# General Astronomy - Spring 2013
# Examination #2 - April 8

Name KEY

Calculators may be used during the exam. An equation sheet is provided. Notes and the textbook may **not** be used.

**Short answer**

**1. (6 pt)** List three types of objects which are mainly found in spiral arms.

Massive (O+B) stars, HII regions, gas clouds

**2. (2 pt)** What resides at the center of the Milky Way?

A supermassive black hole.

**3. (6 pt)** List three different types of galaxies and describe their stellar orbits and gas content.

Elliptical - random orbits, little or no gas
Spiral - ordered orbits in disk, random orbits in bulge and halo, significant amounts of gas
Irregular - random orbits, large amounts of gas

**4. (4 pt)** What evidence do we have for dark matter in the Milky Way?

Stars in the outer regions have larger orbital speeds than can be explained by gravity from luminous matter.

**5. (2 pt)** Does a more massive white dwarf have a larger or smaller radius than a less massive one?

Smaller

**6. (6 pt)** What is the Schwarzschild radius of a 10 solar mass black hole?

$$R_s = 3\,\text{km}\,\frac{M}{M_\odot} = 3\,\text{km} \cdot 10 = 30\,\text{km}$$

**7. (6 pt)** A galaxy has a measured recession velocity of 12,000 km/s. How far away is it? (Assume that the Hubble constant is 68 km/s/Mpc – the new value recently measured by the Planck mission.)

$$v = Hd \quad d = \frac{v}{H} = \frac{12000\,\text{km/s}}{68\,\text{km/s/Mpc}} = 176\,\text{Mpc}$$

**8. (8 pt)** The accretion disk around a black hole has a luminosity of $10^{36}$ W. What can one say about the black hole?

$L_E = 3\times10^4 L_\odot \frac{M}{M_\odot} = 3\times10^4 \times 3.8\times10^{26}\ W \frac{M}{M_\odot}$

$= 1.14\times10^{31}\ W\ M/M_\odot$

$M > \frac{L}{1.14\times10^{31} W} M_\odot \qquad M > 88000\ M_\odot$

$M > 10^5 M_\odot$ is also OK

**9. (2 pt)** The distribution of gamma-ray bursts on the sky is: a) isotropic, b) concentrated along the Galactic plane, c) correlated with the local group of galaxies, d) lumpy.

a) Isotropic

**10. (2 pt)** Long gamma-ray bursts are thought to be related to: a) the collapse of massive stars, b) mergers of neutron stars, c) elliptical galaxies, d) twinkies.

a) collapse of massive stars

**Long answer. Work must be shown to receive full credit.**

**11. (12 pt)** A Cepheid is found to have the same oscillation period, but is 1,000,000 times dimmer than a Cepheid at a known distance of 500 pc. How far away is the dimmer Cepheid?

Luminosities are the same because oscillation periods are the same.

$F = \frac{L}{4\pi D^2}$

$\frac{F_1}{F_2} = \left(\frac{D_2}{D_1}\right)^2 \qquad \left(\frac{D_2}{D_1}\right) = \sqrt{\frac{F_1}{F_2}}$

$D_2 = D_1 \sqrt{F_1/F_2}$

$= 500\,pc \cdot \sqrt{1000000} = 500\,pc \cdot 1000$

$= 500{,}000\,pc = 5\times10^5\,pc$

**12. (16 pt)** Calculate the power output from a pulsar with a mass of 1.4 solar masses, a radius of 12 km, with a spin down rate of $-1.0 \times 10^{-10}\,\mathrm{s}^{-2}$ and an initial spin rate of 30 Hz. Convert your answer to solar luminosities.

$$P = 4\pi^2 I \nu \frac{d\nu}{dt} = 4\pi^2 \frac{2}{5} M R^2 \nu \frac{d\nu}{dt}$$

$$= \frac{8\pi^2}{5} 1.4 \times 2\times10^{30}\,\mathrm{kg}\,(12\times10^{3}\,\mathrm{m})^2\, 30.0\,\mathrm{s}^{-1}\, 1\times10^{-10}\,\mathrm{s}^{-2}$$

$$= 1.9 \times 10^{31}\,\mathrm{kg\cdot m^2 s^{-3}}$$

$$\frac{P}{L_\odot} = \frac{1.9\times10^{31}\,\mathrm{W}}{3.8\times10^{24}\,\mathrm{W}} = 5\times10^{4}$$

Power = $5\times10^{4}\,L_\odot$

**13. (14 pt)** Joe is taking 29:62 and decides to go to Sirius, 8.6 light years away, for spring break. He wants to spend only 9 hours (0.0010 years) traveling from Earth to Vega. How fast must he go? What grade will he get in the class when the semester ends?

$$t' = t\sqrt{1 - v^2/c^2}$$

$t' = 0.001$ year

$t = 8.6$ years

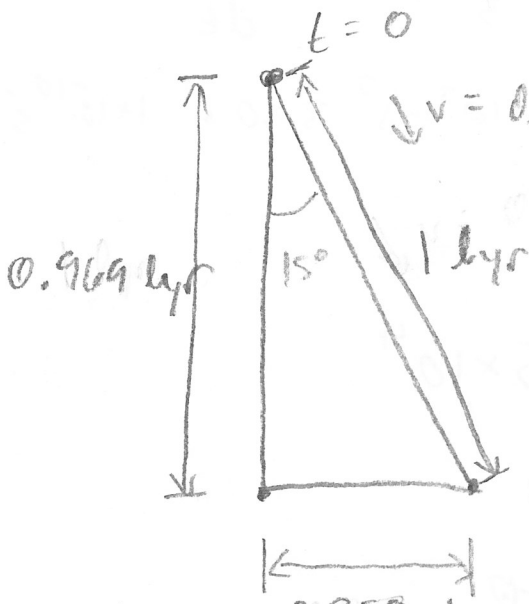
Since Joe will be traveling at $v \approx c$, in our frame trip will take 8.6 years

$$1 - \frac{v^2}{c^2} = \left(\frac{t'}{t}\right)^2 \qquad \frac{v}{c} = \sqrt{1 - \left(\frac{t'}{t}\right)^2}$$

$$\frac{v}{c} = 0.999999993c \qquad 1 - \frac{v}{c} = 6.7\times10^{-9}$$

Joe will get an 'Incomplete'.

**14. (14 pt)** An AGN ejects two blobs of matter moving in diametrically opposite directions inclined by 15° to our line of sight to the AGN. Each blob is moving at a speed of 0.90 c relative to the AGN. The AGN is at rest relative to us. How fast do the blobs appear to move on the sky as seen by us?




$t = \frac{1}{0.9}\,yr = 1.111\,yr$

$0.259\,lyr = 1\,lyr \cdot \tan 15°$

$\Delta x = 0.259\,lyr$

$\Delta t = 1.111\,yr - 0.969\,yr = 0.145\,yr$

$$v_{app} = \frac{0.259\,lyr}{0.145\,yr} = 1.78c$$

$$v_{app} = \frac{v \sin\theta}{1 - \frac{v}{c}\cos\theta}$$