Stars, Galaxies & the Universe (29:50)
Professor C.C. Lang
Exam #3 - Fall 2010
Wednesday, November 17th

FORM B - SOLUTIONS

Questions 1-5: Match. Match each part of the Galaxy with the correct description of its appearance. Each answer choice will be used once.

1. A Milky Way Spiral Arm **(d)**
2. HII region **(e)**
3. The Milky Way Bulge **(a)**
4. Dust surrounding a bright star **(b)**
5. A star behind interstellar dust **(c)**

(a) Glows yellow because of old stars.
(b) Glows blue because of scattering and reflecting.
(c) Glows red because of reddening.
(d) Glows blue because of young, hot stars.
(e) Glows red because of hydrogen alpha (Hα) emission.

6. Both Supernova Type Ia (SN Type Ia) explosions and Cepheid variable stars are used in astronomy to calculate distances. Why are SN Type Ia explosions used to calculate the distance to more distant galaxies than Cepheid variables?

(a) SN Type Ia explosions only occur in the most distant galaxies.
(b) Cepheid variables change their brightness too quickly to detect at great distances.
(c) Most galaxies in the universe are elliptical and don't have Cepheid variables.
(d) The luminosity of SN Type Ia explosions is much greater than Cepheid variables.
(e) Cepheid variables are not found in the most distant galaxies.

7. Which of the following best describes the environment at the center of the Milky Way Galaxy?

(a) physically more extreme than near the Sun, with many massive star clusters, a strong magnetic field and dense gas clouds
(b) very similar to that of the Solar neighborhood, with loosely-spaced stars like the Sun
(c) empty; the supermassive black hole at our Galaxy's center has consumed everything in its vicinity
(d) the center of the Galaxy is receding away from the Sun at very high speeds
(e) we have never been able to see any EM radiation from our Galaxy's center

8. Which of the following provides evidence that a supermassive black hole exists at the center of the Milky Way galaxy?

(a) Stars close to the supermassive black hole are orbiting at very high speeds.
(b) Stars close to the supermassive black hole are all sucked in so that none are left.
(c) There are powerful jets of radiation emitted by our Galaxy's supermassive black hole.
(d) The supermassive black hole is a very bright source at optical wavelengths.
(e) The Galactic center is 25,000 light years away.

9. Galaxy A has a recessional velocity of 2500 km/s and Galaxy B has a recessional velocity of 5000 km/s. What can you say about the two galaxies?

(a) Galaxy A is twice as luminous as Galaxy B.
(b) Galaxy B is located twice as far away as Galaxy A.
(c) Galaxy A's spectral lines will be more strongly redshifted than Galaxy B's.
(d) Galaxy A is located twice as far away as Galaxy B.
(e) There is not enough information to say anything about either Galaxy A or B.

10. The rotation curve of a galaxy is a plot showing the galaxy's speed of rotation at different distances from its center. The *observed* rotation curve for THE OUTER PART of a large spiral galaxy (similar to our Milky Way)

(a) decreases suddenly to zero at the visible edge of the galaxy.
(b) decreases smoothly with increasing distance from the center, similar to planetary motion.
(c) has a value of zero everywhere since spiral galaxies do not rotate.
(d) increases drastically with increasing distance from the center.
(e) is quite flat (roughly the same speed for all outer distances).

11. How are galaxies distributed in the universe on large scales?

(a) They are distributed more or less evenly throughout the universe.
(b) They are distributed into narrow "walls" surrounding large "voids".
(c) They are concentrated around the Milky Way, and most galaxies in the universe are part of the Local Group.
(d) They are distributed into long, evenly spaced strings covering the universe.
(e) The universe is so vast and infinite, that we have no way of knowing how galaxies are distributed.

12. The nearby Large Magellanic Cloud is an example of which type of galaxy?

(a) irregular galaxy
(b) spiral galaxy
(c) lenticular galaxy
(d) elliptical galaxy
(e) it is not a galaxy, but a Giant Molecular cloud

13. Which of the following does NOT describe an elliptical galaxy?
(a) The stars in them are not well organized and have random motions.
(b) They are mainly yellowish in visible color.
(c) They are continuously forming stars out of gas and dust.
(d) They can be the most massive galaxies in the universe.
(e) They often have very massive supermassive black holes at their cores.

