Class Activity (CA) 13

Binary Black Hole Mergers and Gravitational Waves

Our goal today is to compare (1) very accurate merger times from the best simulations we (humanity) have to (2) our predicted merger timescale,

$$t_0 = \frac{5}{256}\frac{c^5}{\mu M_1 M_2 G^3} a_0^4, \tag{1}$$

where a_0 is the initial binary separation, M_1 and M_2 are the individual masses of the black holes, $\mu = M_1 M_2/(M_1+M_2)$ is the reduced mass of the binary, G is the gravitational constant, and c is the speed of light.

We will be using simulated gravitational waveforms from the Simulating Extreme Spacetimes (SXS) collaboration. Everything will be done in the interactive Python notebook hosted here: Gravitational Waveforms

For you to do:

1. Open the notebook above and connect to the runtime (top right corner)
2. Run the cells until you get to the section "Getting binary parameters". **Write down and submit** the individual black hole masses, the initial binary separation, and calculate the reduced mass μ.
3. Run the cells in the notebook until you plot a gravitational waveform. **Save this plot and submit it**. Furthermore, identify the merger timescale and write it down. Call this t_{sim}.
4. Keep reading the notebook until geometrized units are explained. **In your own words**, what are geometrized units?
5. Write down the merger timescale, equation 1, in geometrized units. **Submit this expression.**
6. Calculate the merger time predicted by equation 1 and call it t_{eq} (remember your geometrized units from parts 4 & 5). **Is this merger time (t_{eq}) shorter or longer than the merger in the simulation (t_{sim})?**
7. (optional) Find the code where I choose which binary simulation to plot. Change the name to: SXS:BBH:1415. Test the merger time of this binary against our prediction from equation 1. **Is it a better prediction? Why is it (not) a better prediction?**