PHYS 2410 General Astronomy Final 1/6/2009

Brief Essay (40%)

1. How will the Sun die? (5%) What will be left after the Sun die? (5%)
   (1) The sun will first become a red giant and fuse helium, then loss mass into space. Finally, when the helium shell stops burning, its core will collapse to become a white dwarf.
   (2) A planetary nebula and a white dwarf.

2. How do massive stars die? (5%) What will be left after the massive stars die? (5%)
   (1) The massive stars on the upper main sequence fuse nuclear fuels up to iron but cannot generate further nuclear energy because iron is the most tightly bound of all atomic nuclei. When a massive star forms an iron core, the thermal pressure at the center of the star can no longer support its own gravity. Therefore, the core collapses and triggers a supernova explosion known as a Type II supernova.
   (2) a supernova remnant and a neutron star or a black hole (depending on the mass of the remaining core)

3. How can you estimate the age of a star cluster? (5%)
   You can judge the age of a cluster by looking at the turnoff point, the location on the main sequence where the stars turn off to the right and become giants. The life expectancy of a star at the turnoff point equals the age of the cluster.

4. What is the evidence for the existence of Dark Matter? (5%)
   Answer either (1) or (2):
   (1) The mass of the Milky Way and other galaxies derived from their rotation curve is much more than the visible matter. Astronomers call the mass not detectable through electromagnetic radiation "dark matter".
   (2) The gravitational lensing caused by the mass of galaxy clusters reveal that the clusters must be much more massive than can be accounted for by the visible matter.

5. What evidence shows that the Universe began with a big bang? (5%)
   Answer either (1) or (2):
   (1) Edwin Hubble's 1929 discovery that the redshift of a galaxy is proportional to its distance is known as the Hubble law. Tracing this expansion backward in time brings you to an initial high-density, high temperature state commonly called the big bang.
   (2) The occurrence of the big bang is supported by the cosmic background radiation. This radiation is the redshifted radiation emitted from the gas when the Universe was cooled down enough to allow electrons and nuclei to combine to form atoms.

6. How do we know the Universe is accelerating? (5%)

The evidence for an acceleration in the expansion of the universe comes from using type Ia supernovae as distance indicators. The luminosity of type Ia supernovae can be calibrated so that distance can be calculated once the brightness is determined. The distance to several very distant galaxies were determined using type Ia supernova. This data was used along with the galaxies recession velocity and the distances and recessional velocities of more nearby galaxies. When comparing the relatively nearby galaxies to those of the most distant galaxies, it was found that the universe is expanding at a greater rate now than in the past.

Multiple Choice (60%, 3% for each question)

1. The main sequence has a limit at the lower end because

a. low mass stars form from the interstellar medium very rarely.
b. hydrogen fusion combined 4 hydrogen nuclei to form 1 helium nucleus.
c. pressure does not depend on temperature in degenerate matter.
d. the lower limit represents when the radius of the star would be zero.
* e. there is a minimum temperature for hydrogen fusion.

2. There is a mass-luminosity relation because

a. hydrogen fusion produces helium.
b. stars expand when they become giants.
* c. stars support their weight by making energy.
d. the helium flash occurs in degenerate matter.
e. all stars on the main sequence have about the same radius.

3. A white dwarf is composed of

a. hydrogen nuclei and degenerate electrons.
b. helium nuclei and normal electrons.
* c. carbon and oxygen nuclei and degenerate electrons.
d. degenerate iron nuclei.
e. a helium burning core and a hydrogen burning shell.

4. A Type I supernova is believed to occur when
   a. the core of a massive star collapses.
   b. carbon detonation occurs.
* c. a white dwarf exceeds the Chandrasekhar limit.
   d. the cores of massive stars collapse.
   e. neutrinos in a massive star become degenerate and form a shock wave that explodes the star.

5. The escape velocity at the event horizon around a black hole is
   a. smaller than the speed of light.
* b. equal to the speed of light.
   c. larger than the speed of light.
   d. irrelevant since nothing (including light) can escape from a black hole.

6. The density of a neutron star is
   a. about the same as that of a white dwarf.
   b. about the same as that of the sun.
* c. about the same as an atomic nucleus.
   d. about the same as a water molecule.
   e. smaller than expected because the magnetic field is so strong.

7. What behavior do galactic rotation curves exhibit to suggest the existence of dark matter?
   a. Small velocities are seen at large distances from the galactic center.
   b. Small velocities are seen at distances close to the galactic center.
* c. Large velocities are seen at large distances from the galactic center.
   d. Large velocities are seen at distances close to the galactic center.

8. The mass of the black hole at the center of our galaxy can be estimated using the ________ of a star orbiting it.

   a. semi-major axis
   b. orbital period
* c. Both answers a and b.
   d. Neither answer a nor b.

9. The mass of a single galaxy might be found by
   a. the double galaxy method.
* b. the rotation curve method.
   c. the cluster method.

d. any of these methods.

e. none of these methods

10. The Milky Way is

a. a spiral galaxy.

