Astr 323: Extragalactic Astronomy and Cosmology

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Homework Problem Set 3

(each answer is worth 1 point)

1) **Timescales in Galaxies and Clusters**

a) How long does it take the Sun to orbit the center of the galaxy? You may assume that we are moving at 220 km/s, and are 8.0 kpc from the center of the galaxy.

b) How many times would the Sun have completed an orbit during the age of the universe? You may assume 13.8 Gyrs for the age of the universe.

c) As an observational aside, how long would we have to wait to observe a star in Andromeda move through an angle of 1 arcsecond – i.e. to directly detect its rotation? You can assume a rotation speed of 250 km/s, and a distance of 750 kpc to Andromeda. You can neglect the inclination of the galaxy for now. Will you live this long? (1 arcsecond would be very easily measurable with ground-based telescopes – HST could measure changes of 0.1 arcseconds. Will you live long enough to see an 0.1 arcsecond change, either?)

d) Now consider clusters of galaxies. The Coma cluster has a velocity dispersion of roughly $\sigma = 1000$ km/s, a core radius of 0.3 Mpc, and a total radius of about 3 Mpc. How long would it take a galaxy to completely cross the Coma cluster, if it were moving at the typical velocity dispersion?

2) **Distance Scales**

Assume you have an SDSS-like telescope that you can use to detect and measure stars as faint as V=22.5, and that you are observing towards a region with negligible interstellar extinction.

a) How far can you detect an RR Lyrae star (M_V=0.7)?

b) What is the distance of an RR Lyrae star (M_V=0.7) with V=20.7?

c) What would be apparent magnitude of this RR Lyrae star at the distance corresponding to redshift of 0.1? Assume that H_o=68 km/s/Mpc.

3) **Uncertainties in Distance Measurements**

a) Suppose I mis-measure the apparent flux from a galaxy by 10%, and that I'm using the Tully-Fisher relationship to derive the galaxy's distance. Assuming that the Tully-Fisher relationship and my measurement of the rotation speed of the galaxy are both perfect, what is the corresponding percentage error I would make in the distance to the galaxy?

b) Given that the distance $D = [\frac{L}{4\pi F}]^{1/2}$ (where F is the flux, and L is the luminosity), what is the percentage distance uncertainty which results from the combination of my 10% uncertainty in the measured flux from part (a), and an intrinsic 0.25 magnitude scatter in the Tully-Fisher relationship?

c) Assuming that the Tully Fisher relationship is $L \propto V^4$, what is the percentage distance uncertainty which results from the combination of errors from b), AND an additional error of 10% in the rotation speed (e.g. due to inclination effects)?