

PHYSICS 176: ASTRONOMY

Special Final Exam, September 3, 1999

Name:

Lab section and TA:

Score:

As a member of William and Mary community, I pledge not to lie, cheat or steal, either in my academic or personal life. I understand that such acts violate the honor code and undermine the community of trust of which we are all stewards.

Signed:

You have three hours to complete this exam. You may use a hand-held calculator and a single sheet of formulas. In the following, circle or underline the *best* answer. Mark your answer clearly. Ambiguous answers will be incorrect.

Possibly useful formulae or constants:

- $c = 3 \times 10^8$ m/s; $\lambda f = c$;
- (arc length) $s = R\theta$ (θ in radians);
- $A_{\text{circle}} = \pi R^2$; $V_{\text{sphere}} = 4/3 \pi R^3$;
- 1 radian = 57.3 deg.;
- 1 deg. = 60'; 1' = 60";
- 1 A.U. = 1.5×10^8 km;
- 1 nm = 1×10^{-9} m; 1 μ m = 1×10^{-6} m;
- $R_{\text{Earth}} = 6400$ km; $R_{\text{Sun}} = 700,000$ km;
- 1 pc = 3.3 LY = 3×10^{13} km = 2×10^5 A.U.

**A FREEBIE! NO RIGHT OR WRONG ANSWER!
PONDER IT FOR A FEW MOMENTS...OR A LIFETIME:**

What is your best guess regarding how common intelligent life is in the Universe?

- very common
- common, but not under every rock
- fairly rare, but not so scarce that we're 'alone'
- extremely rare, possibly we're unique

HAVE A GREAT SUMMER!

Jupiter is about ? times bigger in diameter than the Earth.

- 10
- 100
- 1,000
- 10,000

Approximately how many times more *massive* than the Earth is Jupiter?

- 1,000
- 10,000
- 300,000
- 1 million

An object has a parallax of 1 degree. What is the parallax for a similar object at twenty-five times this distance?

- 1/2 deg.
- 1/5 deg.
- 25 deg.
- 1/25 deg.

In a few *seconds*, light leaving Los Angeles will reach approximately as far as (choose the closest)

- San Francisco (about 500 km).
- London (roughly 10,000 km).
- the Moon (400,000 km).
- the Sun (150,000,000 km).

In about a *day* light leaving Los Angeles will reach approximately as far as (choose the closest match)

- the Sun
- Jupiter
- the Kuiper belt
- the Oort cloud.

Given that the distance to the Moon is 4×10^5 km and its angular size is 1/2 degree, calculate the Moon's diameter.

- 5,000 km
- 3,500 km
- 2,000 km
- 1,000 km

At 3 cm/yr, how long would it take a typical plate to traverse the present width of the Pacific Ocean, about 10,000 km?

- 250 million years
- 330 million years
- 200 million years
- 500 million years

The elapsed time between passage of two crests of a wave is its:

- wavelength
- frequency
- amplitude
- period

For which of the following forms of electromagnetic radiation is the Earth's atmosphere completely *transparent*?

- x-rays
- visible light
- ultraviolet
- all of these

How does the apparent brightness of light emitted by a supernova change with distance?

- It does not change.
- It is proportional to the distance.
- It is inversely proportional to the distance.
- It is inversely proportional to the square of the distance.

What is the wavelength of a 30 MHz radio signal?

- 100 m
- 10 m
- 1 m
- 10 cm

What is the frequency of a 30 nm photon?

- 2×10^{15} Hz
- 1×10^{14} Hz
- 1×10^{16} Hz
- 2×10^{14} Hz

A 2-m telescope can collect a given amount of light in 1 hour. Under the same observation conditions, how much time would be required for a 4-m telescope to perform the same task?

30 minutes 2 hours 15 minutes 4 hours

What is the cause of tectonic plate motion?

Earth's rotation
 convection in the upper mantle
 tidal forces from the Moon
 earthquakes

If you were standing on the *near* side of the Moon, which object(s) would *not* show phases?

