the mass present is in the form of dark matter.

4b. See exam1-sol-part2.pdf

4c. See exam1-sol-part2.pdf

4d. See exam1-sol-part2.pdf

Q5

5a. When MACHOS cross the line of sight between an observer on Earth and a distant star located in the LMC, SMC or in the bulge of the Milky Way,it gravitationally lenses the light from the star, causing up to two images of the star to be produced. Due to the small separation between the 2 images (~ 2 x Einstein radius ~ 1 milli arcsecond), they appear as a blended single image. However, the flux from the image is magnified compared to the flux of the unlensed source, and the observed magnification typically lasts for 1 to a few months, and is the same at all wavelengths. By mapping tens of millions of stars at several wavelengths over several years, and searching for such microlensing events in their light curves, astronomers are able to estimate the fraction of the mass of the Milky Way halo that is in the form of MACHOS.

5b. See exam1-sol-part2.pdf

Q6

In HDM models, dark matter particles have relativistic speeds at early times and escape from the shallow gravitational potential wells associated with overdensities on small scales. Thus, small-scale overdensities are washed out and the first structures to grow are large-scale overdensities. Thus, in HDM models, we have a top-down buildup of structure, with superclusters forming first at early epochs, and small galaxies forming at later epochs.

In CDM models, at early times dark matter particles have speeds well below the speed of light and can therefore collect in the shallow gravitational potential wells associated with small-scale overdensities. Thus we have a hierarchical or bottom-up buildup of structure, with small galaxies forming first at at early epochs and superclusters forming at later epochs.

Observations show that small mass galaxies exist at high redshifts, while most rich clusters and superclusters are only seen at later epochs ($z<=1$), thus favoring CDM models.