**The King's University College**
**Astronomy 201 Mid-Term Exam**
**Solutions**

**Instructions:** The exam consists of two sections. Part A is 20 multiple choice questions - please record answers on the sheet provided. Please answer the questions as completely as possible and record them in the booklet provided. You may use a calculator.
**Time Limit: 80 minutes**

## PART A Multiple Choice

1. Which of the following techniques - when applicable - will give the most reliable distance measurements:
   a. parallax measurement
   b. "standard galaxy" and/or brightest member methods
   c. supernovae brightness measurements
   d. Cepheid and RR Lyrae period - luminosity relation

2. Which of the following techniques would provide useful distances within our own galaxy and the local group of galaxies?
   a. parallax measurement
   b. "standard galaxy" and/or brightest member methods
   c. supernovae brightness measurements
   d. Cepheid and RR Lyrae period - luminosity relation

3. In the 1930s the Swiss-American astronomer Robert Trumpler showed that the galaxy was filled with "dust". How did this discovery change the distance measurements that had been done up to that time using the Cepheid Period-Luminosity relation?
   a. the distances were revised downward- ie the galaxy became "smaller".
   b. the distances were revised upward - ie the galaxy became "bigger".
   c. no change at all - dust didn't affect the periods
   d. the change was completely random - sometimes bigger, sometimes smaller.

4. Globular clusters are:
   a. association of several hundred stars that are evidence of recent star formation.
   b. large clusters of thousands to hundreds of thousands of stars that orbit the nucleus of our galaxy
   c. clusters of galaxies found in deep space
   d. proto-galaxies about to become elliptical galaxies

5. Which of the following are almost always found in the spiral arms of our galaxy:
   a. open clusters
   b. open clusters and globular clusters
   c. planetary nebulae
   d. young open clusters and hot, young stars

6. Two stars of similar spectral type are examined spectroscopically. Even though their hydrogen lines are similar, one of the stars has roughly one hundred times as much heavy element (ie. - greater than helium) content than the other star. This likely means that:
   a. the metal rich star is younger
   b. the metal rich star is much older
   c. the metal poor star is a Population I star
   d. the metal rich star is a Population II star

7. Which of the following facts are consistent with the spiral density wave theory of galactic structure:
   a. the spiral arms are traced by young O and B type stars
   b. hot open clusters are often found in the spiral arm region of our own galaxy
   c. hot stars embedded in emission nebulae are usually found in the spiral arms of galaxies.
   d. all of the above choices support the theory.

8. Galactic collisions are:
   a. exceedingly rare
   b. much less frequent than stellar collisions
   c. are common events in the lifetime of a galaxy which is the member of a cluster of galaxies.
   d. purely hypothetical - there is no compelling evidence for collisions.

9. Which anomaly is often cited as evidence for **dark matter**?
   a. the very low orbital velocities of the outer planets
   b. the high rotational velocities of the outer disks of most spiral galaxies
   c. the two distinct stellar population classes
   d. the phenomenon of the instability strip on the HR diagram

10. It is now believed that star formation began to occur before the collapse of the proto-galaxy into our present galaxy. Which of the following is evidence for this?
   a. the disk of the galaxy consists of mostly metal poor stars.
   b. the halo of the galaxy contains metal poor stars travelling with high velocities
   c. very hot stars are found primarily in the spiral arms of the galaxy
   d. in order for black holes and pulsars to exist very long time scales are needed.

11. How long does it take to send a radio message to the Virgo cluster which is 13 Mpc away?
   a. about as long as first class mail in Canada!
   b. about 13 million years
   c. about 50 million years
   d. about 100 million years

12. Which of the following is often cited as evidence for super massive black holes in the nuclei of some galaxies?
   a. bright, starlike cores that vary in brightness over short time intervals
   b. the abnormal rotational velocities of most spiral galaxies
   c. the absence of dust in elliptical galaxies
   d. the very high redshifts seen in some galaxies

13. An astronomer measures the position of the hydrogen alpha line for a star and finds that it is blue shifted by about 0.1%. This most likely implies that:
   a. the star is part of a binary system
   b. the star is moving away at about 3000 km/s
   c. the star is moving toward the astronomer
   d. the star is probably a quasar

14. Harlow Shapley determined the correct relationship between our sun and the center of the galaxy by
    a. discovering the Period-Luminosity relation
    b. measuring the distances to a large number of globular clusters and comparing that to their position in the sky.
    c. detecting the microwave emission of large hydrogen cloud complexes
    d. mapping the orbits of high velocity stars

15. Shapley's work was made possible by a fundamental discovery made by
    a. Heber Curtis
    b. Maria Mitchell
    c. Cecilia Payne
    d. Henrietta Leavitt

16. Stars forming in our galaxy today would be expected to
    a. have much lower metal abundances than the sun or stars that formed earlier in the history of the galaxy
    b. be primarily O or B type stars
    c. have enhanced metal abundances compared to the sun
    d. be high velocity stars travelling on orbits carrying them high above the galactic plane.

