Assignment 1, Computational Astrophysics
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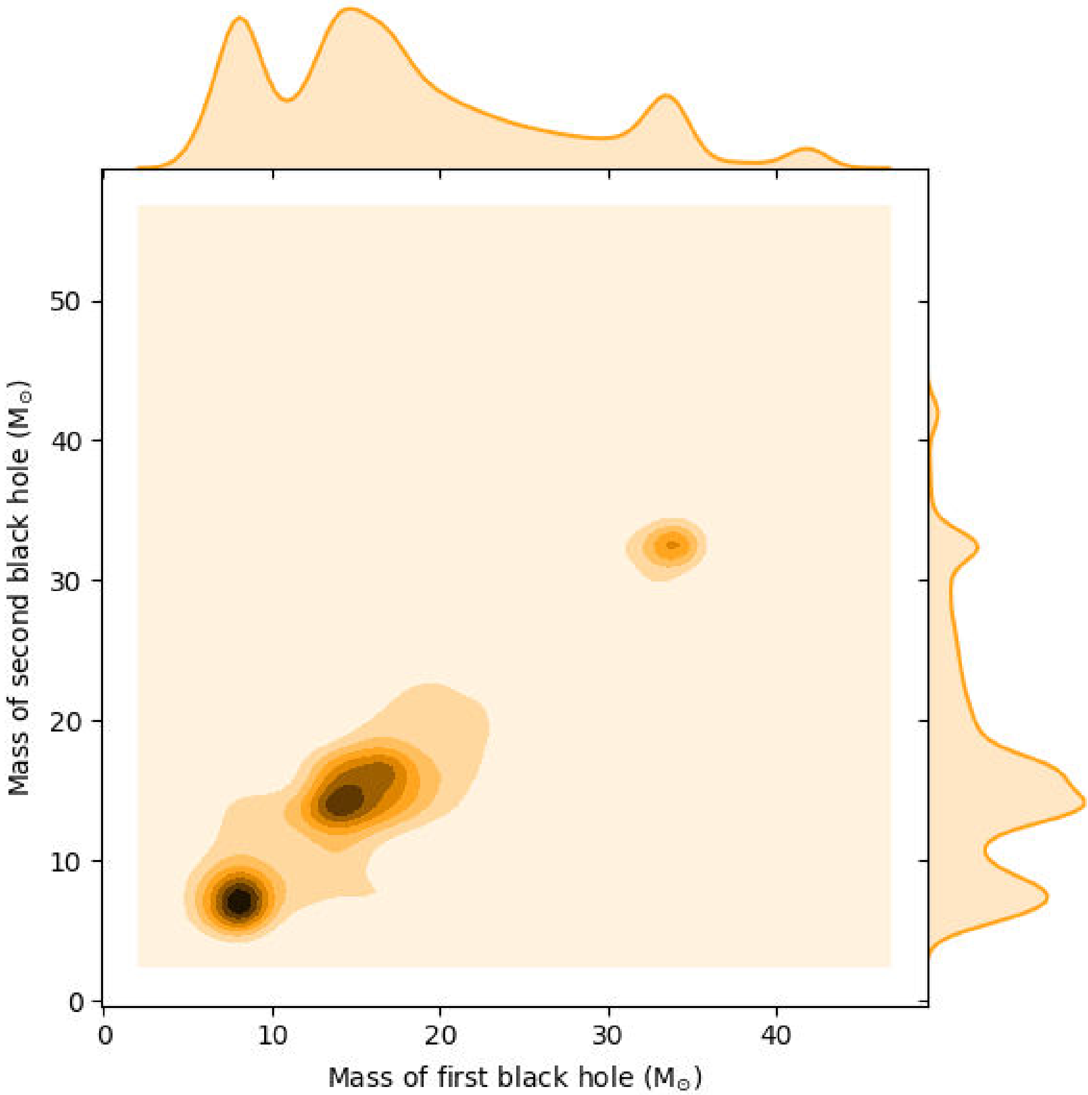
Below are the regular .png images I made for things that I didn't manage in bokeh (either because it's rather complicated or because I ran out of time). The interactive pages with plots which I created with Bokeh can be found on my github:

