29:50 Stars, Galaxies, and the Universe
Final Exam
December 13, 2010
Form A

There are 40 questions. Read each question and all of the choices before choosing. Budget your time. No whining.

Walk with Ursus!

1. Why are regions of glowing gas seen around hot, luminous stars?
   (a) the glowing gas is attracted by the gravity of those stars
   (b) the gas is reflecting the bright light from the stars
   (c) the gas is what is left of the cloud from which the stars formed
   (d) the gas is in contact with the hot stars, and emits continuum blackbody radiation
   (e) such stars emit many photons with enough energy to ionize a hydrogen atom ∗

2. Let's assume you measure the spectrum of the Orion Nebula. What do you see?
   (a) a continuum spectrum peaking at about 300 nanometers
   (b) emission lines of hydrogen and other elements ∗
   (c) absorption lines of hydrogen and other elements
   (d) radiation only at a wavelength of about 550 nanometers
   (e) a continuum spectrum peaking at about 500 nanometers

3. Think about the *shape* of the Milky Way. Which of the following statements is true?
   (a) it is approximately spherical in shape
   (b) it is spheroidal in shape, like a football
   (c) it is irregular, and cannot be classified in terms of simple geometric figures
   (d) it is cubical
   (e) it is disk-shaped ∗

4. We discuss the classes of galaxies, based on their shapes, masses, etc. What type is the Milky Way?
   (a) elliptical
   (b) irregular
   (c) spiral ∗

(d) lenticular
(e) Seyfert galaxy

5. Describe the motion of the Sun in the Milky Way.
(a) a circular orbit around the galactic center ∗
(b) .it moves in close to the galactic center, then out to the edges of the galaxy, with a period of 980 years
(c) an orbit with a big difference between closest approach and most distant
(d) the Sun doesn't orbit the galactic center, but instead the Orion Nebula
(e) the Sun, like all stars, does not move in the Milky Way

6. What is *roughly* the typical distance between galaxies in our neighborhood?
(a) 15 - 30 parsecs
(b) one Megaparsec to a few Megaparsecs ∗
(c) 400 - 800 astronomical units
(d) 5000 - 10000 parsecs
(e) 700 - 1000 Megaparsecs

7. There is a type of astronomical object which is used to determine the distance to *nearby* galaxies. This class of object is
(a) HII regions
(b) planetary nebulas
(c) pulsars
(d) globular star clusters
(e) Cepheid variables ∗

8. How can we measure the motion of a galaxy relative to us?
(a) a shift in its sky position relative to a more distant galaxy
(b) trigonometric parallax
(c) from a change in the angular size over a period of many years
(d) Doppler shift in its spectrum ∗
(e) from the existence of synchroton radiation from the galaxy

9. Let's say we make a radio picture or image of a luminous radio galaxy. What would it look like?
(a) an extended image that is brightest in the middle, then gets progressively fainter towards the edges
(b) a bright cloud of emission with a central hole lacking emission
(c) two clouds of radio emission flanking a point of emission at the center of the galaxy ∗
(d) a starlike point of emission, no matter what resolution the radio telescope

has
(e) a roughly spherical region surrounding the bright stars responsible for ionizing the gas in the galaxy

10. We need to know or measure two quantities to determine the redshift of a galaxy.
(a) the brightness of the galaxy in blue light and the brightness in red light
(b) the rest wavelengths of two spectral lines of the same atom
(c) the rest wavelength of a spectral line and the wavelength of the same line in the spectrum of a galaxy ∗
(d) the rest wavelength of a spectral line in the spectrum of a galaxy and its apparent magnitude
(e) the mass of a galaxy and the type of galaxy it is

11. What is an observation that indicates energy is generated in the centers of galaxies, then flows out to regions hundreds of kiloparsecs from the galactic centers?
(a) thin cords of emission called jets the connect galactic centers with the distant clouds of emission ∗
(b) circular rings produced by the shock waves generated in the centers of these galaxies
(c) a delay in the time a brightening occurs in the center of a galaxy, and when it is seen in the outer parts
(d) the fact that radio galaxies are always brightest in the center, the dimmer towards the edges
(e) the fact that all galaxies are receding from us

12. The interstellar medium differs from the Earth's atmosphere in many ways. One of those differences is given below. Pick it.
(a) There are huge variations in temperature, density, etc from place to place in the interstellar medium. ∗
(b) The atmosphere of the Earth is formed of gases. That is not true for the interstellar medium
(c) There is no particulate matter (small solid particles) in the interstellar medium.
(d) The elements in the interstellar medium are not found in the atmosphere and ocean of the Earth
(e) The interstellar medium is opaque to visible light.