* b. a barred spiral galaxy.

c. a dwarf elliptical galaxy.

d. an irregular galaxy.

e. a giant elliptical galaxy.

11. In the unified model of active galactic nuclei, the broad line region in an active galactic nucleus is

* a. composed of clouds of gas and stars moving at very high orbital velocities.

b. composed of a super massive black hole.

c. responsible for producing the bright continuous radiation observed in blazars.

d. responsible for the narrow absorption lines seen in Type 2 Seyfert galaxies.

e. located further from the core than the narrow line emission region.

12. Why do astronomers believe black holes are the source of an AGN’s energy?

a. It’s expected since black holes have been found at the center of most galaxies.

b. Radio jets are seen in many AGN and those only come from black holes.

c. Black holes have been observed directly there.

* d. Only black holes can produce so much energy in such a small place.

13. The resolution of Olbers' paradox suggests that the sky gets dark at night because

* a. the universe is not infinite in age.

b. the universe is accelerating.

c. the universe is closed.

d. the universe is flat.

e. the universe is isotropic.

14. If the universe is closed, then its age will be (H is the Hubble Constant)

* a. less than 1/H.

b. more than of 1/H.

c. equal to 1/H.

d. equal to H squared.

e. equal to the square-root of H.

15. Why is the cosmic microwave background (CMB) so cold if the early universe was so hot?

a. Enough time has passed for matter to release enough heat to cool down.

b. The CMB constantly interacts with atoms, which effectively cool down the photons.

* c. The expansion of the universe has redshifted those photons to an effectively cooler temperature.

d. Misleading; The Big Bang was initially hot but the CMB was released from cold material much later on.

16. The best current scientific data and models suggest that the universe is

a. open, expanding, and accelerating.

b. open, expanding, but decelerating.

c. closed, expanding, and accelerating.

d. closed, expanding, but decelerating.

* e. flat, expanding, and accelerating.

17. What is the content of the Universe?

a. 33% Visible Matter, 33% Dark Matter, 34% Dark Energy

* b. 4% Visible Matter, 26% Dark Matter, 70% Dark Energy

c. 10% Visible Matter, 30% Dark Matter, 60% Dark Energy

d. 50% Visible Matter, 25% Dark Matter, 25% Dark Energy

18. The structure and evolution of a star is NOT determined by the law of

a. Hydrostatic equilibrium

b. Energy transport

c. Conservation of mass

* d. Equivalent Principle

e. Conservation of energy

19. We should expect galaxies to collide with each other fairly often because

a. a galaxy’s size is only a little smaller than the average distance between galaxies.

b. galaxies contain large amounts of neutral hydrogen.

c. galaxies occur in clusters.

* d. a and c

e. none of the above

20. A Cepheid variable with a mass of 10 $M_\odot$ _________________ than a Cepheid of 3 $M_\odot$.

a. is less luminous

b. has a greater surface temperature

c. has a smaller radius

* d. has a longer period

e. a and c

Extra Credit (10%, Need to write down your calculations)

1. The mass of the super black hole at the center of the Milky Way is 2.6 million solar mass and the distance between the Sun and the Galactic Center is 8.5 kpc.
   a. If the Milky Way only consists of the central black hole and the Sun, what is the escape velocity of the Sun?
   b. If the Sun suddenly turns into a black hole with 2.6 million solar mass, will the Earth fall into the black hole?

Hints:

The kinematic energy of an object is − m v

The potential energy between two objects is - ——

1 solar mass = 2×10^{33} g

1 pc = 3.1×10^{18} cm

1 AU = 1.5×10^{8} km

G = 6.67300×10^{-11} m^3 kg^{-1} s^{-2}

Ans:

a. The escape velocity v_{esc} is calculated from

$$\frac{1}{2}\, m\, v \qquad \frac{GMm}{r} \qquad 0$$

Therefore, $v \qquad \overline{} \qquad 1.6 \quad 10 \;\; m/s$,

for M=2.6 million solar mass and r= 8.5 kpc.

b. Solution 1:

The Schwarzschild Radius for M=2.6 million solar mass is

$$R \qquad \frac{2GM}{c} \qquad 7.7 \quad 10 \;\; km \qquad 1$$

So the Earth is outside of the Event Horizon. Now, we need to compare the escape velocity of the Earth and the current velocity of the Earth. The escape velocity for M=2.6 million solar mass and r= 1 AU is

$$v \qquad \sqrt{\frac{2GM}{r}} \quad 6.8 \quad 10 \;\; km/s$$

The rotation speed of the Earth is

$$v \qquad \frac{2\,\pi \qquad 1\,AU}{1\,yr} \quad 30\,km/s$$

Since $v_{rot} < v_{esc}$, the Earth will gradually fall in to the black hole.

Solution 2:

The current rotation speed of the Earth is the same as the escape velocity for M=1 solar mass and r= 1AU. When the mass increases, the required escape velocity must be bigger than the current velocity. Therefore, the Earth will be falling into the black hole.