AST 301, Fall 2015 **Introduction to Astronomy**

Comments on Homework 3

Part A

A1. See Seeds, Fig. 6-3 where he orders the spectrum left to the right in order of increasing wavelength. Also, recall that $c=\lambda f$ and, therefore, increasing frequency corresponds to decreasing wavelength.

A2. b. $E= hf$ but $c = \lambda f$ and, therefore, $E = hc/\lambda$.
Energy of photon is **directly** proportional to frequency, but **inversely** proportional to wavelength.

A3. 50 times more energy – see A2.

A4. Red

A5. Diffraction causes a point-like object (a star) to be imaged as a fuzzy bright patch surrounded by alternate bright and dark rings with the ring brightness decreasing for larger and larger rings (see Seeds, Figure 6-10).

The angular size of the fuzzy central bright patch is proportional to λ/D where λ is the wavelength of the light and D is the diameter (≡ aperture) of the telescope. The smaller the fuzzy patch, the greater the ability to separate (resolve) two close objects (see Figure 6-10). Seeds defines the resolving power as the size of the patch; the <u>smaller</u> its size the <u>higher</u> the resolving power. I prefer to think of resolving power as a quantity for which 'bigger is better'. In this case, RP is proportional to D/λ. In light of this potential confusion between my interpretation and Seeds', I accept a or b as correct answers. The answer to A6 is <u>not</u> affected by this confusion

A6. b. You can arrive at this answer either by working out D/λ (or λ/D) for each of the four examples, or by a process of elimination.

A7. The 60-inch telescope gathers <u>much</u> more light than the 4-centimeter telescope.
1 inch = 2.54 cm thus 60 inch = 23.6 cm. LGP is proportional to diameter-squared.
Ratio of LGPs is $(23.6)^2 / 4^2 = 34.8$

A8. d.

A9. b.

A10. Receding

A11 b, c, a, e, d

A12. Y is 4 times more distant than X. For the same luminosity, brightness scales as $1/(\text{distance})^2$. That is, X is brighter than Y by $4^2 = 16$ times.

A13. Same argument as A12. Brightness scales on $1/(\text{distance})^2$. If A is 40,000 times brighter than B, B is $(40{,}000)^{1/2} = 200$ times more distant than A or 200 x 250 = 50,000 ly distant.

A14. A positive ion has lost one or more electrons from its electron cloud and, thus, has a net positive charge.

A15. b.

Part B

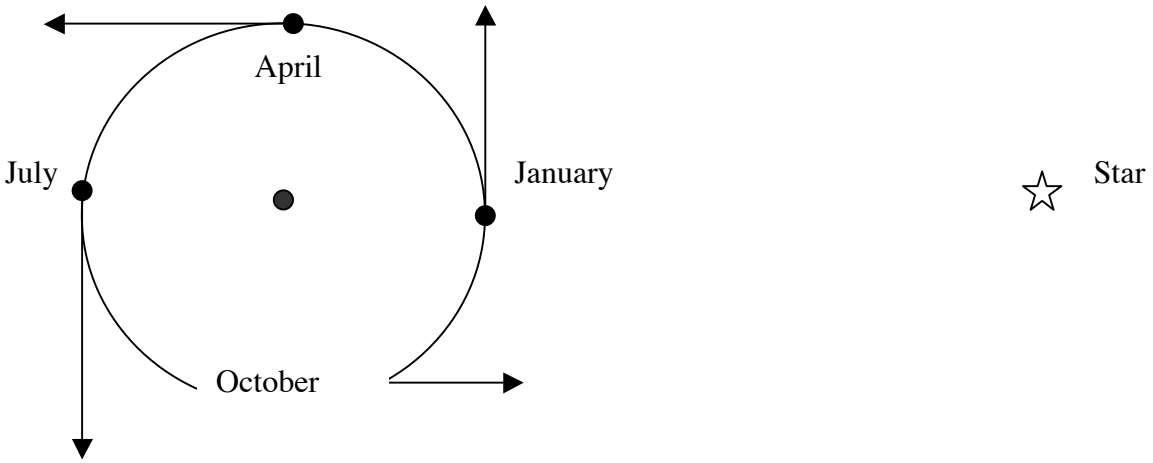
NOTE: I remind you that Part B questions generally require a few coherent well-written sentences as answers. Such prose cannot be written in the margins and, if so, cannot be easily read.

