

ASTR 1120-001 Final Examination  
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FINAL EXAM MAY 6<sup>th</sup> 2006: Closed books and notes, 1.5 hours. Please PRINT your name and student ID on the places provided on the scan sheet. ENCODE your student number also on the scan sheet.

Questions 1-25 are based on the first two thirds of the class

1. The frequency of a wave is:

- (a) Measured in seconds
- (b) The distance between crests of the wave
- (c) The distance between troughs of the wave
- (d) The number of peaks passing by any point per second**
- (e) The same for all forms of electromagnetic radiation

2. Sunspots are observed as:

- (a) Dark spots in the Solar corona
- (b) Bright regions in the Solar corona
- (c) Dark spots on the Solar photosphere**
- (d) Bright regions on the Solar photosphere
- (e) Places where no light is emitted by the Sun

3. From short to long wavelengths, the correct order of the electromagnetic spectrum is:

- (a) Ultraviolet, X-rays, visible, infrared, radio
- (b) X-rays, visible, ultraviolet, infrared, radio
- (c) Ultraviolet, X-rays, visible, radio, infrared
- (d) X-rays, ultraviolet, visible, infrared, radio**
- (e) Radio, infrared, visible, X-rays, ultraviolet

4. Planetary systems around other stars are hard to detect primarily because:

- (a) Dim light from the planet is hard to see against the glare of the star**
- (b) Jupiter mass planets are extremely rare
- (c) Jupiter mass planets are fairly abundant, but often have elliptical orbits around their star
- (d) Massive stars are the most common type of star, and these have short lifetimes

5. You observe 2 stars and note that star A appears blue while star B appears red. From this, you deduce:

- (a) The photosphere of star A is hotter than star B**
- (b) The photosphere of star B is hotter than star A
- (c) Nothing can be deduced about the surface temperature from this observation

6. Which object emits more infrared radiation?

- (a) The Earth
- (b) The Sun
- (c) A star that is the same size as the Sun, but twice as hot**
- (d) A star that is the same size as the Sun, but cooler
- (e) A brown dwarf

7. A thermal spectrum depends upon:

- (a) The temperature and density of the emitting source
- (b) The temperature and composition of the emitting source
- (c) The temperature of the source only**
- (d) The density of the source only
- (e) The composition of the source only

8. The Sun derives energy today primarily from:

- (a) The glow from a very hot plasma
- (b) The combining of light elements into heavier ones**
- (c) The breaking apart of heavy elements into lighter ones
- (d) Nuclear fission
- (e) Radioactive processes

9. Neutrinos are difficult to detect because;

- (a) They pass through matter with only a small probability of interactions**
- (b) They travel at the speed of light
- (c) They have less energy than photons
- (d) They have zero rest mass
- (e) Muon neutrinos and tau neutrinos can change into electron neutrinos before reaching Earth

10. The net result of hydrogen burning (nuclear fusion) in the Sun today is that:

- (a) Iron and other heavy elements are synthesized from hydrogen
- (b) Helium nuclei are formed, and energy and neutrinos are absorbed
- (c) Individual protons are linked into long chains of protons
- (d) Energy is liberated as electrons fall into the ground state of helium atom
- (e) Helium nuclei are formed, and energy and neutrinos are emitted**

11. A pulsar is:

- (a) A type of star subject to pulsational instability
- (b) A binary black hole
- (c) A white dwarf
- (d) A Kerr black hole
- (e) A type of rotating neutron star**

12. The average density of matter would be lowest in which type of star?

- (a) A red giant star**
- (b) A star like the Sun
- (c) A white dwarf
- (d) A neutron star

13. Astronauts in the Space Shuttle feel weightless because:

- (a) Of the vacuum in space
- (b) The Space Shuttle moves in a straight line while in orbit
- (c) There's no gravitational force from the Earth acting on the Space Shuttle
- (d) The Space Shuttle is free falling while in orbit**

14. If you stand on weighing scales in an elevator, your weight varies noticeably depending upon:

- (a) The velocity of the elevator
- (b) The acceleration of the elevator**
- (c) The height of the elevator above ground level

15. Which of the following is *not* relative in the Special Theory of Relativity:

- (a) Intervals of time
- (b) Motion
- (c) Lengths
- (d) The speed of light**

16. The effects predicted by Special Relativity are not normally noticed in everyday life because:

- (a) **Everyday velocities are small compared to the speed of light**
- (b) The Earth's gravity is extremely weak
- (c) The Earth is free falling as it orbits the Sun
- (d) Typically we experience only very small accelerations
- (e) The Earth is not an inertial frame, so Special Relativity does not apply

