Stars, Galaxies and the Universe (29:50 – Dr. Lang)
Final Exam - December 15th 2005
Form A

1. What is dark energy?
   (a) matter which is not detectable visually, but by the effects of gravity
   (b) matter which is detected visually but is very cold
   (c) a little understood component of the universe which causes the universe's expansion to accelerate
   (d) the material which resides in black holes
   (e) a component of the universe which is not very important compared to dark matter

2. WMAP is a satellite which made which important discovery?
   (a) the detection of the first EM radiation from the early universe
   (b) the first detection of an extrasolar planet around a star
   (c) the detection of the faintest brown dwarf star known
   (d) that the universe is full of dark matter
   (e) that the Big Bang did not happen

3. Why does the Cosmic Microwave Background have a measured temperature of 3 K?
   (a) it was very cold (near absolute zero) in the early universe
   (b) the early universe was not very dense and lost its energy easily
   (c) it is an "average" temperature; parts of the early universe were hot, others cold
   (d) the radiation has cooled greatly because of the expansion of the universe
   (e) its an optical illusion due to the fact the Earth is moving through space rapidly

4. Most searches for extra-terrestrial intelligence are carried out at radio wavelengths because
   (a) it is likely that extra-terrestrial beings will have developed radio transmitters before more complex lasers or infrared light transmitters
   (b) interfering radiation is "quietest" in the radio part of the EM spectrum
   (c) there are many amateur radio operators who could help to search for such signals
   (d) radio signals carry the most amount of information per unit time
   (e) radio signals travel the fastest through interstellar space

5. The winter solstice will occur next week. In astronomy, what does this signify?
   (a) the most auspicious day for a wedding
   (b) the time of year when day and night are equal
   (c) the most Northerly location of the Sun in the sky
   (d) when the paths of the celestial equator and the ecliptic intersect
   (e) the most Southerly location of the Sun in the sky

6. What is the approximate age of our universe?
   (a) 5 million years
   (b) 10 million years
   (c) 4.5 billion years
   (d) 14 billion years
   (e) 30 billion years

7. What is the most common element in the universe?
   (a) hydrogen
   (b) helium
   (c) oxygen
   (d) iron
   (e) all elements have equal proportions in the universe

8. Which of the following is a true statement, explaining why astronomers are interested in the metallicity of stars?
   (a) a “metal rich” star formed earlier in the universe than a “metal poor” star
   (b) a “metal poor” star is more massive than a “metal rich” star
   (c) metallicity has nothing to do with when a star formed
   (d) a “metal poor” star formed earlier in the universe than a “metal rich” star
   (e) a “metal rich” star is brighter than a “metal poor” star

9. If you see the moon rising at sunset, which phase of the moon?
   (a) first quarter
   (b) third quarter
   (c) new moon
   (d) full moon
   (e) there is not enough information to determine

10. Which of the following types of electromagnetic radiation travels the fastest through the vacuum of space?
   (a) x-ray radiation
   (b) ultraviolet radiation
   (c) infrared radiation
   (d) radio waves
   (e) none of them – the speed of light travels at a constant speed in a vacuum

For the following questions, match the type of interstellar media with the appropriate and best description from the choices given below. All choices will be used once.

11. Ionized gas
12. Atomic gas
13. Molecular gas
14. Dust
15. Debris disk

(a) studied by the spin-flip transition in the radio part of the EM spectrum
(b) the location of gas and dust out of which planets form
(c) cold (T~10 K) gas out of which stars form
(d) detected by absorption and scattering of EM radiation
(e) gas which is heated by nearby hot (T~20,000 K) stars

16. Which distance indicator can you use to determine the distance to the most distant galaxies in the universe?
(a) Mira variable star
(b) Quasar
(c) Pulsar
(d) Supernova Type I explosion
(e) Cepheid variable star

17. Hubble's Constant H_o tells us about which of the following?
(a) the rate of expansion of the universe
(b) the density of galaxies in the distant universe
(c) how bright the early universe was
(d) the temperature of the universe now
(e) the likelihood of life in the universe