13. Which of the following astronomical facts or laws shows that the universe had

a beginning
(a) Wien's Law
(b) Hubble's Law ∗
(c) Maxwell's equations
(d) the period-luminosity relationship for variable stars
(e) the galactic quaternion relationship

14. In the early evening in summertime, we see many globular star clusters in the sky. In the early evening in the winter there are none. This basic observations indicates which of the following?
(a) the direction to the center of the Milky Way ∗
(b) the evolutionary history of star formation in the Milky Way
(c) the direction to the Virgo Cluster
(d) the expansion of the universe
(e) the luminosity of globular clusters

15. Which kind of astronomical object permits us to measure the distances to nearby galaxies?
(a) Type II supernovae
(b) planetary nebulae
(c) red dwarf stars
(d) cataclysmic variable stars
(e) Cepheid variable stars ∗

16. What kind of galaxy is the Milky Way?
(a) elliptical galaxy
(b) barred spiral galaxy ∗
(c) irregular galaxy
(d) radio galaxy
(e) quasar

17. Where is the Sun located in the Milky Way?
(a) in the galactic disk, and at the center of the Milky Way
(b) in the general spherical distribution of stars in the Milky Way, and about 10,000 light years from the center
(c) in the galactic disk, about 25,000 light years from the center ∗
(d) approximately 5,000 light years above the disk of the Milky Way
(e) the Sun is not located in the Milky Way

18. Which of the following statements correctly describes the motion of the sun in space?

(a) The Sun is moving in a random path through space, scattering off of other stars, and its path cannot be described in terms of simple mathematical curves.
(b) The Sun is moving in an elliptical orbit centered on the Andromeda Galaxy.
(c) The Sun moves in a circular orbit around the center of the Milky Way. ∗
(d) The Sun is too massive to move, and is therefore stationary in space.
(e) The Sun moves on a linear orbit in which it falls into the galactic center, then travels to great distances from the galactic center.

19. General Relativity is a physical theory which describes
(a) gravity. ∗
(b) nuclear forces.
(c) quantum mechanics.
(d) the ultimate vagueness and uncertainty in our knowledge of the universe.
(e) electricity and magnetism.

20. How do we measure the mass of galaxies, as well as the way in which that mass is distributed? By measuring
(a) how the orbital speed of stars depends on distance from the center of the galaxy ∗
(b) the brightness of starlight as a function of distance from the center of the galaxy
(c) the Zeeman effect of neutral hydrogen gas at different distances above the galaxy
(d) how fast they move around in clusters of galaxies
(e) the change in masses of brightest stars at different distances from the center of the galaxy

21. Most of the mass in the Milky Way is in the form of
(a) stars like the Sun
(b) Dark Matter ∗
(c) stars more massive than the Sun
(d) helium gas
(e) massive planets like Jupiter

22. How do we know the distances to very distant galaxies, billions of light years away?
(a) We measure the speed at which they are receding, and apply Hubble's Law. ∗
(b) We use the known absolute magnitudes of Cepheid variable stars to give us the distance modulus, and thus the distance.

(c) We measure the parallaxes of brilliant objects at the nuclei of these galaxies.
(d) We use measurements of the Fizeau effect, which relates distance to the polarization of the light.
(e) We know the times of giant explosions in these galaxies, then measure the time the light signals arrive at Earth.

23. The physical significance of the Hubble Constant is that it
(a) corresponds to the time since the universe began to expand. ∗
(b) gives the total mass of the universe.
(c) represents the age of the Sun.
(d) represents the age of the solar system.
(e) proves the validity of General Relativity.

24. We believe that there are huge black holes at the centers of many galaxies. An observation which indicates this is
(a) measurement of the Schwarzschild radius of objects at galactic centers.
(b) the phenomenon of "gravitational lensing", which is seen in many clusters of galaxies.
(c) dark regions at the centers of many galaxies.
(d) radio galaxies and quasars, which show filaments or jets of radio emission going into the very centers of these objects. ∗
(e) the presence of luminous pulsars in the Virgo Cluster.

25. The objects responsible for the huge power output of quasars are
(a) supergiant stars in the centers of galaxies, where the collision of matter and antimatter results in direct conversion of mass to energy.
(b) supermassive white dwarfs in the middle of clusters of galaxies.
(c) larger pulsars than we observe closer to us, with very much larger magnetic fields.
(d) black holes at the centers of galaxies, with 5 - 10 solar masses.
(e) black holes at the centers of galaxies, with 1 to 10 billion solar masses.∗

26. What is the evidence that "Dark Matter" exists?
(a) The gravitational forces active in galaxies, and clusters of galaxies, are larger than can be accounted for from matter in stars and other known forms. ∗
(b) It has been demonstrated that in galaxies, the gravitational force between two pieces of matter does not decrease as the inverse square of the distance.
(c) We have evidence that in the centers of galaxies, matter consists purely of protons, with no electrons accompanying them.

(d) The brightness of the light from galaxies rather sharply drops off at distances greater than about 10 kiloparsecs, indicating that the matter further out is not emitting light.
(e) Cosmic rays exist at much higher energies than can be explained by any of our theories, so they must be composed of a new type of particle which is called by this name.