17. The Principle of Equivalence can be stated as:

- (a) The results of experiments conducted by moving observers are equivalent
- (b) **The effects of gravity and acceleration are equivalent**
- (c) Experiments conducted by accelerating observers are equivalent to those carried out by stationary observers
- (d) The effects of velocity and gravity are equivalent

18. As we look at stars closer and closer to the exact center of the Milky Way galaxy, the velocities of the stars:

- (a) Decrease
- (b) Stay the same
- (c) **Increase**

19. Adaptive optics is a technique used:

- (a) To correct images taken by the Hubble Space Telescope
- (b) To overcome the effect of dust obscuration toward the Galactic Center
- (c) **To mitigate the distortion caused by the Earth's atmosphere**
- (d) To improve the resolution of radio telescopes
- (e) To allow the accurate measurement of apparent brightness

20. Those gamma-ray bursts with longer durations (10s of seconds) are thought to arise from:

- (a) The merger of binary neutron stars
- (b) **The collapse of the cores of very massive stars**
- (c) The merger of a black hole with a neutron star
- (d) Planetary nebulae
- (e) Their origin remains a complete mystery

21. A Hertzsprung-Russell diagram for stars displays the relationship between:

- (a) Stellar mass and stellar luminosity
- (b) Stellar mass and stellar surface temperature
- (c) **Stellar luminosity and stellar surface temperature**
- (d) Stellar luminosity and stellar radius
- (e) Stellar radius and stellar mass

22. Which of the four fundamental forces is intrinsically the weakest?

- (a) Electromagnetism
- (b) **Gravity**
- (c) Weak nuclear force
- (d) Strong nuclear force

23. Suppose that another star, just like the Sun, collided and merged with the Sun (this happens very very rarely in dense places such as globular clusters). The new star would be:

- (a) Hotter (at the surface) and longer lived than the Sun
- (b) **Hotter and short lived compared to the Sun**
- (c) Cooler and longer lived than the Sun
- (d) Cooler and short lived compared to the Sun

24. When two black holes collide, some energy is lost in the form of gravitational radiation. If each of the original black holes has a mass of 10 Solar masses, the final black hole formed after the merger will have a mass of:

- (a) 20 Solar masses
- (b) Less than 20 Solar masses**
- (c) More than 20 Solar masses

25. A star made entirely of iron could derive a large amount of energy from:

- (a) Nuclear fusion
- (b) Nuclear fission
- (c) Contracting or collapsing**
- (d) Radioactive decay
- (e) Neutrino emission

Questions 26-75 are based on the final third of the class

26. Matter and antimatter can be created in the early Universe because:

- (a) Of the rapid expansion that we call inflation
- (b) Of dark energy
- (c) It was very hot and photons had very high energies**
- (d) The early Universe was smooth and uniform in different places

27. Which kind of rotation curve provides the most convincing evidence for dark matter in spiral galaxies such as the Milky Way?

- (a) A falling rotation curve at large radii
- (b) A flat rotation curve at distances beyond most of the visible stars**
- (c) A steeply rising rotation curve close to the center of the galaxy
- (d) A Keplerian rotation curve similar to that of the planets in the Solar System
- (e) Large random velocity components in addition to rotation

28. Evidence that the expansion of the Universe may now be accelerating comes primarily from observations of:

- (a) The Cosmic Microwave Background
- (b) Distant supernovae**
- (c) Galaxy rotation curves
- (d) Clusters of galaxies

29. A spectral line of hydrogen from Galaxy A is observed to have a wavelength of 660 nm, while the same line from Galaxy B has a wavelength of 700 nm. From this, you would conclude:

- (a) That Galaxy A is further away than Galaxy B
- (b) That Galaxy B is further away than Galaxy A**
- (c) That Galaxy B is likely approaching us at high speed
- (d) That there is intervening transparent gas between us and Galaxy B
- (e) That Galaxy B is more likely to be an elliptical Galaxy

30. Having measured the velocity of a galaxy, Hubble's Law would not give a reliable estimate of the distance in which of the following situations:

- (a) A bright galaxy in the Local Group of galaxies**
- (b) A galaxy in a moderately distant cluster of galaxies
- (c) Spiral galaxies
- (d) Elliptical galaxies
- (e) Galaxies involved in ongoing mergers

31. Dark matter can best be described as:

- (a) A consequence of Einstein's theory of General Relativity
- (b) Cool gas that emits little radiation in elliptical galaxies
- (c) Unseen mass whose gravity affects the observed motion of gas and stars**
- (d) A force or substance that is causing the expansion of the Universe to accelerate

