Astronomy 102: Stars and Galaxies

Fall, 2003

Final Exam Review Solutions

1. (d)

2. (a)

3. (c)

4. (g)

5. (b)

6. (d)

7. (b)

8. (b), (c), (g), (i) (We haven't talked about gammay ray bursters, so they won't be on the real final.)

9. (d)

10. (d)

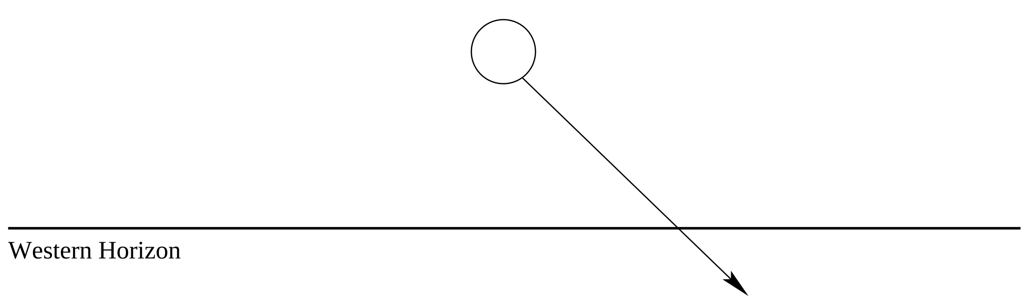
11. (a), (d) (making the first B an A!), (f)

12. (b)

13. (a)

14. (b)

15.



16. The first reason is that while low mass stars live hundreds of millions or billions of years, planetary nebulae are only bright for thousands or tens of thousands of years. The planetary nebula is a brief flash at the end of a low-mass star's life, and so you have to look at just the right time to see it. The second reason is that most of the low mass stars (less than around 0.8 solar masses or so) live longer than the age of the Universe, so none of them have even gotten to the planetary nebula stage yet.

17.

(a)

$$\begin{aligned} d_A &= \frac{1}{p_A} \\ d_B &= \frac{1}{p_B} \\ \frac{d_A}{d_B} &= \frac{1/p_A}{1/p_B} \\ \frac{d_A}{d_B} &= \frac{p_B}{p_A} \\ \frac{d_A}{d_B} &= \frac{0.05}{0.1} \end{aligned}$$

$$\boxed{\frac{d_A}{d_B} = \frac{1}{2} = 0.5}$$

Sanity check: A has a bigger parallax, thus must be closer. Sure enough, we have d_A coming out less than d_B.

(b) We have $R_A = R_B$ and $T_A = 2T_B$. We know:

$$\begin{aligned} L_A &= 4\pi\, {R_A}^2\, \sigma\, {T_A}^4 \\ L_B &= 4\pi\, {R_B}^2\, \sigma\, {T_B}^4 \end{aligned}$$

Thus

$$\begin{aligned} \frac{L_A}{L_B} &= \left(\frac{R_A}{R_B}\right)^2 \left(\frac{T_A}{T_B}\right)^4 \\ \frac{L_A}{L_B} &= 2^4 \end{aligned}$$

$$\boxed{\frac{L_A}{L_B} = 16}$$

(c) First, let's figure out F_A^*/F_B, the brightness ratio we would see if there were no dust.

$$\begin{aligned} F_A^* &= \frac{L_A}{4\pi\, {d_A}^2} \\ F_B &= \frac{L_B}{4\pi\, {d_B}^2} \end{aligned}$$

$$\frac{F_A^*}{F_B} = \frac{L_A/(4\pi\, {d_A}^2)}{L_B/(4\pi\, {d_B}^2)}$$

$$\frac{F_A^*}{F_B} = \left(\frac{L_A}{L_B}\right)\left(\frac{d_B}{d_A}\right)^2$$

$$\frac{F_A^*}{F_B} = (16)\ (2)^2$$

$$\frac{F_A^*}{F_B} = 64$$

In fact, we only observe $F_A/F_B = 8$. Thus, the ratio of the flux we would observe if there were no dust to the flux we do observe (F_A^*/F_A) is $(64/8) =$ $\boxed{\text{a factor of 8}}$.

18. As you look very far away, you are looking back in time. Thus, you are looking at the Universe closer to its beginning. Knowing that the Universe did have a beginning, there was a time when the first stars formed. Type II supernovae come from high-mass, short-lived stars, whereas Type Ia supernovae come from white dwarfs– the endpoint of the life of a longer lived star. Therefore, you would expect that after it made the first stars, there would be Type II supernovae exploding before the more moderate mass stars have time to get to the white dwarf stage. As such, as you look far away, and back in time, eventually you see to an epoch where you would only see Type II supernovae, and no Type Ia supernovae. Thus, you'd expect to find Type II supernovae farther away (and thus to higher redshifts, as the uniform expansion of our Universe means that something with a higher cosmological redshift must be farther back in time).

