AS102 - Homework Assignment #4
Due: no later than 5:00pm on Thursday, March 4, 2010
Be sure to put your homework in the right slot of the Homework Box

Quick quiz questions below are taken from the 5th edition of "Stars, Galaxies, and Cosmology" by Bennett, Donahue, Schneider and Voit.

Chapter S3, page 469

Quick Quiz questions (8 points each): 31, 32, 34, 36, 37, 38

Quantitative Question #1 - Journey to a Black Hole (20 points)

Suppose you were to travel to a black hole in a space ship whose maximum speed is $v_{\max} = 0.2c$ (where $c = 300,000$ km/s is the speed of light). The black hole has a mass equal to 10 times the mass of the sun, where $M_{\text{sun}} = 1.99 \times 10^{30}$ kg.

a) Compute the Schwarzschild radius of the black hole. Express your final answer in units of kilometers.

b) How close can you get to the black hole before your ship would be unable to escape from its gravitational pull? Express your final answer in units of kilometers.

c) How large is your answer in part b) compared to the Schwarzshild radius of the black hole? (i.e., compute a ratio). Would you say that you are safely able to "get up close" to the black hole?

Quantitative Question #2 - Dueling Professors (32 points)

Professor X and Professor Y both suspect that a newly-discovered object (named Quargle-X1) is the residence of a black hole. Both professors decide to study Quargle-X1, and both take different approaches to studying it.

a) Professor X discovers a disk of gas that is rotating around the center of Quargle-X1. The disk has a radius of 6.5×10^{18} m, and at the very edge of the disk the rotation speed is 10^6 m/s. Using this information, compute the mass of the black hole that might be at the center of Quargle-X1. Express your final answer in units of kilograms and also in unit's of the sun's mass (where $M_{\text{sun}} = 1.99 \times 10^{30}$ kg). Also compute the size of the Schwarzschild radius that Professor X's observations imply for the black hole. Express your final answer for R_{Sch} in units of kilometers.

b) Professor Y discovers that X-ray light emitted by Quargle-X1 flickers on and off with a time scale of $\Delta t = 6$ hours. Compute the maximum diameter, D, of the region that these X-rays would be coming from. Express your final answer in units of kilometers.

c) If, indeed, Quargle-X1 is the residence of a black hole, have the two professors arrived at results that are consistent with each other? (That is, can both of them be right?) Why or why not?

Notes:

- When you answer the Quick Quiz questions, write down the letter for your answer (e.g., "a", "b", or "c") **AND** and explanation for why the letter you chose is the correct answer. Your explanation of your answer is worth 3 of the 5 points for each question.

- On the quantitative problems **show all of your work.** If you just write down an answer and don't show how you got it, you will receive a grade of zero.

- Be sure to include **units of measurement** as appropriate to your solution for quantitative problems.

- If a quantitative problem asks you to "compare" two values, you should **compute a ratio**.

- You may need to use the book to look up some numbers to solve the quantitative problems.