Name ____________________

Midterm Exam
October 20, 2017

This test consists of three parts. For the first and second parts, you may write your answers directly on the exam, if you wish. For the other parts, use separate sheets of paper.

Units	**Physical Constant**	**Black Body Radiation**
$1\text{ AU} = 1.496\times10^{11}\text{ m}$	$k_B = 1.381\times10^{-23}\text{ J/K}$	$u = \frac{\pi^2}{15}\frac{(k_B T)^4}{(\hbar c)^3}$
$1\text{ pc} = 3.086\times10^{16}\text{ m}$	$k_B = 8.671\times10^{-5}\text{ eV/K}$	$\lambda_{\max} T = 2.8978\times10^{-3}\text{ m}\cdot\text{K}$
$R_\odot = 6.955\times10^{8}\text{ m}$	$\sigma = 5.670\times10^{-8}\text{ W/m}^2\text{/K}^4$	
$M_\odot = 1.989\times10^{30}\text{ kg}$	$\hbar = 1.055\times10^{-34}\text{ J}\cdot\text{s}$	**Distance and Magnitudes**
$L_\odot = 3.839\times10^{26}\text{ W}$	$\hbar = 6.582\times10^{-16}\text{ eV}\cdot\text{s}$	$d = 10^{1+\frac{m-M}{5}}$
$T_\odot = 5777\text{ K}$	$G = 6.673\times10^{-11}\text{m}^3\text{/kg/s}^2$	$m - M = 5\log(d) - 5$

Cepheid Period/Luminosity	**Type Ia SN**	**Planetary Nebula**
$M = -2.81\log(P) - 1.43$	$M_{\max} = -19.3$	$M^* = -4.47$

Part I: Multiple Choice Everyone: Answer all questions
For each question, choose the best answer (2 points each)

1. Which of the following does not typically occur when two galaxies collide or nearly collide?
   A) Individual stars collide with each other
   B) A burst of star formation occurs in the galaxies
   C) Tidal friction transfers kinetic energy into some of the internal motion of the galaxies
   D) Any gas gets heated and can be completely knocked out of the galaxy
   E) The galaxies can become irregular galaxies

2. The two types of stars which are young, hot, and blue, are
   A) A and B B) K and M C) O and B D) O and M E) F and G

3. When the supernova SN1987a blew up, a ring of gas around it lit up later on. Why was there this delay?
   A) It takes a long time for the light to heat up the gas in a ring and make it start glowing
   B) The expanding gas from the explosion had to collide with the ring of gas, which took time
   C) The light comes from radioactive decay, which takes a while
   D) The light had to travel the extra distance to reach the ring before traveling to Earth
   E) The ring was illuminated by neutrinos, and it took a long time for the neutrinos to get there

4. What is the approximate age of the oldest known stars?
   A) 23 Gyr B) 13 Gyr C) 10 Gyr D) 8 Gyr E) 5 Gyr

5. The spectral lines from quasars often are not sharp lines; instead they tend to be very broad. Why is that?
   A) The gas they come from consists of many different isotopes, which have different wavelengths
   B) They are surrounded by gas and dust, which can shift the wavelengths slightly
   C) They have been gravitationally lensed by intervening galaxy clusters
   D) They are produced by gas under high pressure, which leads to pressure broadening
   E) The gas is orbiting the black hole at high velocity, which causes red and blue shifts in the spectral lines

6. Which of the following is <u>not</u> a characteristic that would help one identify a nearby star as a halo star
   A) The star has a very small metallicity
   B) The star is moving at a speed very different from the orbital velocity of the Sun, 200 km/s
   C) The star is a very young star
   D) The star has a large vertical motion, perpendicular to the plane of the galaxy
   E) All of these actually <u>are</u> signs that they are halo stars

7. The galactic supercluster we live in is called
   A) Laniakea B) Virgo C) Local Group D) Milky Way E) Andromeda

8. What types of galaxies tend to occur at the center of large clusters of galaxies?
   A) Irregular B) Spiral C) Barred Spiral D) Giant Elliptical E) Dwarf Spheroidal

9. The approximate diameter of the disk of the galaxy we live in is probably about
   A) 300 Mpc B) 30 Mpc C) 3 Mpc D) 300 kpc E) 30 kpc

10. Globular clusters are mostly found in
    A) The nucleus B) The halo C) The disk D) The spiral arms E) Satellite galaxies

Part II: Short Answer PHY 310: Choose two of the questions PHY 610: Answer all three questions

Write 2-4 sentences about each of the following [10 each]

PHY 310: Answer two of the three questions

PHY 610: Answer all three questions

11. The following three words all are reasons why a galaxy might appear especially red. Explain why in each case: Dust, Motion, Age

12. The Sun is currently moving both vertically, perpendicular to the plane of the galaxy, and slightly inwards, towards the center of the galaxy. Explain over the long term what the effects of these two types of motion are.