18. Which of the following best approximates the distance to the nearest star (besides the Sun), the center of the Galaxy, the nearest spiral galaxy (in that order)?
(a) 100,000 light years, 1 million light years, 1 billion light years
(b) 1 billion light years, 1 million light years, 100,000 light years
(c) 1 AU, 100,000 light years, 1 million light years
(d) 4 light years, 25,000 light years, 2.5 million light years
(e) 25,000 light years, 100,000 light years, 2.5 million light years

19. Why must the Chandra X-ray Observatory orbit the Earth?
(a) the ozone and oxygen in the Earth's atmosphere absorb X-rays
(b) water vapor in the Earth's atmosphere scatters X-rays
(c) it is cheaper to put a telescope in space rather than on Earth
(d) x-rays pass through the Earth making it impossible to observe them on the surface
(e) putting a telescope in space makes it physically closer to other stars and galaxies

20. What two forms of energy are generated at the core of the Sun?
(a) neutrinos and sound waves
(b) gamma rays and x-rays
(c) protons and electrons
(d) neutrinos and neutrons
(e) neutrinos and gamma rays

21. How is the tilt of the Earth's axis responsible for a summer being warmer than winter?
(a) the Earth is closer to the Sun in summer due to the tilt of the Earth's axis
(b) the Sun is more directly overhead in summer due to the tilt of the Earth's axis
(c) the Sun's tidal pull is stronger in summer due to the tilt of the Earth's axis
(d) the Sun rises due East in the summer
(e) the tilt of the Earth's axis is not responsible for the seasons

22. How is the length of a star's lifetime related to its mass when it is on the main sequence?
(a) a star's lifetime has no relation to its mass; only its luminosity
(b) the lifetimes of stars are too long to measure, so their dependence on mass is not known
(c) lower mass stars run through their lives more quickly and have shorter lifetimes
(d) higher mass stars run through their lives more quickly and have shorter lifetimes
(e) a star's lifetime only depends on its surface temperature

23. Active galaxies (quasars, radio galaxies, AGNs) appear to be
(a) very distant, intrinsically luminous objects
(b) bright galaxies in our Local Group
(c) very distant, bright galaxies moving toward us at high speeds
(d) galaxies very similar to the Milky Way or the Andromeda galaxy
(e) galaxies formed during the Big Bang

24. A planetary nebula is?
(a) the gas cloud surrounding a planet after its formation
(b) the spherical, rapidly expanding cloud of gas produced in a supernova
(c) the spherical shell of gas ejected from the surface of a red giant star
(d) the cloud of gas surrounding a massive star as it forms
(e) the debris disk of material which forms as part of a protostar

25. Observations suggest that dark matter is present in which of the following?
(a) our Galaxy
(b) many spiral and elliptical galaxies
(c) many dwarf galaxies
(d) clusters of galaxies
(e) all of the above

26. The source of energy in an active galaxy is?
    (a) many simultaneous supernova explosions going off
    (b) gas in an accretion disk radiating and falling onto a supermassive black hole
    (c) a vigorous burst of star formation
    (d) movement of gas in the outer parts of the galaxy at very high speeds
    (e) strong magnetic activity in the outer parts of the galaxy

27. Pulsars are the remnant of which type of star?
    (a) a star like the Sun
    (b) a white dwarf which undergoes nuclear fusion for a second time
    (c) a Red Giant
    (d) pulsars are not stars; they are quasars which emit pulsed radio emission
    (e) a massive star, 10-50 times the mass of the Sun

28. The interstellar medium has become enriched in heavy elements since it formed. What is responsible for the enrichment?
    (a) nuclear reactions in interstellar clouds
    (b) the infall of heavy elements from intergalactic space
    (c) the transformation of cosmic rays into heavy elements
    (d) nuclear reactions in massive stars, followed by supernova explosions
    (e) the collision of galaxies

29. A glowing hot solid object surrounded by cool gas will have which type of spectrum?
    (a) continuous radiation
    (b) it will appear red in color
    (c) emission lines
    (d) both emission and absorption lines
    (e) absorption lines

31. Which of the planets in our solar system has the lowest average density?
    (a) Earth
    (b) Venus
    (c) Mars
    (d) Pluto
    (e) Saturn

32. What does the plot below tell us about how Hubble's constant has changed over the history of the universe?

(a) that the rate of expansion has always remained constant
(b) that the rate of expansion has increased since the early universe
(c) that the rate of expansion has decreased since the early universe

33. Observations of which object in the distant universe can be used to help generate the data points on this plot?

(a) white dwarfs
(b) Sun-like stars
(c) rich clusters of galaxies
(d) Cepheid variable stars
(e) supernova Type 1 explosions

The next two questions refer to the two H-R diagrams below.