(19.)

(a) Type Ia supernovae. Elliptical galaxies haven't formed stars in the last couple of billion years (see Question 5), and any stars of high enough mass to explode in a Type II supernova will long ago have done that. However, there will be white dwarfs in elliptical galaxies, and if they have companions from which they are drawing mass, they could explode in a Type Ia supernova. (In fact, this is observed; the only type of supernova that has been seen from elliptical galaxies is Type Ia.)

(b) Both. Spirals have stars formed long ago, so will have the white dwarfs necessary to make SNe Ia. They are also forming stars now, so they have the short-lived high-mass stars necessary to make SNe II.

(c) You would expect to see Type II supernovae only in the disk, as that's where stars are forming. You could see Type Ia supernovae anywhere, either in the disk or in the bulge, as you have low-mass stars everywhere. (There are more in the disk, though, so you're more likely to have a Type Ia supernova in the disk.)

20.

(a) Because this is a standard candle, the luminosity is always the same. Thus, $L_A = L_B$ (where those represent the luminosities of the standard candles, not of the galaxies).

$$F_A = \frac{L_A}{4\pi\, {d_A}^2}$$

d is what we are interested in, so solve this for d:

$$d_A = \sqrt{\frac{L_A}{4\pi\, F_A}}$$

Similarly, we have:

$$d_B = \sqrt{\frac{L_B}{4\pi\, F_B}}$$

Divide the two to get the ratio:

$$\frac{d_A}{d_B} = \sqrt{\left(\frac{L_A}{L_B}\right)\left(\frac{F_B}{F_A}\right)}$$

We have already said that $L_A/L_B = 1$, and the problem statement tells us that $F_B/F_A = 1/4$, so:

$$\frac{d_A}{d_B} = \sqrt{\left(\frac{1}{4}\right)}$$

$$\boxed{\tfrac{d_A}{d_B} = \tfrac{1}{2}}$$

Sanity check: the standard candle is dimmer in galaxy B, so galaxy B should be farther. Sure enough, we have the distance to A as being less than the distance to B.

(b)

$$v_A = H_0\, d_A$$

$$v_A = (72\,\frac{\text{km/s}}{\text{Mpc}})\,(30\,\text{Mpc})$$

$$\boxed{v_A = 2,160\,\text{km/s}}$$

(Really, 2,200 km/s to two significant figures.)

(c) From (a), we have $d_B = 2d_A$, so:

$$v_B = H_0\, d_B$$

$$\frac{v_B}{v_A} = \frac{H_0, d_B}{H_0} d_A$$

$$v_B = \left(\frac{d_B}{d_A}\right) v_A$$

$$\boxed{v_B = 4320\,\text{km/s}}$$

(d) For velocities much less than the speed of light (which works for these), we have $z = v/c$. We also have the redshift:

$$z = \frac{\lambda_{\text{obs}} - \lambda}{\lambda}$$

Solve this for λ_{obs}, which is what we care about:

$$\begin{aligned}
\lambda\, z &= \lambda_{\text{obs}} - \lambda \\
\lambda\, z + \lambda &= \lambda_{\text{obs}} \\
(1 + z)\,\lambda &= \lambda_{\text{obs}} \\
(1 + \frac{v}{c})\,\lambda &= \lambda_{\text{obs}}
\end{aligned}$$

Thus, we have:

$$\lambda_A = (1 + \frac{2160\,\text{km/s}}{3 \times 10^5\,\text{km/s}})\,(6563\,\text{Å})$$

$$\boxed{\lambda_A = 6610\,\text{Å}}$$

$$\lambda_B = (1 + \frac{4320\,\text{km/s}}{3 \times 10^5\,\text{km/s}})\,(6563\,\text{Å})$$

$$\boxed{\lambda_B = 6660\,\text{Å}}$$

21. We need high-energy events that inject lots of energy into the interstellar gas to do this ionization. How about…supernovae? Type Ia supernovae do the trick.

22. Remember that high redshift means the Universe was smaller when the light was emitted. Because the Universe is expanding, and always has been, smaller means back in time. If galaxies are merging, then there should have been more of them back in time (they've all merged since then to make fewer, bigger galaxies), so you'd expect the average mass of a galaxy at high redshift to be *lower* than the average mass of a galaxy at low redshift.

23. Every high-mass star which has formed up until a few tens of million years ago (i.e. all but the very most recent crop) has gone through its entire life, exploded, and left behind a neutron star or black hole. However, there are many low mass stars which live longer than the current age of the Universe, and thus have not had time to go all the way to white dwarf.