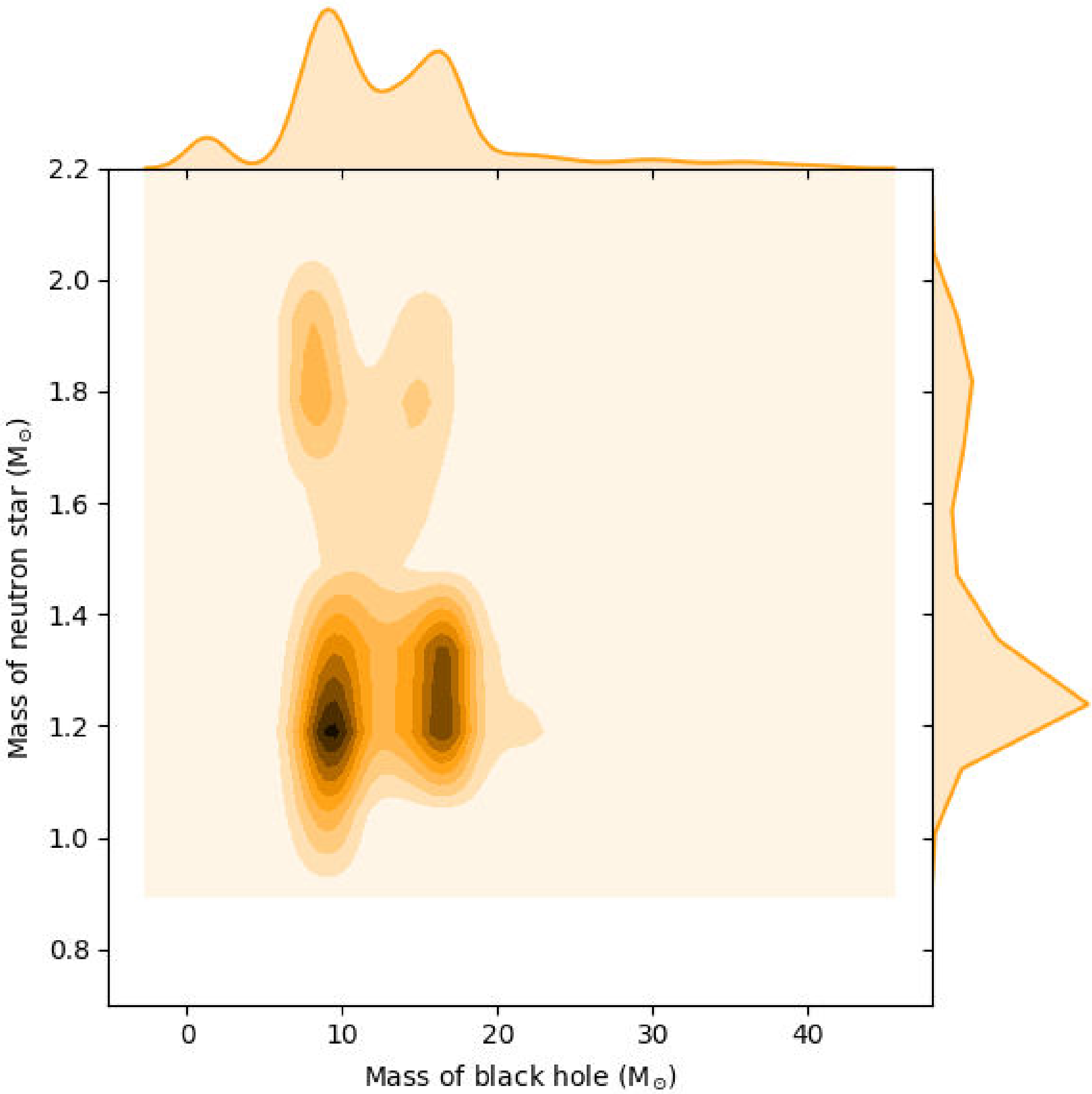
https://github.com/BartvBaal/CompAstro

Downloading this repo should allow you to open the .html files there, unfortunately github itself doesn't have an option to preview these type of files on the website itself. There will be some comments on these plots at the end of this file.