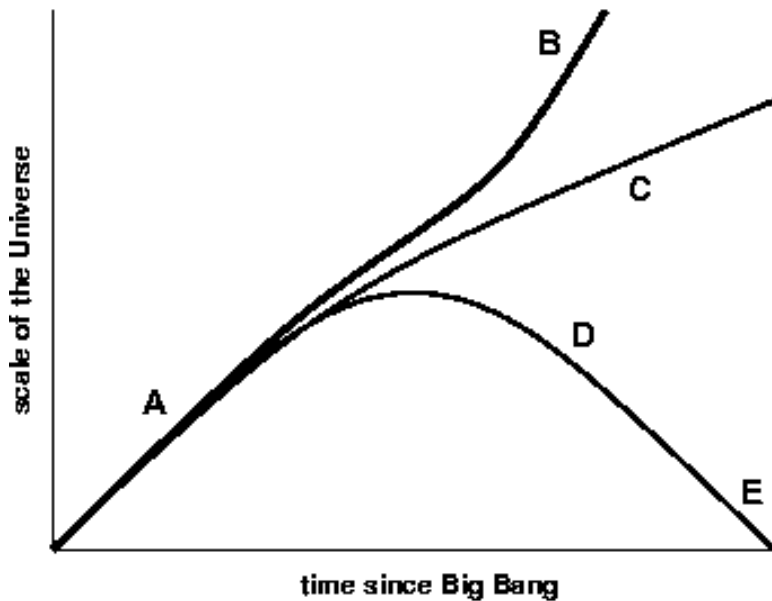
32. As the Universe aged, it passed through eras in which different physical processes occurred. In sequence, these are believed to be:

- (a) Nucleosynthesis, inflation, recombination
- (b) Inflation, nucleosynthesis, recombination**
- (c) Recombination, inflation, nucleosynthesis
- (d) Nucleosynthesis, recombination, inflation

33. If the rotation curve of a galaxy were observed to rise steadily with distance beyond the visible extent of the galaxy's disk you would conclude that:

- (a) The mass of the galaxy was concentrated in the center
- (b) It's mass distribution is very similar to that of the Milky Way
- (c) It's especially rich in dark matter**
- (d) Dark energy dominates the rotation of the galaxy

The next 5 questions refer to the following schematic figure showing how the scale of the Universe evolves with time in different cosmological models



34. In which Universe would the average density be highest? **E**

35. In which Universe would we expect to find evidence for dark energy? **B**

36. At which point would we expect the distribution of matter to be smoothest? **A**

37. Observations suggest that at the current time we are closest to living in which Universe? **B**

38. When we observe very high redshift galaxies and quasars, the light we see was emitted when the Universe was closest to which point? **A**

39. The environment of the Milky Way is that of:

- (a) **A galaxy group**
- (b) A galaxy cluster
- (c) A void region of the Universe

40. Hubble's Law means that:

- (a) The age of the Universe is about 5 billion years
- (b) The Milky Way lies at the center of the Universe
- (c) **A galaxy twice as far away is typically receding at twice the velocity**
- (d) A galaxy twice as far away is typically receding at four times the velocity
- (e) Light from most galaxies is blueshifted

41. You observe two supernovae (of the type that are good standard candles). Supernova 2006a is 9 times brighter (in apparent brightness) than supernova 2003f. You deduce:

- (a) 2006a is 3 times as far away as 2003f
- (b) 2006a is twice as far away as 2003f
- (c) 2006a is at half the distance of 2003f
- (d) **2006a is at one third the distance of 2003f**

42. Galaxies are classified as spirals, ellipticals, or irregulars based primarily on:

- (a) Their luminosity
- (b) **Their appearance**
- (c) Whether there is a bar or not in the center of the galaxy
- (d) Whether they are part of a galaxy cluster

43. Which type of galaxy is not observed to be forming stars at the present time?

- (a) Spirals
- (b) **Ellipticals**
- (c) Irregulars

44. Which type of galaxy's appearance can often be explained as a consequence of ongoing interactions or mergers with other galaxies?

