ASTR421 Galaxies
Fall 2012
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Homework 5

1) S+G problem 6.4
2) Why do we think that the formation of ellipticals is related to mergers?
3) Describe the Faber-Jackson relation and how it is connected to the fundamental plane?
4) Problem 6.7 – is the increase in M/L supported by observations?
5) Is the shape of elliptical galaxies due to rotation? S+G Problem 6.5
6) Why do we believe that elliptical galaxies are old- give 2 observations that support this idea. What does this mean for the color of the galaxy and the nature of the stellar population? How should the color and luminosity of the galaxy change over cosmic time and what do the observations tell us?

Comments

1 Change variables for the integral; dz and dr are related by $(dz/dr)_R$. Lower limit also changes to $r = R$ when $z = 0$. Then substitute $x = r/R$. Some lost points for missing or muddled steps.

2 a. Lack of cool gas and dust. Collisions trigger star bursts, exhaust cool gas, expel gas and dust, consistent with lack of gas and dust observed, and lack of star formation.
b. Collisions mince galaxies together and they relax into triaxial bodies.
c. Higher incidence of ellipticals in higher density regions, with higher merger rates.
d. Observational evidence that ellipticals have gone through more mergers.
e. Observation of shells and trails of gas likely to have formed in merger event.
f. Observation suggests have undergone mass growth without star formation, ruling out gaining mass through consuming IGM.
Discuss at least 3 of the things for 5/5.

3 Faber-Jackson relation relates photometric properties to kinematics. Luminosity (integrated surface brightness) is related to central velocity dispersion by $L = \sigma^\gamma$. It is a projection of the fundamental plane of ellipticals in the mean surface brightness-central velocity dispersion plane. The fundamental plane is tilted relative to the projection plane so there is large scatter. A number of responses did not state the link between Faber-Jackson and the fundamental plane.

4 For a "show that" question, must justify $\sigma^2 = 3\sigma_r^2$ (isotropic velocity dispersion). Similarly, $L \propto I_e R_e^2$ needs to be shown from equation 6.1 by extracting the dependence on R_e from the integral, instead of quoting results for $n = 4$ given in equation 6.2. For the Faber-Jackson scaling relation $L \propto \sigma^4$, scaling relations from the previous parts of the question should be used. Some answers invoked $L = 4\pi R^2 F$ without basis, implying spherical flux (!). Finally, a handful of responses simply ignored Richard’s add-on one-liner and consequently didn’t make full-mark.

5 The function $F(< q)$ is a cumulative distribution function. Some confusion about how to apply this (!) caused points to be lost. For the following part, need to make some argument that the ratio

$$\frac{F(q > 0.95)}{F(0.8 < q < 0.85)}$$

increases when B/A is made smaller. Either show algebraically or try at least a range of different values. The last part should be answered in the context of how the observed distribution of q squares with the assumption of 2-axis oblate objects (given that true B/A must be smaller than the smallest q observed). This is clearly explained in the text immediately preceding the problem. Many answers made no connection to the data in their arguments; some failed to make an argument at all. Finally some ignored Richard’s add-on question and lost points.

6 One point for satisfying each of the 5 parts of this question. Observations (2): lack of young stars, assuming SSP and age dating it; iron deficiency suggests stars formed prior to Ia supernovae. Color is red and stars are old MS stars and AGB stars (1). Over cosmic time the stellar population ages and gets

redder, while luminosity decreases. (But growth means ellipticals today are more massive and more luminous than those at higher redshift.) The mass-to-light ratio should increase. It is observed to increase from $z = 1.5$ to today in support of this (2)