Astronomy 102, Spring 2003
Solutions to Review Problems from 203 March 31

1. *How might you tell the difference between a Type Ia and a Type II supernova? (I.e. what observations might you make in order to decide if a given supernova was of a given type? Think about this either for a supernova which we've just observed exploding, as well as for a historical supernova where we can only observe the remnant.)*

This is an open ended question designed to force you to think a bit about what's going on. First of all, for an extant supernova, the best way to tell the difference is by taking a spectrum of the supernova; indeed, that's how the types of supernovae are defined (and why I vs. II doesn't perfectly line up with thermonuclear vs. core collapse, thus forcing us to muck about with Type Ia, Ib, and Ic instead of just Type I.)

Beyond that, though, consider that most of the energy of a Type II supernova comes out as neutrinos. (A lot of neutrinos will come out in a Type Ia as well, but not as big a fraction.) *If* the supernova is close enough and you have a good enough neutrino detector, measuring the number of neutrinos you see from the supernova might tell you that it's a Type II. (So far, there's only been one supernova in history close enough such that we've been able to do this.)

For an older supernova, where you see the expanding gasses of a supernova remnant, if you find a pulsar at the center of the remnant, you know it was a core collapse supernova. A pulsar is a rotating neutron star, and a neutron star is what's left behind (usually) from the core collapse of a Type II supernova. However, a lack of a pulsar doesn't guarantee that it's a Type Ia supernova; the "lighthouse beams" of the pulsar could just not be pointing in the right direction for us to see them, or the supernova could have been from a hugely massive star that left behind a black hole rather than a pulsar.

Sometimes there's just no way to know. We observe supernovae now where the type is in doubt; the lightcurve and spectrum are consistent with both types. This is also true of remnants observed from historical supernoave.

2. *Consider a binary system consisting of a main sequence star and a white dwarf companion. Which star is older? Which star started its life with more mass?*

Given that we've talked about how far apart stars are in the galaxy, they almost never run into each other. (It's a different matter in the cores of globular clusters, and even right at the center of our galaxy, but consider the Solar neighborhood for now.) Thus, if there is a binary star system, almost certainly the stars formed together, as it is very unlikely that they would have come across each other and captured each other into a binary system. If the two stars formed together, then they must be the same age.

If they're the same age, and one is still on the main sequence while the other has evolved through all of its post-main sequence stages and has left behind a white dwarf, then you know that the white dwarf started with more mass. It might not have more mass now, though, because a star loses a lot of its mass (e.g. when it throws off a planetary nebula) before leaving behind a white dwarf.

3. *Why do no images of the Milky Way resemble the image of NGC6744 in Figure 18.9 of the text?*

Just the matter of vantage point; we're stuck inside the disk of the galaxy, so we can't help but look at it from edge on. The galaxy is thousands of light-years across. Even if we could travel very close to the speed of light, it would take us many tens (or even hundreds) of thousands of years to get far away out of the plane of the galaxy to take a picture from that vantage point and send it back.

4. Chapter 16, Question 4: *Why does the accretion disk around a neutron star have so much more energy than the accretion disk around a white dwarf, even though both stars have approximately the same mass?*

Although we haven't talked much about the observations we see in the sky that are associated with accretion disks around neutron stars (read the relevant sections in Chapter 16 if you're interested), we *have* talked about enough to answer this question.

The important point is what we've talked about before with gravitational potential energy: for objects of a given mass, as you get them closer together, you release more energy. A white dwarf and a neutron star both are within a small factor of the Sun's mass. However, the neutron star is much smaller: only $\sim 10\,\text{km}$ in radius, in comparison to the white dwarf which has a radius similar to that of the Earth. Thus, you can get the gas in the accretion disk much closer to the neutron star than you can to the white dwarf, so a lot more gravitational potential energy is released (which goes into emission and into heating up the gas in the accretion disk).

5. Chapter 16, Question 14: *The Moon has a mass equal to* $3.74 \times 10^{-8}\,M_\odot$. *Suppose the Moon suddenly collapsed into a black hole.*

(a) *What would be the radius of the event horizon (the "point of no return") around the black hole Moon?*

(b) *What affect would this afe on tides raised by the Moon on the Earth? Explain.*

(a)

$$R = \frac{2\,G\,M}{c^2}$$

It's easly enough to look up the values and plug in the numbers to get $\boxed{R = 0.11\,cm}$. You have to be careful to convert solar masses to kilograms properly. This is tiny! It's neary 30 million times smaller than the 3 km radius we heard about for the Sun. This is not surprising, because 3.74×10^{-8} is about 1/30 million. . . i.e. the Moon is one thirty-millionth the mass of the Sun, so the size of a Moon mass black hole is one thirty-millionth the size of a Sun mass black hole.

(b) None! If there is a black hole of the same mass as the moon the same distance from the Earth, the gravitational force that a point on the Earth feels from the black hole will be the same as it felt from the Moon. The tides come from the difference between the gravitational force on the side of the Earth near the moon and the gravitational force on the side of the Earth opposite the moon. That difference wouldn't change; it would just be a black hole rather than a hunk of rock exerting the forces.

6. Chapter 18, Question 4: *Why ar the youngest stars concentrated close to the plane of the galaxy?*

Because that's where the gas is. Young stars haven't lived very long, so they haven't had a whole lot of time to drift away from where they formed. Stars from from the gas, so you expect to find the youngest stars close to where the gas is.

7. *We can tell that we're not at the center of our galaxy just by looking at the distribution of globular clusters at different places on the sky. How does this work? Why would looking at the distribution of open clusters not give us the same answer as looking at distribution of globular clusters?*

If globular clusters are distributed evenly about the center of the galaxy (they are), but we're not at the center, we should see more globular clusters in the direction where most of the galaxy is (which is the same as the direction towards the center) than we do in the opposite direction. In fact, we do see this asymmetry in the distribution.

The same asymmetry ought to apply for open clusters: there should be more of them where there is more of the galaxy. The problem here is that globular clusters are up in the halo, and there's little or no dust in the halo, so we can see globular clusters fairly far away as long as we're lucky enough to get to look out of the disk. We're never so lucky with open clusters: we always have to look at the murk of the disk. Thus, its easiest to find the ones relative close to us. Looking in the direction where there is more disk means looking through more dust, so it gets harder and harder to see the open clusters that are further away. The open clusters we find will not necessarily be limited by where the *are*, but how far into the dust we can see. Thus, by looking where open clusters are, we might think that we're closer to the center of the galaxy than we really are.