AST 301 Introduction to Astronomy

COMMENTS ON QUIZ 3

Part A

A1. b.

A2. d. A black hole near the Sun is very likely to have arisen from a massive star which end its life as a Type II supernova. This led to ejection of much of the star's mass and left behind a remnant with a mass of several solar masses.

A3. The principal reason why the number of known pulsars is far fewer than the expected number of neutron stars is that pulsar emission is beamed like the signal from a lighthouse. The pulsar is seen only if the beam sweeps into our line of sight - a rare occasion!

A4. Type II SN exhibit Balmer lines of hydrogen in the visible spectrum Type Ia SN do not show these hydrogen lines. Can you tie this difference in the spectra to the nature of the explosion?

A5. A white dwarf is supported against gravitational collapse by the pressure from degenerate electrons. Such electrons provide a pressure that is independent of temperature.

A6. Although hot, they are very small - just about 10 kms. And in the luminosity proportional to radius-squared times temperature to the fourth power equation, the radius-squared kills the contribution of the temperature to the fourth power unless temperature is very high. Check this conclusion!

A7. The Sun and Mars are - on the scale of this drawing - one point in the disk at about 10 kpc from the center of the Galaxy. The globular cluster will be in the Galactic halo at 20 kpc (use thescale provided). Since most globular clusters are inside about 10 kpc from the Galactic center this particular cluster might be spotted over or under the Galactic bulge.

A young open cluster and the H II region are in the disk.
A very metal-poor star will be in the halo.

A8. In order of increasing mass:
H atom → Yourself → the Sun → Betelgeuse → Globular cluster→ Galaxy → Local Group

A9. d.

A10. a.

A11. The Period-Luminosity law from Cepheids corresponds to increasing luminosity with increasing Period. In UT-900, the 75 day Cepheid will have a higher luminosity than the 15 day one and the 15 day Cepheid will be more luminous than the 5 day one. Since all stars in the cluster are effectively at the same distance, the ordering by luminosity will be the ordering by brightness:
5 → 15 → 75

A12. I = Young, H II region, dark clouds, Type II SN, H I cloud, Sun
II = metal poor, high velocity relative to the Sun, globular cluster

A13. c.

A14. In order of increasing size:
atomic nucleus → H atom → centimeter → kilometer → neutron star → white dwarf → AU → light year → kiloparsec → Galaxy

A15. d.

A16. Our Galaxy and the Andromeda galaxy (nebula)

A17. d.

A18. Dust along our line of sight to the Galactic center obscures our view at visible wavelengths. But dust is more transparent at IR wavelengths and fully transparent at radio wavelengths and at these parts of the electromagnetic spectrum the vicinity of the central black hole is observable.

A19. Solar system → Galaxy → Universe

A20. The Zone of Avoidance IS the Milky way, the ribbon of stars visible from the N and S hemispheres.

Comments on Part B questions:

B1. a. See Seeds Chapter 14
b. See Seeds Chapter 14
c. Given that this question appear in HW5 and was addressed in the Comments, the majority of the answers was a disappointment. Several answers implied or even stated that while light could not escape the

black hole infrared and radio waves could. NOT SO! All electromagnetic radiation - X-rays to radio waves including visible wavelengths (light) - is trapped inside the black hole's Schwarzschild radius. (I am presuming the erroneous idea about IR and radio waves arose from question A18.)

A black hole may be detected by electromagnetic emission from the accretion disk in the immediate vicinity of the black hole but - of course - outside its Scharzschild radius. You were expected to give a brief description of an accretion disk and how it arises and why it's hot. Figure 14-18 from Seeds is a crisp illustration -- his text for more information. Often, the accretion disk is very hot and, therefore, is a copious emitter of X-rays.

A neutron star is a compact object much like a stellar black hole and, if fed with gas from a companion star, can support an accretion disk similar to that around the stellar black hole. (Masses of NS and BH can be similar. Radius of NS and Schwarzschild radius of BH are similar too. Thus, gas falling into NS and BH can gain and disperse similar amounts of kinetic energy and so accretion disks are similarly hot. (White dwarfs too can sustain an accretion disk but this will not be as hot because the white dwarf will generally have a larger radius and a lower mass; less kinetic energy gained in falling it to the white dwarf.)

How do you distinguish a NS from a BH? You have to estimate the mass of the compact object. For this you must hope the object belongs in a binary system. It probably does because a companion is the likely, indeed required, source of gas with which the accretion disk is fed. The mass estimate will not be very certain but if the mass of the compact object is clearly far greater than 3 solar masses, you have a BH. Otherwise, it's likely a NS.

B2. a. Think resolving power - Seeds pp109-111.
Stars in distant galaxies appear very close together. Observations from the ground, even with large telescopes, may blur stars into one another thanks to blurring by the Earth's atmosphere: stars closer than about one arc second will not be resolved (i.e., seen as two). The HST works close to the theoretical resolving power - see equations on page 110. This theoretical limit in arc seconds is 0.113/D(meters) which with D= 2.4 meter for the HST primary mirror gives a resolving power of 0.05 arc seconds or some 20 times better than a ground-based telescope. And this enables HST to separate Cepheid variables from nearby stars in distant galaxies.

b. See Seeds p.265 and Figure 12-14 in particular.

c. YES! This says that all cepheids have the same luminosity. Provided that the relation is calibrated using Cepheids with known distances (trig parallax, open cluster members), it can be used for all Cepheids.

B3. a. Well done. Very helpful to give numbers and not just an adjective: old versus young is very vague as a difference between Pop. I and II.

b. See Seeds on top-down and bottom-up models. Probably the simplest differences to account for are age and composition. Gas starts as pure H and He from the Big Bang with no metals (carbon and heavier elements).

Stars synthesise metals and ejecta from stars pollute the interstellar gas from which new stars are formed. The cycle of star formation, element synthesis and ejection and pollution continues. Young stars have a composition with more metals than older stars.

B4. a. See A20. Elliptical galaxies lack dust (and gas) and therefore should be transparent in all directions enabling distant external objects to be seen in all directions.

b. NOT WELL ANSWERED in general. The crucial observation required is a spectrum in optical/visible light. Although the shape of the continuum can be distorted by dust (blue depressed relative to the red), the presence of key absorption lines in not affected. If the red star is in fact a hot one, its spectrum will show lines of helium. If it is a cool star, it will show bands of TiO.

c. Small particles of dust or aerosols scatter blue light more than red light. At sunset, the Sun is viewed through a longer path of the atmosphere than earlier in the day. The longer path means that more blue light
is scattered out of the line of sight leaving the Sun appearing redder than at noon (say).

d. Water droplets in clouds are larger than the wavelengths of visible light and so scatter blue-red wavelengths with about equal efficiency. Thus, the color of the Sun - white - is approximately maintained on cloud days.

B5. a. The Andromeda galaxy is so far away that stars in our local visual binaries would be too close to be resolved.
b. and
c. were part of Q2 -see comments on B6.

B6. a. b. c. See B7 on HW 5

B7. a. Well done.
b. Obviously, you do not pick just one galaxy and observe it intensively. You need to pick a large sample and observe galaxies in the sample about once a week (why weekly or so?). But YOU could get

lucky - see the story about University of London undergraduates who found a Type Ia SN in the galaxy M82 just as clouds were rolling in. Their observatory is adjacent to a busy highway much like I35 and MoPac - see Seeds p.291. See B2 on HW5.