14. When an astronomer observes a Cepheid variable star, she ***measures*** which of the following quantities?
(a) brightness (flux) and distance
(b) distance and luminosity
(c) temperature and luminosity
(d) brightness (flux) and period
(e) period and luminosity

15. After obtaining these measurements, the astronomer is able to ***infer*** ___ and _____ for the Cepheid variable star.
(a) brightness (flux) and distance
(b) luminosity and distance
(c) spectral type and luminosity class
(d) temperature and distance
(e) period and radius

16. Which of the following best describes a Type Ia supernova?
(a) The collapse of a core of a massive star.
(b) Mass transfer onto a white dwarf in a binary, resulting in a brightness change.
(c) Mass transfer onto a white dwarf in a binary, resulting in destruction of the system.
(d) The release of energy by the gravitational collapse of a star cluster.
(e) The merger of a neutron star-neutron star binary.

17. Atomic hydrogen gas (also known as HI) is one of the major components of the Milky Way and many other spiral galaxies. How do we detect HI gas?
(a) by the rotations and vibrations of atoms in the microwave part of the spectrum.
(b) by the "spin-flip" transition in the radio spectrum at a wavelength of 21 cm.
(c) by movement of electrons up and down in the energy levels of the hydrogen atom
(d) by strong X-ray radiation
(e) we can't detect HI gas; it is thought to be the main component of "dark matter".

18. A gravitational lens or Einstein ring
(a) attracts and bends matter toward the center of the universe.
(b) focuses light near the center of a galaxy cluster.
(c) magnifies the light from a cluster of galaxies.
(d) is a purely theoretical object.
(e) is produced by the distortion of light from a background galaxy due to dark matter in the galaxy cluster.

Questions 19+20: As a class project, you make observations of a unusual binary star. One of the components is a spectral class G2V star (a twin of the Sun) and it is clearly moving in an orbit. You cannot detect the light from the other component of the binary, but from your measurements you deduce that it has a mass of 4 solar masses and you also read that it is a strong X-ray emitter.

19. How do we know that the G2V star and its companion are moving around a common center of mass?
(a) We observe brightness changes over time.
(b) We observe Doppler shifting (both red and blue) of the G2V's spectral lines.
(c) The star looks red.
(d) The star appears to be a visual binary.
(e) The X-rays indicate that the star is moving.

20. What kind of object is the companion?
(a) an identical G-type star
(b) an M giant star
(c) white dwarf
(d) neutron star
(e) black hole

21. Which of the following is *NOT* evidence for the fact that as much as 90% of the universe may be made of dark matter?
(a) The rotation curve of our Galaxy indicates that additional mass must be present to explain the high orbital velocities at large distances from the Galactic center.
(b) Gravitational lenses show that dark matter is present in galaxy clusters.
(c) The velocities of the planets in our solar system decrease with increasing distance from the Sun.
(d) The rotation curves of other galaxies indicate that additional mass must be present to explain the high orbital velocities at large distances from their centers.
(e) The orbital velocities of galaxies in clusters indicate that additional mass must be present to explain the large velocities observed.

22. An **eclipsing** binary star system is detected by observing

(a) blue and red Doppler shifts in the spectral lines of a star.
(b) brightness changes of a star over time (usually days) as the stars pass in front of each other
(c) a luminous explosion of a star
(d) the moon pass in front of the star system
(e) the binary system at intervals of 6 months

23. What is the **source** of ionization (heating) of the hydrogen gas in an HII region?

(a) a supernova explosion
(b) interstellar dust
(c) the accretion disk surrounding a black hole
(d) photons (mostly ultraviolet) from nearby hot stars
(e) red visible light

24. Which of the following statements about active galaxies and quasars is **true**?
(a) They are commonly found in the local universe near the Milky Way.
(b) They are only found in the Virgo Supercluster.
(c) They are located within the Milky Way.
(d) They are thought to contain primordial black holes.
(e) Their energy arises from the accretion disk of a supermassive black hole.

25. Hubble's relationship between the distance to a galaxy and its speed of recession is interpreted as evidence for
(a) the Big Bang.
(b) supermassive black holes being present in most galaxies.
(c) the Doppler effect.
(d) the overall expansion of the universe.
(e) galaxies being distributed uniformly throughout the universe.