

# Studying Gravitational Waves from Exceptional Binary Black Hole Merger Events

(LIGO SURF 2020 Interim Report 2)

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## I. CURRENT PROJECT PROGRESS

During the first few weeks of my project, event residuals were created from general waveform family templates by using the matched filtering methods detailed in Tutorial 2.2. However, these waveform templates only included 2 or 3 parameter options. As a result, the residuals created from these waveform templates still contained a bit of power in them from the signal due to an ill-fitting waveform template. Thus, since the last interim report, greater focus has been put on creating more accurate waveform templates to match GW data.

Instead of creating a general waveform template with limited parameter availability, I have spent the majority of my time learning how to create the best-fit waveform template based on individual strain data. To complete this, I practiced creating a best fit waveform for the event GW150914, LIGO's loudest recorded event. I then downloaded the parameter estimation samples that were generated for GW150914. After reading the file into my script, I added 8 more parameters to the waveform template, **each to the maximum likelihood of their occurrence**. Thus, I was able to create a much more accurate waveform template to subtract from the GW150914 strain data. The resulting residual was then completely devoid of excess power (signal), and as composed of only noise as expected.

To further test the quality of the residuals, I learned how to run a Gaussianity test on the residual to make sure the resulting noise from subtracting the waveform template from the signal was consistent with Gaussian

noise. Far away from transient disturbances, the data observed by LIGO can be assumed to be Gaussian.

## II. CURRENT PROJECT PROBLEMS AND FUTURE GOALS

At this moment, the code created to create event residuals works well. However, the script is very long due to event strain data from each detector having to be whitened, filtered, and fit to an accurate waveform template derived from each event's parameter estimation samples. Considering that the goal of my project is to run a residual test on all of the O3b events, running such a long script for each individual event would prove to be inefficient and computationally taxing. Thus, the main goal for the coming weeks is to find a way to (1) shorten the script so that events may be analyzed more quickly and (2) loop through each event in O3b.

The remaining goal of this summer's research is to continue to debug and shorten the residual code so that more O3b event residuals can be created and statistically analyzed in less time. In these analyses, the main goals are to make sure that (1) all of the signal data is completely removed from the strain data for each event, (2) ensure that the remaining noise in the residual matches the noisy event data observed earlier or later than the event **such that it is Gaussian**, and (3), cross-correlate the residuals from both the Hanford and Livingston detectors **to ensure that there are no glitches present** in the data.