34. Which cluster is older?
35. Which cluster is likely to still have a 40 solar-mass star on the main sequence?

(a) Cluster A
(b) Cluster B
(c) Not enough information to determine this.

36. The rising and setting of stars at night is caused by which of the following motions?
(a) the motion of the Earth on its axis
(b) the motion of the Sun around the Milky Way Galaxy
(c) the motion of the Galaxy in the Local Group
(d) the motion of the Earth around the Sun
(e) the motion of the Sun on the ecliptic

37. Whose theories predicted that black holes should exist?
(a) Edwin Hubble
(b) Chandrasekhar
(c) Albert Einstein
(d) William Herschel
(e) Issac Newton

38. Which of the following elements are **not** created in nuclear fusion in a star like the Sun?
(a) helium
(b) carbon
(c) oxygen
(d) iron
(e) all of these elements are created in a star like the Sun

39. The Sun is kept from collapsing under its own gravity by
(a) neutrinos generated by nuclear fusion.
(b) a hard inner core.
(c) thermal (gas) pressure generated by nuclear fusion.
(d) thermal (gas) pressure left over from the Sun's own formation.
(e) the solar wind.

40. Which technique has discovered the largest number of “exoplanets” around other stars?
(a) Looking for variations in the star’s position in the sky, due to the gravitational pull of a planet orbiting the star.
(b) Looking for small Doppler shifts of the star’s spectral lines, due to the gravitational pull of a planet orbiting the star.
(c) Looking for excess infrared radiation from the star due to a planet.
(d) Using space-based telescopes to search for tiny pinpoints of light that follow circular or elliptical paths around the star.
(e) Using ground-based telescopes to search for slight changes in the brightness of a star, due to an eclipsing planet orbiting the star.

41. Which of the following has your ``universal address" in the correct order?
(a) you, Earth, solar system, Milky Way, Local Supercluster
(b) you, Earth, solar system, Local Group, Local Supercluster, Milky Way
(c) you, Earth, Local Group, Local Supercluster, solar system, Milky Way
(d) you, Earth, solar system, Milky Way, Local Supercluster, Local Group
(e) you, Earth, solar system, Milky Way, Local Group, Local Supercluster

42. Which planet was the brightest in the night sky during late October and early November?
(a) Jupiter
(b) Uranus
(c) Saturn
(d) Mars
(e) Venus

43. A star has a surface temperature which is twice as hot as the Sun – which of the following is a true statement?
(a) the star will have its peak intensity at a longer wavelength than that of the Sun
(b) the star will have twice as many sunspots as the Sun
(c) the star's internal temperature is twice as hot as the Sun
(d) the star is a Red Giant
(e) the star will have its peak intensity at a shorter wavelength than that of the Sun

44. Which three objects in the solar system (besides Earth) are likely candidates for finding evidence for some form of life?
(a) our Moon, Mars and Saturn
(b) Titan, Europa and Mars
(c) Europa, Io, and Jupiter
(d) Saturn, Jupiter and Neptune
(e) Venus, Mars and Mercury

45. What gets trapped in the Earth's Van Allen Belts?
(a) neutrinos from the Sun
(b) fast-moving charged particles from the solar wind
(c) cellphone signals from the Earth
(d) high energy photons from the core of the Sun
(e) alien spacecraft

Match each of the following objects with the following observational techniques used to detect the object (all choices will be used)

46. interstellar dust
47. atomic hydrogen
48. molecular gas
49. ionized gas
50. distant active galaxy

(a) emission of the H-alpha spectral line at 656.3 nm
(b) emission from the vibration and rotation of molecules
(c) the absorption of all visible light
(d) highly redshifted emission lines
(e) the spin-flip transition at a wavelength of around 20 cm