- (a) Spirals
- (b) Ellipticals
- (c) **Irregulars**

45. The Milky Way galaxy in which we live is a:

- (a) **Spiral galaxy**
- (b) Elliptical galaxy
- (c) Irregular galaxy

46. The observation that the cosmic microwave background radiation has a thermal spectrum suggests:

- (a) That the Universe was very smooth when the radiation was produced
- (b) **That the radiation originates from a time when the Universe was opaque to photons**
- (c) That the radiation has interacted with gas along the line of sight
- (d) That the photons have been highly redshifted since when they were emitted
- (e) That the radiation originates from the era of nucleosynthesis

47. The observation that the cosmic microwave background radiation is observed to come from all directions with only very small departures from isotropy suggests:

- (a) **That the Universe was very smooth when the radiation was produced**
- (b) That the radiation originates from a time when the Universe was opaque to photons
- (c) That the radiation has interacted with gas along the line of sight
- (d) That the photons have been highly redshifted since when they were emitted
- (e) That the radiation originates from the era of nucleosynthesis

48. Measuring Hubble's constant is a difficult task because:

- (a) Measuring the velocity of distant galaxies is extremely difficult
- (b) Measuring the distance to distant galaxies is extremely difficult**
- (c) The 'constant' changes with time
- (d) Of the confusing effects caused by dark energy

49. A standard candle refers to a class of astronomical objects with the property that:

- (a) Their luminosity is known independent of their distance**
- (b) The apparent brightness is a constant
- (c) Their distance is a constant independent of the brightness
- (d) Their luminosity is high enough to allow detection in distant galaxies

50. Which of the following objects make good standard candles?

- (a) White dwarf supernovae**
- (b) Planetary nebulae
- (c) Massive stars
- (d) Globular clusters
- (e) Spiral galaxies

51. The low temperature of the microwave background radiation suggests:

- (a) That the Universe was very smooth when the radiation was produced
- (b) That the radiation originates from a time when the Universe was opaque to photons
- (c) That the radiation has interacted with gas along the line of sight
- (d) That the photons have been highly redshifted since when they were emitted**
- (e) That the Universe was very cool at early times

52. Evidence for dark matter in galaxy clusters comes from:

- (a) X-ray emitting gas that is cooler, and galaxy velocities that are lower, than expected if there were no dark matter
- (b) X-ray emitting gas that is hotter, and galaxy velocities that are higher, than expected if there were no dark matter**
- (c) X-ray emitting gas that is cooler, and galaxy velocities that are higher, than expected if there were no dark matter
- (d) X-ray emitting gas that is hotter, and galaxy velocities that are lower, than expected if there were no dark matter

53. Hubble's constant has been measured to be about 70 km/s per Megaparsec. If future observations lead to a downward revision in the value of Hubble's constant to 65 km / s per Megaparsec, the inferred age of the Universe would:

- (a) Decrease
- (b) Stay the same
- (c) Increase**

54. A violent end to the Universe in a Big Crunch is most likely:

- (a) If the effects of dark energy are strong at the present time
- (b) If the mean density of matter in the Universe is very low
- (c) If the mean density of matter in the Universe is very high**
- (d) If the expansion is presently accelerating
- (e) If Hubble's constant is large

55. Observations suggest that a rough census of the constituents of the Universe might look like:

- (a) 70% dark energy, 15% dark matter, 15% ordinary matter
- (b) 70% dark energy, 25% dark matter, 5% ordinary matter**
- (c) 30% dark energy, 65% dark matter, 5% ordinary matter
- (d) 30% dark energy, 55% dark matter, 15% ordinary matter
- (e) 85% dark matter, 15% ordinary matter

56. The Big Bang is a theory in which the Universe at early times was:

- (a) Hot and dense**
- (b) Cool and dense
- (c) Hot and very low density
- (d) Cool and very low density

57. The most direct evidence for the Big Bang comes from observations of:

- (a) Distant galaxies
- (b) Distant supernovae
- (c) Galactic rotation curves
- (d) Hubble's Law
- (e) The Cosmic Microwave Background**

58. Helium is believed to have formed:

- (a) Within the first  $10^{-10}$ s after the Big Bang
- (b) Within the first few seconds after the Big Bang
- (c) Within the first few minutes after the Big Bang**
- (d) About 380,000 years after the Big Bang
- (e) When the Universe was about 10% of its current age

59. The best estimates for the age of the Universe are about:

- (a) 5 million years
- (b) 14 million years
- (c) 5 billion years
- (d) 14 billion years**
- (e) 50 trillion years

60. Dark matter within spiral galaxies appears to be distributed:

- (a) Primarily within the spiral arms
- (b) In a large spherical halo**
- (c) In a cluster surrounding the central black hole
- (d) In the same way as the stars and gas

