Ay 1 – Homework #6

Distributed on May 20, due by 5 pm on Friday, May 27, directly to your section TA, or to the Head TA’s mailbox in 249 Cahill.

Your name: __________________________________________________ Your section: __________

Collaboration policy: you can discuss it among yourselves in general terms, but everyone has to write or derive their own solutions.

Multiple choice questions have only one correct answer, worth 1 point; circle only one.

1. True or False? In Hubble’s galaxy classification scheme (referred to as the Hubble tuning fork), galaxies are ordered sequentially, with ‘early-type’ ellipticals evolving over time into ‘late-type’ spirals.
   A. True
   B. False

2. Which of the following is/are true of spiral galaxies?
   A. Spiral galaxies are the most numerous type of galaxy by number.
   B. They do not contain dark matter halos.
   C. Their bright spiral arms are the sites of star formation.
   D. The central bars which occur in approximately half of spiral galaxies are formed by spiral density waves.

3. Dwarf galaxies…
   A. Typically have more dark than luminous matter.
   B. Have low surface brightness.
   C. Are often tidally disrupted by gravitational interactions with more massive nearby galaxies.
   D. All of the above.

4. Elliptical galaxies are not forming very many new stars because:
   A. They are very gas-poor, and have no clouds of gas to collapse and form new stars.
   B. They are very gas-rich, but it is in the form of hot, X-ray gas which is not cold enough to form stars.
   C. They are mostly dark-matter dominated.
   D. Over-densities created by spiral density waves (i.e. spiral arms) are necessary to create sites of star formation.

5. What is the physical significance of the Tully-Fisher relation for spiral galaxies?
   A. It implies a link between the dark matter halos of galaxies and those galaxies’ star formation histories.
   B. It implies a difference in the formation histories of spiral and elliptical galaxies.
   C. It allows us to probe the amount of dark matter in a galaxy using its rotation velocity.
   D. All of the above.
6. The Fundamental Plane describes the relationship between which of the following properties of elliptical galaxies?
   A. Radius and mean surface brightness.
   B. Radius and velocity dispersion.
   C. Luminosity and rotation velocity.
   D. Radius, velocity dispersion, and mean surface brightness.
   E. Radius, luminosity, and mean surface brightness.

7. Dynamical friction is responsible for what processes in galaxies?
   A. High-mass galaxies retaining their supernova ejecta.
   B. Dissipation of spiral arm structures in a spiral galaxy over time.
   C. One galaxy slowing and eventually merging as it passes through another.
   D. All of the above.

8. Star formation history is…
   A. Is roughly the same for all types of galaxies.
   B. Is best fit by a burst of early star formation followed by a more “passive evolution” for ellipticals.
   C. Is best fit by an approximately constant or slowly declining rate of star formation for spirals.
   D. B and C

9. Exponential density profiles are characteristic of…
   A. Elliptical galaxies.
   B. Spiral galaxies.
   C. Dwarf galaxies.
   D. All of the above.

10. The observed shapes of elliptical galaxies are determined by…
    A. Rotation.
    B. Velocity anisotropy of stars.
    C. Projection effects.
    D. All of the above.

Homework continues on next page…
Computational question:

11. (4 points) When a gravitationally bound systems (such as a galaxy) forms, it transitions from a just bound state ($E_{\text{kin}} = |E_{\text{pot}}|$) to a virialized state ($E_{\text{kin}} = \frac{1}{2} |E_{\text{pot}}|$); the excess binding energy has to be radiated away. Consider an idealized disk galaxy with an exactly flat rotation curve with the rotation speed of $V_{\text{circ}} = 220$ km/s (you can neglect the kinetic energy in random motions). Its density profile cuts off abruptly at the radius of $R_{\text{max}} = 50$ kpc. Assume that it took 500 million years for this galaxy to collapse to its present state. What was its mean luminosity (in solar units) due to the release of the binding energy only during that period?

Show your calculations (intermediate steps) here:

Write your answer here: