Astronomy 160b - Spring 2007

Problem Set #4 — due March 1, 2007 in class

As noted in class, there's lots of useful information on the black hole website

http://www.cmi.yale.edu/bh

I (6 points). The formula for the relativistic Doppler shift is

$$\Delta\lambda/\lambda_0 = \left\{\frac{1+v_R/c}{1-v_R/c}\right\}^{1/2} - 1.$$

Show that the post-Newtonian approximation reproduces the result we used before, namely that $\Delta\lambda/\lambda_0 = v_R/c$. What happens when v_R approaches $+c$ or $-c$? Does this result make sense?

II (6 points). Consider a black hole and a neutron star in a circular orbit around each other, where the black hole is twice as massive as the neutron star. Use the equations we derived in the first part of the course to answer the following questions.

a) If the black hole is moving at a speed of $0.2c$, how fast is the neutron star moving?

b) Given the information in (a), how far apart are these two objects? What is the orbital period of the system?

III (2 points). The assumption that you can use the equations derived in the first part of the course in the situation described in problem II is clearly wrong. Explain.

IV (6 points). *I will say some things relevant to this problem in class on Tuesday, but there's no reason not to read the articles and start thinking about the question before that.* Read the articles on the classes server about the discovery of Neptune and the search for "Vulcan". At the time, the discovery of Neptune was hailed as a "proof" that Newton's theories of motion and gravity were correct. To what extent did this discovery in fact constitute such a proof? To what extent did the failure to discover Vulcan *dis*prove Newton's theories?