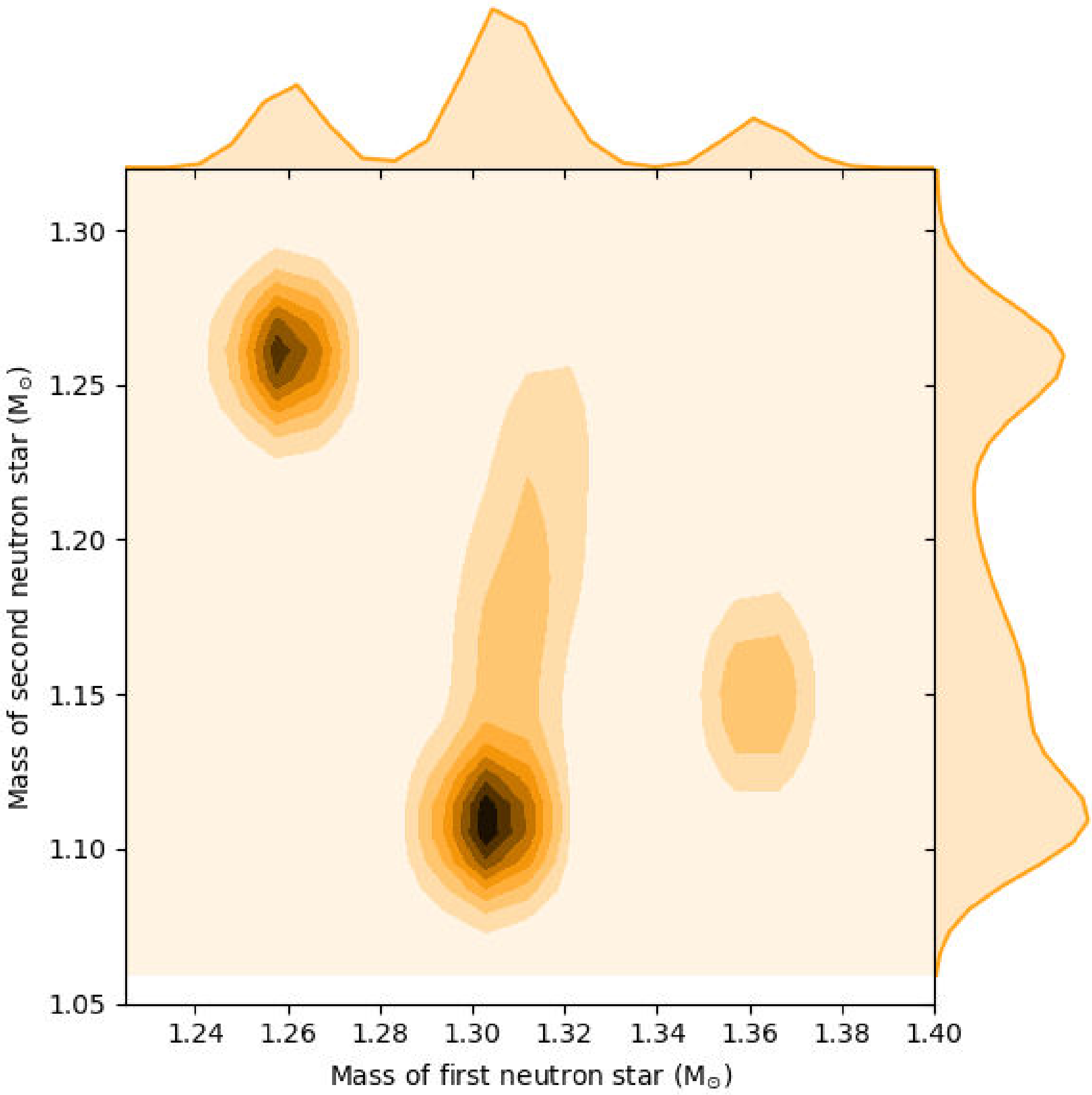
Below are the plots I made using Seaborn for the 2D histogram: first for the BH-BH systems, then the BH-NS systems and finally the NS-NS ones. There are a few things to note, I failed to get a title on a decent spot for these images so they aren't here, the shapes along the top/right side of the plots sometimes look like a negative mass would be possible, but this is an artifact which comes in when one creates a plot like this with smooth lines rather than histograms. Furthermore, specifically for the second figure (the BH-NS one) there are a few systems which are not on the plot, because for a few systems the second star is the one which becomes a black hole, and not the first one. As this results in a very large area of the plot which appears close to empty, so I've chosen to limit the y-ranges of the plot to 0.8-2.2, where the neutron stars should reside. Furthermore, there is a small region for the x-axis around 1 M⊙ where a



