Your name: ____________________

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AST 10: Homework 6b

1. Einstein calculated a formula predicting the angle that light bends by (for small angles) when it passes a spherical mass:

$$\text{angle} = (2.06 \times 10^5)\frac{4Gm}{bc^2}$$

where m is the mass of the object that's bending light, b (called the "impact parameter") is the distance of closest approach. G and c are, well, G and c. The values are below. The formula gives the angle in "seconds." For a light ray that grazes the sun, we use:

$b = r_\odot = 7 \times 10^8$ m,
$m_\odot = 2 \times 10^{30}\, kg$,
$G = 6.7 \times 10^{-11}$ m^3/kg·sec^2,
$c = 3 \times 10^8$m/s.

What is the angle?

2. In the formula for the angle (above), as the the mass, m, goes up does the angle go up or down? Does this make sense?

3. In the formula for the angle (above), as the the impact parameter, b, goes up does the angle go up or down? Does this make sense?

4. I said that the term $f(r)dt^2$ in the Schwarzschild "metric" (distance formula for spacetime surrounding a spherically symmetric object) determines the "proper time" felt by an observer. Remember that $f(r) = 1 - \dfrac{r_s}{r}$.

For $r = 1000r_s$, what is $f(r)$?
For $r = 1.001r_s$, what is $f(r)$?

5. From the previous, does time move more slowly or more quickly close to a back hole compared to far from it?

6. Are gravitational waves hard to detect or easy? Why?

7. Why two detectors for gravitational waves?

8. As we said in class, a supernova that was seen in 2014 seemed to have been seen before in 1995 and 1964, and we expect to see it again by 2020. Why is this supernova flaring up again and again, and how is that even possible, or is something else happening?