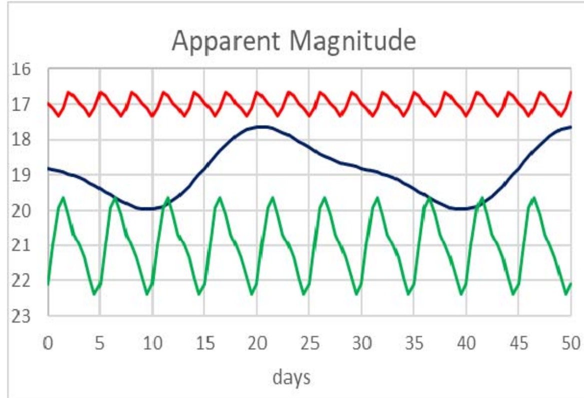
13. Explain qualitatively how we are pretty confident that the dark matter is not primarily brown dwarfs, Jupiters, white dwarfs, neutron stars, or black holes.

Part III: Calculation: PHY 310: Choose three of the problems PHY 610: Do all four problems
For each of the following problems, give the answer, explaining your work. [20 points each]

PHY 310: Answer three of the four questions

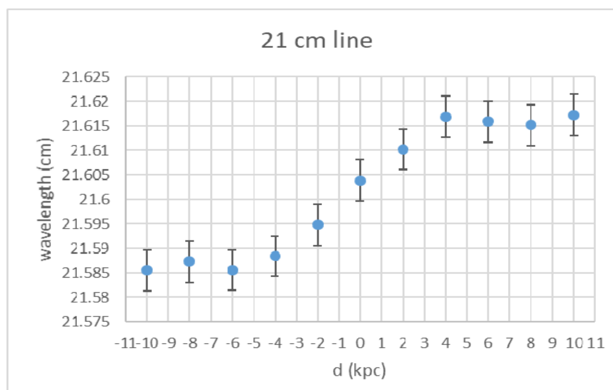
PHY 610: Answer all four questions

14. Three Cepheid variable stars all in the direction of a nearby galaxy have their apparent magnitude *m* plotted as a function of time.
    (a) Find the period and absolute magnitude for each of the three stars
    (b) Find the distance to each of the three stars
    (c) In fact, two of the stars are in the galaxy, and one is just coincidentally in the same direction. Which one is not in the galaxy?



15. Suppose a galaxy has a luminosity comparable to the Milky Way ($L = 1.20\times10^{10} L_\odot$), and is a sphere comparable in size to our galaxy ($R = 16$ kpc). It is completely surrounded by dust, which completely thermalizes the radiation, so it radiates at a uniform temperature *T*.
    (a) What is the power in W coming out of this galaxy? What is the flux *F* of power per unit area (W/m^2) coming out of this galaxy?
    (b) What will be the temperature of the thermal radiation coming from the galaxy, in K?
    (c) At what wavelength will this radiation be strongest?

16. A certain galaxy is edge on to us, and the 21 cm line (whose actual wavelength is 21.106 cm) is measured at various distances from the center of the galaxy.
    (a) Find the velocity of the hydrogen at the right edge of the galaxy, and from the left edge of the galaxy.
    (b) Find the speed at which the galaxy is moving towards or away from us, and the speed at which it is rotating. Which side is rotating towards us?
    (c) Does this galaxy show evidence for dark matter?



17. A group of stars called Carlson Stars have just been discovered! Listed at right are the parallaxes *p* and apparent magnitudes *m* of a group of Carlson Stars. You may put some of your answers in the box at right if you wish.
    (a) For stars A, B, and C, use the parallax to find the distance to these stars in pc.
    (b) For the same three stars, find the absolute magnitude of these stars.

Star	*p* (″)	*m*	*d* (pc)	*M*
A	0.0530	16.04		
B	0.0280	17.43		
C	0.0130	19.10		
D	?	27.56		

(c) Is there evidence, based on part (b), that Carlson Stars are good standard candles?
(d) Star D is too distant to use parallax. Estimate the distance to star D anyway.