small bump appears, which are the primary stars which became neutron stars instead of black holes. Again, it looks like these can have negative masses but that is an artifact created by the plotting style and not real.



Finally there is the NS-NS plot, where both stars became a neutron star. What is interesting to see here is that the masses are very limits (the lightest are around 1.2M☉ while the heaviest are around 1.4M☉, so there is only a very small range of masses which binary (eventually) colliding neutron stars can have, according to the simulations.



Comments on the interactive plots:
General comments first: zooming in will make the dots appear bigger, so zooming in too far will block view of the plot. You can use the toolbar to change from a dragging tool to a selection tool or zoom in tool, or to reset back to the original view. All plots have mouse over information, but this takes a long time to load up if you mouse over a big cluster. Finally, I tried to get the solar symbol into my axis texts, but I didn't find a working solution for bokeh's gridplot, which is how these plots were made.

* assignment_plots.html

This plot has three graphs. In the left figure, the masses of the two compact objects are plotted against each other for the three datasets (BHBH, BHNS, NSNS). The regions where no compact objects are formed are also marked in light green. It's possible to make each of the sets appear and dissapear by clicking on their names in the legend on the top left of the plot.
One can also select part of the dataset, although this has no interaction with the other plots in this case.
Lastly, when you hover your mouse over one of the objects you will see the masses of the two objects, how long it takes for the objects to merge and the time between the supernovae events of the original stars. Do note that the merge time is displayed in Myr, but due to difficulties in properly representing these large numbers bokeh still gives them a postscript:
k for 10^3, m for 10^6 and t for 10^9, but nothing larger. So 340 tMyr actually

means it takes $340*10^9$ Myr for the system to merge.
The center figure shows a histogram for the three datasets on what the spread of merge times looks like, with a vertical dashed line for the age of the universe added in. I've been unable to name this vertical line in the legend, as it's not possible to easily name this specific bokeh object (bokeh.models.Span).
Finally, the right figure was my initial attempt at creating a heatmap in bokeh, but that kind of failed. I did want to show where I ended at though, where it currently plots the first compact object vertically and the second one horizontally, where it should be noted that these both were rescaled as there are about 3000 secondary objects with a mass around 12M☉. For both axes this rescaling factor is around 67 (so a bar with height 20 is actually 20*67=1340 objects)

* interactive_masses.html

First of all it should be noted that this one has some issues with loading as there are so many points on the graphs and it has to load 6 of them, so if you are asked to stop the script or continue, please press continue initially (it will probably have loaded at least a partial page already).
Once the plots show up, there are two groups. The top three images are different combinations of the initial star mass, the compact object mass and the chirp mass. Again, it's possible to make a set disappear by clicking on its label in the legend. Furthermore, once you select part of a plot, the corresponding points in the other graphs will also be selected (this might also take a while to do). On the lower three plots the eccentricity, initial separation and center of mass velocity is plotted against the merger time, which might show interesting clues upon combined investigation, which is why I picked them. I've also included another line which shows the age of the universe, again. Interestingly enough, if you select the high-mass black holes (CO A > 40M☉.) you see that almost all of these have way longer inspiral times than this. This is extra strange when you consider that the first gravitational waves detection was actually a merger between 38M☉ and 20M☉ mass black holes, which according to the simulation data typically have such long inspiral times that we would never detect them.

Initially I wanted to create these plots with the option of switching between the three datasets but I didn't have the time to get that working unfortunately, so instead I expanded it with the lower three plots.