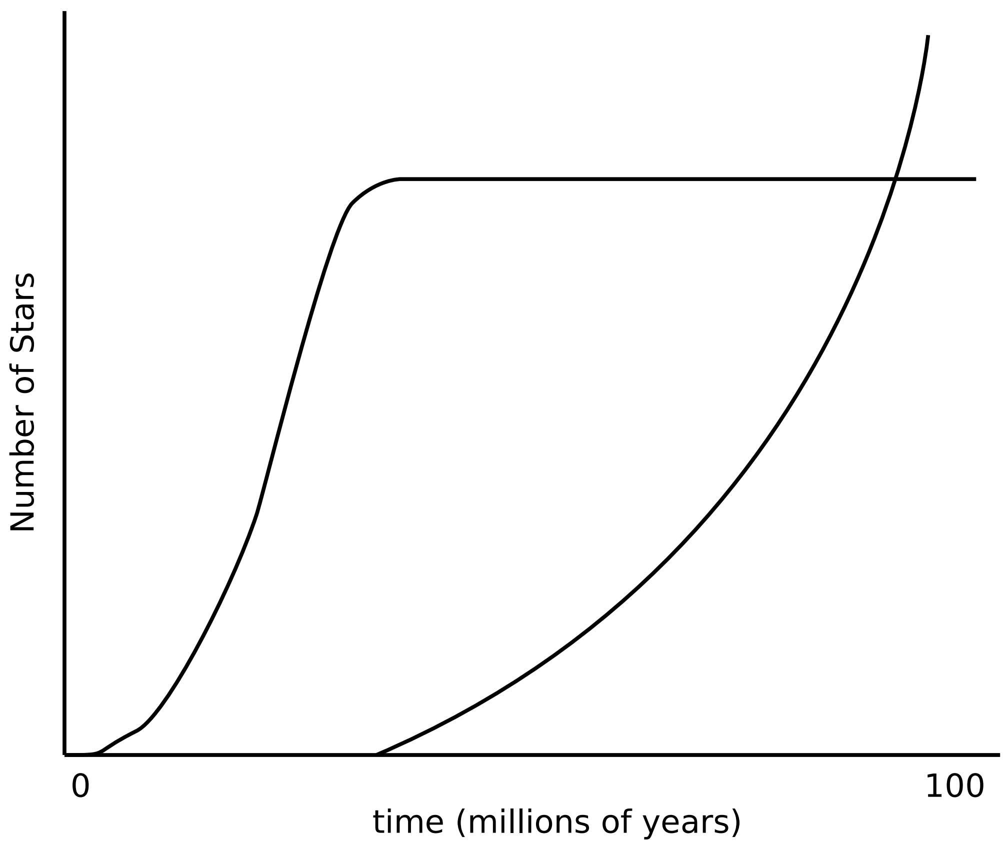
Astro 102 Review Problem Set #3
Solutions

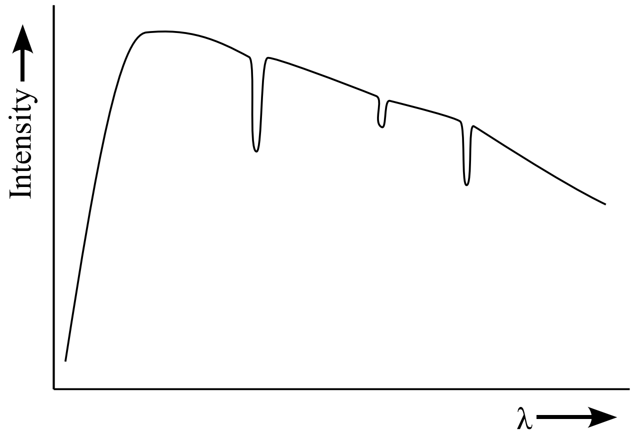
1. You can say nothing. You might be tempted to say that Vega is farther away, because a hotter star will tend to be more luminous, so to have the same brightness as a cooler star it must be farther. However, that would be wrong. You don't know anything about the sizes of the stars. It could be that Betelgeuse is huge, and (despite being cooler) much more luminous than Vega. In that case, Betelgeuse would be farther away. You can say nothing from just this information.