Jupiter Earth Venus all of the above

Which of the following provides evidence that water once flowed on Mars?

runoff and outflow channels
 Valles Marineris
 Olympus Mons
 icecaps

What is the source of Jupiter's excess energy?

gravitational potential energy from its formation
 tidal heating by Io
 decay of radioactive elements
 greenhouse effect

What is the source of Io's volcanic activity?

radioactive decay of elements
 impacts from meteorites
 tidal heating by Jupiter
 excess heat emitted from Jupiter

What is the process that produces the Sun's energy?

burning of hydrogen and oxygen
 heat left over from its formation
 fusion of helium into heavier elements
 fusion of hydrogen into helium

What is the main-sequence (hydrogen core burning) lifetime for stars like the Sun?

10 million years 10 billion years
 100 million years 100 billion years

The Crab Nebula is now about 1 pc in radius. If it was observed to explode in A.D. 1054, roughly how fast is it expanding? (Assume constant velocity.)

100 km/s 1,000 km/s
 5,000 km/s 10,000 km/s

A 20-km radius neutron star is spinning 200 times per second. Find the speed of a point on its equator, and compare it with the speed of light. (Consider the equator as the circumference of a circle, and recall that $\text{circumference} = 2\pi r$.)

8 % speed of light .0008 % speed of light
 80 % speed of light .008 % speed of light

A major discovery made by Shapley using RR Lyrae stars and globular clusters established

That the spiral nebulae are actually galaxies outside the Milky Way.

That the spiral arms are regions of star formation.
 The size of the galaxy and the Sun's position in it.
 That globular clusters lie outside the Milky Way at large distances.

Where is active star formation most often found in the Galaxy?

halo disk galactic bulge spiral arms

According to Hubble's law, with $H_0 = 75 \text{ km/s/Mpc}$, what is the recessional velocity of a galaxy at a distance of 500 Mpc?

3,750 km/s 1,500 km/s
 37,500 km/s 15,000 km/s

What is the size of the largest observed structures in the universe?

50 Mpc 80 Mpc 200 Mpc 1000 Mpc

What is Olber's paradox?

Why is the sky dark at night?
 Why do we appear to be at the center of the expanding universe?
 Why is the Hubble law isotropic?
 Will the universe expand forever?

What happened at the *decoupling* transition in the standard Big Bang model?

Strong, weak, and electromagnetic forces were no longer one single force.
 electrons and nuclei combined to form atoms forming neutral hydrogen.
 Neutrons and protons were formed by combining quarks.
 Dark matter and baryonic matter no longer interacted.

Why is the possible discovery of water *ice* on the Moon important?

possible source of fresh water for Earth
 possible that life would form there
 possible use as a resource for human habitation of the Moon.
 proves the solar system formed over 4 billion years ago.

Why is the possibility of *liquid* water on Europa important?

possible source of cheap fresh water for Earth
 possible that life would form there
 the hydrogen can easily be used as rocket fuel
 proves the solar system formed over 4 billion years ago.

The star Betelgeuse has been measured by the Hubble Telescope to have a radius of about $7.5 \times 10^8 \text{ km}$. What is this in A.U.? About how far out would this extend if Betelgeuse were placed at the center of our solar system?

2.5 A.U., beyond Mars but not the asteroid belt
 2.5 A.U., beyond the Earth but not beyond Mars
 5 A.U., radius of Mars' orbit
 5 A.U. radius of Jupiter's orbit

Very roughly, how long would it take the expanding shell of a supernova to cross the Milky Way? To reach the Andromeda Galaxy? (Assume the shell expands at a constant velocity of .1 c.)

- 100,000 years for the Milky Way; 1 million years for Andromeda
- 1 million years for the Milky Way; 20 million years for Andromeda
- 1 million years for the Milky Way; 20 million years for Andromeda
- 10 million years for the Milky Way; 100 million years for Andromeda

A certain telescope can just detect the Sun at a distance of 1,000 pc. What is the maximum distance at which it could detect a supernova with a peak luminosity 10^{12} times that of the Sun?