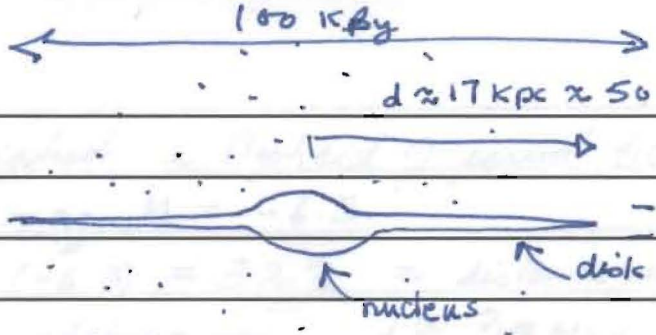
17. The Cosmological interpretation of redshifts is that:
    a. redshifts are due to gravitational effects and are not related to motion at all
    b. all redshifts are the result of the expansion of space and not motion of the object
    c. the increasingly large redshifts of distant galaxies are more a result of the expansion of space than intrinsic motion of the galaxies themselves
    d. redshifts arise from quantum mechanical processes that are still poorly understood

18. In the 1930's Edwin Hubble measured the "Hubble" constant to be 550 km/s/Mpc. Why was this a problem for astronomy?
    a. it implied that the universe was much younger than the earth!
    b. it was so large that it meant distant galaxies were moving faster than the speed of light
    c. it implied that the universe was far too old and that our sun would have become a white dwarf
    d. it predicted that the cosmic background radiation would be "clumpy" rather than smooth

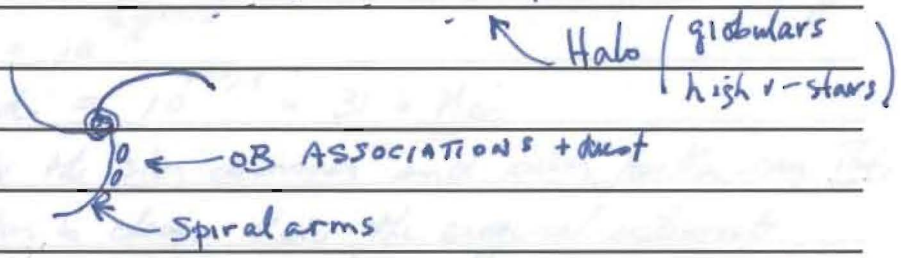
19. Olber's Paradox refers to the problem of explaining
    a. why the nighttime sky is a dark as it is
    b. why the background radiation is as homogeneous as it is
    c. how they got the Caramilk into the chocolate
    d. why there are no blue shifted quasars

20. The 2.7 K microwave background radiation is believed to be
    a. a remnant of energy left over from the formation of our galaxy
    b. the glow of the universe at the epoch that marked the end of the radiation dominated era and the beginning of the matter dominated era
    c. the radiation emitted by molecular clouds of hydrogen gas in our galaxy
    d. the radiation emitted by electrons spiraling in intergalactic magnetic fields.

#1) Galaxies




something like this:

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b) Spiral galaxies: 1) contain dust & new gstars (gaseous nebulae etc) star forming regions

2 2) found in outer parts of clusters of galaxies

Elliptical galaxies: no dust or new stars, very little gas no spiral arms
large ellipticals found in cluster centers

c) If most of the mass of the galaxy was concentrated in the center (nucleus) you would expect the velocity to be much lower the farther you move outward. The stars in the outer part of
3 the galaxy are moving much too fast. There must be much more mass in the outer part of the galaxy (halo region) - implies presence of dark matter

d) Galactic collisions should be relatively common - galaxies are large objects and distance between galaxies in a
2 cluster are comparable to the sizes of galaxies.

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2) a) From the graph supplied a Cepheid of period $60^d$ should
2 have an absolute mag $M = -6.3$

3 b) $m - M = 26 - (-6.3) = 32.3$ = distance modulus

3 c) from the distance modulus graph $d \simeq 20$ Mpc or by the formula $d = 10^{\frac{m-M+5}{5}}$

$\therefore d = 10^{37.3/5} = 31.6$ Mpc

2 d) Dust would make the star dimmer and seem farther away. This means that the star is closer than the original estimate.

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3) a) The recession of galaxies (Hubble's Law) is the most direct evidence for the expanding universe. The rate of expansion is essentially the same in all directions and gives us the
3 relation $V = Hd$

A key assumption is that the laws of physics are the same everywhere in the universe and there is no centre. Assumptions are: homogeneity, isotropy, universality

b) $V = Hd \quad \therefore d = V/H = \frac{(0.1)(300\,000 \text{ km/s})}{71 \text{ km/s/Mpc}}$

3 $V = zC$ if $z < 0.15$

$\therefore V = (0.1)(300\,000 \text{ km/s}) \quad \therefore d = 422.5$ Mpc

assume the distance & velocity are due to cosmic expansion

c) $t = 1/H \simeq$ age of universe & $H = 250$ km/s/Mpc would
2 imply a universe that was far too young!

d) There are 3 compelling arguments for dark matter:

i) abnormally high rotational velocity in outer parts of galaxies

2 ii) galaxies moving too fast in clusters

iii) gravitational lensing of background galaxies by foreground clusters of galaxies.

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