(In fact, Betelgeuse is about 130 pc away, while Vega is only about 8 pc way. Betelgeuse is a giant, and is, indeed, huge.)

2. When the cluster stars, there are *no* white dwarfs or neutron stars, because those stars are the endpoints of star lifetimes... and no stars have been through their lifetime first! Neutron stars are left behind from the deaths of the most massive stars, so they will start to build up first, because the most massive stars have the shortest lifetimes. After a few times ten million years, all of the massive stars will have died, and after that the number of neutron stars will remain constant. (We have the ones we've made, but no more get made.) At that point, the number of white dwarfs stars to build up, and only keeps building up as lower and lower mass stars are able to go through their lifetimes.



3. (a)



(b) The atmosphere of the star. This a very thin layer of low density gas right at the surface of the star.

4. (a) Because main-sequence K-stars are less luminous than main-sequence A-stars, a survey that can detect main-sequence A-stars to a distance of 3kpc will detect main-sequence K-stars only out to some distance that is less than 3kpc. For Surveys 1 and 2, that means that the survey reach stays inside the Galaxy for both A and K stars. While the volume sampled for A stars is bigger than the volume sampled for K stars, the ratio betweem the volumes sampled is the same in both surveys.

Thus, assuming that the mix of star types throughout the Galaxy is contant, the two surveys should have the *same* ratio of numbers of A and K main-sequence stars.

(b) See the reasponing in (c) below for the argument that N_A/N_K is *lower* in Survey C than it is in Survey B. If Survey B and Survey A have the same ratio as each other, then Survey C must have a lower N_A/N_K than Survey A.

(c) This survey is a little different. It can see main-sequence K-stars all the way to the edge of the Galaxy. Thus, it can see main-sequence A-stars quite a bit farther than that... but there aren't any out there, at least until you get into another galaxy! As such, the number of A-stars seen by Surveys B and C should be the same, since both of them are sensitive enough to see A-stars as far away as the edge of the Galaxy. However, Survey C sees *more* main-sequence K-stars than Survey B, becuase Survey B could only detect main-sequence K-stars to something less than 30kpc.

As such, you expect N_A/N_K to be *lower* in Survey C than it is in Survey B.

5. (a) You can tell your friend that he is wrong. "Sorry, dude," you can say. "Even if you're right that hotter stars are perhaps putting out more light than cooler stars, it's not only how much light a star puts out that determines how bright it is. It also matters how far away it is. A star that's putting out a whole lot more light may be a lot farther away than a less luminous star, and thus the more luminous star might actually be dimmer in our sky."

(b) You should still disagree with the friend. "Dude, you're full of 'em today," you might say. "I mean, c'mon. Yeah, it's true that something that's hotter is putting out more light per square meter of surface area, but something that's bigger might be putting out more light overall! Compare a welding torch to the Sun; the welding torch is actually hotter, but you're not gonna go and tell me that it's putting out more light than the Sun! Unless it's like, you know, a welding torch made by a Bond villan. So, perhaps some of the less hot stars are actually bigger than the hotter stars, and thus putting out more light. That *might* make them brighter, but then we've also gotta worry about the whole distance thing I was just going on about."

(c) The brightest stars you see in the sky tend to be either red giants (which are cooler than the Sun, but huge in radius and thus very luminous), supergiants (which are various different temperatures, and really big, and much more luminous than the Sun), and main-sequence stars of types F and A and bluer, which are all hotter than the Sun, and a bit bigger than the Sun, and just more luminous.

(d) Do you really want to know?

6. (a) If the surface temperature stays the same, then the color will stay the same. Because luminosity goes with surface area, and surface area goes with radius squared, doubling the radius of the Sun while keeping its temperature the same would raise its luminosity to $4L_\odot = 1.5 \times 10^{27}$ W.

(b) If the temperature of the Sun would double, getting to about 12,000 K, it would get bluer in color. It would probably look similar in color to Vega, appearing white to our eyes. The peak intensity would be at a shorter (bluer) wavelength than it is now, but there would be a fair amount of light throught the visible range of the electromagnetic spectrum, so it would all together add up to white light.

Because luminosity goes as temperature to the fourth, a doubling of the temperature would mean a $2^4 = 16$ times increase in the luminosity. We should see $L = 16L_\odot = 6.1 \times 10^{27}$ W.