Astronomy Reading and Discussion for Tuesday, June 1st (meet in Nunn room)

Finish Chapter 14 on Black Holes (Supermassive Black Holes, Gravitational Waves)

Astronomy Problem Set 10 for Tuesday, June 1st

From Chapter 13

(1) Go to Figure 12-22. Copy the figure over onto an 8 1/2 x 11" sheet of paper (no need to be colorful or artistic).

Then, augment your copy of Figure 12-22 with what you have learned in Chapter 13.

As one particular, add Type 1b and Type 1c supernovae to your figure.

For each object in the Figure, note an actual object that has been observed that is of this type (using the textbook or Googling if you want to do it at one of the machines with internet — as an example, Aldebaran is a well-known example of a red giant).

For objects for which it makes sense, on your figure note (a) the absolute magnitude, (b) the temperature of the object, and (c) the radius of the object. For objects that have a wildly changing luminosity (novae and supernovae), report the brightest absolute magnitude.

By the way, in class, we speculated how long a supernova lasts, and I looked it up. As assessed by the duration of the arrival of the neutrinos, which has only been done for SN 1987A, the duration is "tens of seconds." In visible light, the supernova can brighten for a few weeks before reaching peak brightness.

(2) (a) Studying Figure 13-34 (the Taylor-Hulse "binary" pulsar), roughly how many orbits has this pulsar undergone since it was observed? (b) It is now 65 seconds behind schedule. Divide this by the number of orbits (that is how much each revolution has fallen behind)? (c) *Expressed as a percentage of the orbital period*, how on average is each orbit slow?

From Chapter 14

(3) (a) Using the values of G, c, and the mass, M, of the Sun (tabulated on pages 645 to 646 of the textbook), what is $2GM/c^2$ for the Sun? This is its Schwarzschild radius. It is how small the Sun would have to be to crushed down to in order to become a black hole. Once it passed below this size nothing could stop it from collapsing into a singularity. This is how large the singularity's event horizon would be. (b) Actually, quantum mechanics is expected to stop the singularity from being infinitely small. The expected size of the singularity if quantum mechanics is included would be sqrt(hG/c^3). Planck's constant h is also tabulated in the textbook. It is common to divide h by 2π before plugging it into sqrt(hG/c^3). When you divide h by 2π, it is called "h bar."

(4) On the following three pages, I have designed a step-by-step problem to answer the question that was raised in class, which is how much do clocks on Earth run slower than a clock in a plane 10km above the Earth? This experiment has actually been done, and like every other test of Einstein's General Theory of Relativity, Einstein's predictions have come out right.