61. The most likely candidate for dark matter is:

- (a) Stellar mass black holes
- (b) Cool gas
- (c) Very low mass stars that emit little light
- (d) An unknown elementary particle**
- (e) Hot gas

62. Galaxy collisions are more likely than collisions between stars within a galaxy because:

- (a) Relative to their sizes, galaxies are closer together than stars**
- (b) Galaxies have higher redshifts than stars
- (c) Galaxies have higher velocities than stars
- (d) Galaxies are longer lived than stars
- (e) All of the above



63. Which of the following observations cannot be easily explained by the Big Bang theory unless we assume than an era of inflation (or something similar) occurred:

- (a) The fact that about 25% of the ordinary matter in the Universe consists of helium
- (b) The fact that the Universe is expanding
- (c) The existence of the cosmic microwave background
- (d) The fact that the temperature of the microwave background is almost the same in all directions**
- (e) The fact that the density of the Universe is decreasing with time

64. The overall ratio of dark matter to ordinary matter in the Universe can best be estimated by making observations of:

- (a) Spiral galaxy rotation curves
- (b) Elliptical galaxy rotation curves
- (c) Clusters of galaxies**
- (d) Voids between the galaxies
- (e) Distant supernovae

65. Observations of rings, arcs and multiple images within clusters of galaxies are attributed to:

- (a) Gravitational lensing**
- (b) Galaxy mergers
- (c) The interaction of galaxies with the hot cluster gas
- (d) Cosmological redshift

66. Olber's paradox arises when we consider the question:

- (a) Why is the sky dark at night?**
- (b) Can we measure the position and momentum of a particle at the same moment?
- (c) Why some stars seem to have ages older than the estimated time since the Big Bang?
- (d) Why does the microwave background have the same properties in widely separated directions?
- (e) Why intelligent life, if it exists elsewhere in the Galaxy, has not made its presence known to us?

67. Suppose that we lived in a Big Crunch Universe at a time when it was contracting, rather than expanding. If you measured the velocities of many galaxies, you would find that typically:

- (a) Galaxies (except very nearby ones) were moving away from you, with the most distant ones moving away the slowest
- (b) Galaxies are moving toward you, with the most distant ones approaching the most rapidly**
- (c) Galaxies are moving toward you, with the most distant ones approaching the slowest

68. Recombination is the epoch in the history of the Universe when:

- (a) Most of the helium in the Universe formed
- (b) Atoms first formed as the Universe cooled**
- (c) Heavy elements such as iron formed
- (d) Inflation is believed to have ended
- (e) The first stars and galaxies formed

69. The largest scale anisotropy in the Cosmic Microwave Background is caused by:

- (a) The rotation of the Universe
- (b) The motion of the Earth around the Sun
- (c) Doppler shift due to the motion of the Milky Way**
- (d) Quantum fluctuations in the very early Universe

70. When ultraviolet light from hot stars in a very distant galaxy reaches us, it might be observed as:

- (a) X-rays
- (b) Slightly more energetic ultraviolet light
- (c) Visible light**

71. Virtually all galaxies in the Universe appear to be moving away from our own because:
- (a) We are located close to where the Big Bang happened
  - (b) We are near the center of the Universe
  - (c) Observers in all galaxies would see a similar phenomenon due to the expansion of the Universe**
72. The current temperature of the Universe (as measured by the microwave background) is:
- (a) Absolute zero
  - (b) A few degrees**
  - (c) A few thousand degrees
  - (d) A few million degrees
73. The earliest time in the Universe that we can *directly* observe (using photons) is:
- (a) A few minutes after the Big Bang
  - (b) A few years after the Big Bang
  - (c) A few hundred thousand years after the Big Bang**
  - (d) A few hundred million years after the Big Bang
74. Roughly how many galaxies are there in a rich cluster of galaxies?
- (a) A handful
  - (b) About 10
  - (c) 100 or more**
75. Strong evidence for the existence of dark matter comes from observations of:
- (a) Clusters of galaxies**
  - (b) The Solar System
  - (c) The center of the Milky Way galaxy
  - (d) Particle physics experiments conducted on Earth
  - (e) Low mass stars

**Thank you for your attention during the semester! Please check that WebCT accurately reports your clicker, homework, midterm and extra credit scores, and notify me of any problems. If I agreed to scale your scores due to a missed midterm or homework (beyond the one homework that is automatically dropped) that will not show on WebCT immediately. Official grades for the class have to be submitted on Thursday, and should be available through the University system shortly thereafter.**

**We hope that you enjoyed the class and wish you a great summer... Phil Armitage & Bruce Ferguson**