

**ASTR 220 Homework #8**  
**Spring 2005**  
**Due Tuesday, May 3, 2005, at the beginning of lecture.**

Please neatly write or type your homework.

Be aware of potential plagiarism: make sure to put the answer into your own words. Feel free to discuss the questions with your classmates, but write up the answers yourself - do not copy.

Make sure to show your work for any calculations - answers that appear like magic will receive no credit.

1. Ch. 11, Review Problems, #14.
2. Explain why there are almost no old open clusters in our galaxy.
3. Ch. 13, Sensible Statements, #16.
4. White dwarf supernovae.
  - (a) Briefly explain how a white dwarf supernova happens.
  - (b) Why do they all have the same luminosity?
5. We learned in class that white dwarfs, neutron stars, and black holes can all be in close binary systems with another star. **Explain** why the accretion disks around the white dwarf, neutron star, or black hole heat up. Which type of object will have the hottest accretion disk?
6. Ch. 15, Review Questions, #1.
7. How will collisions between galaxies in a cluster gradually change what types of galaxies are in that cluster?
8. We learned in class that the Milky Way is likely to collide with both the Andromeda Galaxy and the Virgo Cluster in the future.
  - (a) The Milky Way is heading toward Andromeda at a velocity of  $1.4 \times 10^5 m/s$ . Andromeda is  $2.2 \times 10^6 ly$  ( $2.1 \times 10^{22} m$ ) away. How long will it be before they collide, assuming the speed is constant? Give your answer in both seconds and years.
  - (b) The Milky Way is heading toward the Virgo Cluster of galaxies at a velocity of  $4 \times 10^5 m/s$ . The Virgo cluster is  $5.5 \times 10^7 ly$  ( $5.2 \times 10^{23} m$ ) away. How long will it be before they collide, again assuming the speed is constant? Give your answer in both seconds and years.
  - (c) Which of these collisions (if any) will occur within the Sun's remaining lifetime?
9. **GalCrash Applet on the Web.** For the next problem, you will be using a web applet called Gal Crash at the website: <http://burro.astr.cwru.edu/JavaLab/GalCrashWeb/> . You will be testing different initial conditions to see how long it takes galaxies to merge. **After running the simulations, there are two questions to answer at the end.**

**Test whether you can run the applet on your computer!** If you have trouble running it, you can come use an astronomy computer during one of these two times: **Friday, April 29, 2 - 3pm**, and **Monday, May 2, 1 - 2pm**. To use an astronomy computer, come during those times to Dr. Hayes-Gehrke's office, CSS 1233.

- To start the applet, click "Applet" on the webpage. A new window will start up. You will have four compass wheels in the upper left: **make sure each one is set to zero**. We will not be using these for this assignment (but you can play with them later).

- The item labeled “peri” is how close the galaxies will come in their first pass. The units are kiloparsecs; 1 kpc is 3300 light-years. You will be changing “peri” to see how that affects the galaxy merger. **Set this value to 10 kpc initially.**
- The item labeled “red galaxy mass” is the mass of the red galaxy compared to the green galaxy. If it is 1, for example, then the two galaxies have equal mass. If it is 2, the red galaxy has twice the mass of the green galaxy. **Set this value to 1 initially.**
- The item “number of stars” is how many stars are in the simulation. Choose whatever value you like; the more stars you add, the slower the simulation will run.
- The box “green centered” **should not be checked.** The box “dynamical friction” **should be checked.** The box “big halos” **should not be checked.**
- The graph across the bottom of the screen shows how the distance between the centers of the galaxies (R) changes over time and how the relative velocities (V) between the galaxies changes over time. The distance is plotted with a red line, and the velocity is plotted with a blue line. The distance is labeled along the lefthand side in kiloparsecs. The velocity is labeled on the righthand side in km/s. The time is in millions of years.
- **IMPORTANT: To first initialize the applet, hit start, stop, and reset.** Then you can run the applet.
- **SECOND IMPORTANT NOTE: Every time you change a setting on the left, hit reset, then run the simulation.**

Run the applet with the initial red galaxy masses and peri distances listed below. For each run, record the relative velocity of the galaxies at their first pass by each other. Also record how long it takes for the galaxies to merge.

Red Galaxy Mass	Peri (kpc)	Relative Velocity (km/s)	Time to Merge (Myr)
1	10		
3	10		
4	10		
6	10		
1	1		
1	10		
1	15		

**NOTE:** You can re-run each simulation as many times as you like. The results should be the same. If you miss something, run it again.

- For the first four experiments when you had the peri value set to 10 kpc, did it take longer for the galaxies to merge if the red galaxy had higher or lower mass? Describe why you think this is the case.
- For the last three experiments when you had the red galaxy mass set to 1, did it take longer for the galaxies to merge if the peri value was higher or lower? Describe why you think this is the case.