B1. a. This calls for a description/definition of the Doppler effect.
b. This calls for an <u>explanation</u>! It does **not** suffice to write "when the source moves toward you, the waves are bunched up and so the frequency is higher." That is **not** an

explanation, but rather is a restatement of the effect. Why are the waves "bunched up"?

c. We observe a star from a moving platform, the Earth. As the Earth orbits the Sun, the relative line of sight velocity between a star and the Earth changes continuously over the course of a year. (The star may also be intrinsically variable – a spectroscopic binary, for example.) (A star at the pole of the ecliptic will not show an effect due to the Earth's motion – why?)

In this particular example, the Earth is moving across the sightline to the star in January and July, a 6-month interval. The diagram shows how from Jan. to July it is moving away from the star (equivalent to a positive radial velocity) and from July to Dec. toward the star (equivalent to a negative radial velocity).



B2. a. See Seeds and Lecture Notes for Sept. 22

b. See Lecture Notes for Sept. 22/23

c. The carbon atom has a nucleus with 6 protons and in it commonest form 6 neutrons and the nucleus is surrounded by 6 electrons. The oxygen atom has a nucleus with 8 protons and in its commonest form 8 neutrons and the nucleus is surrounded by 8 electrons. The oxygen atom's electron cloud and nucleus are both slightly larger than the carbon atom's corresponding entities.

B3. a. Seeds. Luminosity and brightness can be specified for particular wavelengths. In general, I mean both to refer to energy at **all** wavelengths.

b. Seeds – note PROOF was called for. A statement or explication of the law is NOT a proof. A proof in your own words is necessary to show that you understand the problem. See Classnotes 6.

c. See Seeds pp.391-393. However, his 'argument' (basically in the caption to Figure 18-3 is terse in the extreme).

Consider a homogeneous, static, and infinite universe. Now consider the contribution from stars (galaxies) at a distance d. For simplicity assume all stars have the same luminosity L. A single star contributes $B=L/d^2$, which will get smaller and smaller as we consider greater and greater distances. So why bother about very distant stars?

A moment's reflection will show that there are more stars at distance D than at d, where D>d. The surface area of the shell at D is greater than that at d. Now, area of the spherical surface scales as distance-squared.

The total brightness contribution from the shell at D is the product of the contribution from an individual star times the number of stars at that distance D, which, if the Universe is uniform etc., is proportional to the surface area of the shell.

Then, $$B_{shell} \propto \frac{L}{d^2} \times d^2 = L$$

for **all** d.

In other words, whatever the distance, we get the same contribution from stars to the brightness at Earth. To get the total brightness, we have to add up an infinite number of small contributions from nearby stars to those at infinite distance, i.e., the brightness is infinite (day and night).

B4. a. See Seeds section 6-2

b. See Seeds p. 111

c. The lack of an atmosphere would enable your telescope to provide diffraction-limited images and you would, with appropriate telescopes, have access to the entire electromagnetic spectrum. (You would require several different kinds of telescopes to achieve this goal; a telescope designed to focus X-rays would not serve as a radio telescope, for example.)

The lower gravity at the Moon's surface would simplify the engineering; telescope structures and mirrors would distort/sag less than on Earth.

Hardy said that if you can prove two contradictory theorems then you can prove anything. He was then challenged to prove, given that 2 + 2 = 5, that McTaggart is the Pope. "We also know that 2 + 2 = 4, so that 5 = 4. Subtracting 3 we get 2 = 1. McTaggart and the Pope are two, hence McTaggart and the Pope are one."

E.H. Hardy (1877 – 1947), Cambridge mathematician

Physicists and astronomers see their own implications in the world being round, but to me it means only one-third of the world is asleep at any given time and the other two-thirds is up to something.

Dean Rusk (1909 - 1994), Former Secretary of State

Most people tire of a lecture in ten minutes; clever people can do it in five. Sensible people never go to lectures at all.

Stephen Leacock (1869 – 1944)