- 10^7 pc
- 10^8 pc
- 10^9 pc
- 10^{10} pc

Astronomers have observed what they believe to be neutron stars by what means?

- gravitational lensing due to their strong gravity fields
- 'lighthouse' effect due to its rapid rotation
- gravitational redshift of hydrogen spectral lines
- neutrino detectors in mineshafts.

The original shape of the cloud of gas that first formed the Milky Way Galaxy might still be seen in the shape of the _____?

- disk
- halo
- galactic bulge
- spiral arms

The thickness of the Milky Way's disk in the vicinity of the Sun:

- 30 pc
- 300 pc
- 3,000 pc
- 30,000 pc

What evidence suggests that much of the matter in the Milky Way is 'dark'?

- large regions in the galaxy where no stars are seen
- faint radio emission suggesting large regions of cool matter which would not emit visible light
- the rotation velocity vs. radius of stars as they orbit the center of the Milky Way
- detection of gravity waves.

The motion of stars and gas clouds in the vicinity of the center of the Milky Way suggests that it houses a _____.

- wormhole
- very large star cluster of white dwarf stars
- very massive cloud of gas which is too cool to emit visible light
- supermassive black hole

A certain telescope can see a star like the Sun at a distance of 10,000 pc. The brightest Cepheids are 10,000 times the luminosity of the Sun. How far away can this telescope see these Cepheids?

- 10^9 pc
- 10^6 pc
- 10^8 pc
- 10^7 pc

Hubble's law relates which two observed properties of a galaxy?

- recessional velocity and luminosity
- distance and recessional velocity
- peak luminosity and distance
- rotation rate and luminosity

What is the approximate distance to Andromeda?

- 100 kpc
- 10 kpc
- 1 Mpc
- 10 Mpc

Which of the following is the accepted interpretation of Hubble's law?

- As galaxies move outward, they are replaced with new matter created to take its place.
- The farther away a galaxy is from us, the faster it is moving away, because of the Big Bang, much like an ordinary explosion.
- Galaxies are pulled apart as the intervening space expands over time.
- Galaxies are stationary but over time they evolve and redden, giving the appearance of motion.

What is the 'mainstream' explanation for the high redshifts observed in distant objects?

- They are rapidly moving away from us through the background space.
- They are at rest with respect to us, but the light has been gravitationally redshifted.
- Their light has lost energy over time while traveling this distance.
- In the time it took their light to reach us, the Universe expanded and, thus, their wavelengths have increased.

What is the origin of the cosmic microwave background?

- light remaining from the Big Bang
- the combined radiation of all objects too distant to see individually
- billions and billions of stars in the universe
- the total of all the synchrotron sources.

What type of spectrum is the cosmic microwave background?

- black-body
- emission line
- absorption line
- synchrotron

In the early Universe, when most of the energy was tied up in photons, what physical processes would have been common?

- pair creation and annihilation
- nuclear fission of heavy elements
- supernovae
- proton decay.

In the standard Big Bang model, once deuterium forms it is quickly converted into _____.

- helium
- carbon
- iron
- oxygen

At 15 minutes after the Big Bang (and after helium finished forming), what heavy element(s) formed?

- nitrogen
- oxygen
- carbon
- no other heavy elements formed

What is the most common type of galaxy?

- elliptical
- barred spiral
- irregular
- spherical

What future stages is our Sun likely to pass through as it dies?

- supernova
- carbon detonation
- red giant to white dwarf
- collapse to neutron star

What is plotted vs. what on an H-R diagram?

- temperature vs. size
- temperature vs. color
- temperature vs. absolute brightness
- absolute brightness vs. size

What two properties of a Cepheid variable are related to one another in such a way that we can estimate the distance to them?

- size is proportional to absolute brightness
- period is proportional to absolute brightness
- period is proportional to temperature
- size is inversely proportional to temperature

Very roughly: what is our best estimate for the age of the Earth?

- 10 billion years
- 4 billion years
- 1 billion years
- 100 million years

What causes sunspots?

- carbon build-up in photosphere
- magnetic fields
- condensation
- all of these