27. How old is the universe?
(a) 270,000 years
(b) 500 million years
(c) 200 billion years
(d) 14 billion years ∗
(e) 4.5 billion years

28. The best guess about the nature of the Dark Matter, which is consistent with the largest amount of independent evidence, is that it consists of
(a) very cold, dim stars in the halos of galaxies.
(b) fundamental particles that have not previously been seen in any physics experiments. ∗
(c) neutron stars that are not detected in any other way.
(d) white dwarf stars.
(e) massive iceballs similar to giant comets.

29. Which of the following is a true statement about the nature of the universe in which we live?
(a) Clusters of galaxies are all moving away from each other. ∗
(b) Clusters of galaxies are all moving closer together.
(c) New matter is always coming into existence between clusters of galaxies.
(d) The laws of physics were much different in the remote past.
(e) The primary properties of the universe are, and always have been, the same.

30. According to the physical theory of the universe called a *Friedmann Universe*, the future behavior of the universe is determined by one, and only one present characteristic. Which is it?
(a) the fraction of stars which are high mass stars relative to low mass stars
(b) the chemical composition of the stars that make up the universe
(c) the relative abundance of spiral and elliptical galaxies
(d) the average density of the universe ∗

(e) how much of the matter in the universe is Dark Matter, and how much is ordinary matter

31. In class I spoke about the concept of "Dark Energy". The reason for thinking Dark Energy exists is observations which show
(a) a lack of visible light in the outer parts of large spiral galaxies.
(b) the existence of black holes with masses between 5 and 15 solar masses.
(c) otherwise-unexplainable dark regions against the cosmic background radiation.
(d) that the universe is closed, and will begin to contract in approximately 5.4 billion years.
(e) that the expansion of the universe has begun to accelerate. ∗

32. One of the important terms in cosmology is that of a "critical density". What is the meaning of this term?
(a) Within a Friedmann model of the universe, the critical density is the density which separates continued expansion of the universe from eventual contraction. ∗
(b) Within a Friedmann universe, the critical density is the minimum density which will allow stars to form.
(c) The critical density is another name for the Hubble Constant.
(d) If the true density in the universe is less than the critical density, galaxies will begin receding from each other.
(e) The critical density is the energy density contained in the form of Dark Energy.

33. Tonight, if you go out and look in the eastern sky at 9PM, you will see stars that did not rise until much later at the beginning of the semester. This basic phenomenon is due to
(a) the rotation of the Earth on its axis
(b) the fact that the Earth is closer to the Sun at some times of the year than others
(c) General Relativistic aberration effects
(d) the orbital motion of the Earth around the Sun ∗
(e) the motion of the Sun in its orbit through the galaxy

34. The theory of General Relativity is crucial for understanding two topics that were discussed in this course. These two topics were
(a) main sequence stars and the shape of the Milky Way
(b) white dwarf stars and neutron stars

(c) the planet Mars and the Jovian planets
(d) black holes and the evolution of the universe ∗
(e) the formation of stars and distances to galaxies

35. The main sequence lifetime of the Sun is
(a) 4.5 billion years
(b) 13.7 billion years
(c) 350 million years
(d) 10 billion years ∗
(e) 74.8 billion years

36. Imagine that you are on a planet around a star which is at the same distance from the center of M87, the principal galaxy in the Virgo Cluster and a giant elliptical galaxy, as the Sun is from the center of the Milky Way. When you looked at the night sky on that planet, what would be a striking difference with the night sky we see here on Earth?
(a) There would not be the band of light across the sky that we see as the Milky Way. ∗
(b) There would be no naked eye galaxies visible
(c) There would be only 7 or 8 stars visible to the naked eye; all others would be too faint to be seen
(d) The sky would be dominated by the bright glare of the Cosmic Background Radiation
(e) There would be 10 to 12 times as many planets visible in the sky.

37. We see many stars in the night sky. To what extent are they the same and to what extent different?
(a) Stars are very similar, differing by only about 7 percent in mass and surface temperature.
(b) The stars have a huge range of masses, temperatures and luminosities. They share the property that they obtain their energy from nuclear reactions. ∗
(c) The range of masses of stars is from about 85 % that of the Sun to about 123 %. The surface temperatures range from 10000 K to 25000K. It is the luminosity range which is the largest. It ranges from that of the Sun at the lowest to several hundred times the luminosity of the Sun.
(d) The different stars in the night sky are totally dissimilar objects. Astronomers have been unable to find any similarity or relationships between them.
(e) To the best of our ability to determine, all stars except the red giants and

red supergiants are indistinguishable from the Sun.

38. Approximately how far away are the nearest stars?
    (a) 10 - 100 Megaparsecs
    (b) 30 - 50 astronomical units
    (c) a few light years ∗
    (d) at least 5 million miles
    (e) a few kiloparsecs

39. Very far in the future, the Sun will end up as one of the following types of astronomical object. Which is it?
    (a) neutron star
    (b) supernova
    (c) molecular cloud
    (d) elliptical galaxy
    (e) white dwarf ∗

40. When you notice differences in the brightness of stars in the night sky, you are detecting differences in which one of the following stellar parameters?
    (a) absolute magnitude
    (b) apparent magnitude ∗
    (c) spectral type
    (d) luminosity
    (e) color temperature