CMSE401 Project

Steven VanCamp

February 2023

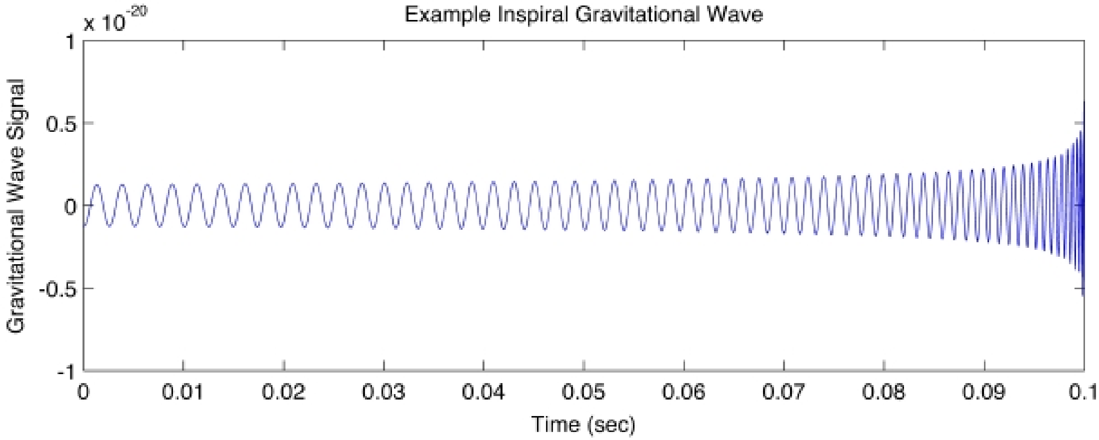

Figure 1: Example of a Gravitational Wave signal from a binary black hole system inspiral event. Source : LIGO

Abstract

Gravitational Waves (GW) present a new method of studying the universe. One method of detecting GW's is by using large scale interferometic detectors capable of observing the small perturbations to space, caused by passing GW's. To effectively use these facilities, GW's signals must be modeled so we can pick out real signals from noise. Physically modeling a system such as a binary black hole system is the first step in achieving this. With this in mind, a linear model will be an effective approach during the early inspiral phase of the binary system. To generate a wide range of GW "template" signals that could be used to match real signals the system will be evaluated with varying input parameters.

1 Schedule

- (2/5/23) Project Proposal Due
- (2/6/23) Continue research
- (2/13/23) Continue research (cont.)
- (2/20/23) Implement linear model
- (2/26/23) Test the binary simulation using the Einstein Toolkit
- (2/27/23) Implement linear model (cont.)
- (3/6/23) Implement parallelization
- (3/13/23) Implement parallelization (cont.)
- (3/20/23) Full test/verification of code
- (3/27/23) Implement visualization
- (4/3/23) Run full simulation with varying parameters to get results
- (4/15/23) Project Due

2 Software Exploration

I intend to write my own code for implementing the linear model for simulating binary black hole systems. However, I will also be exploring the ”Einstein Toolkit” software for simulating binary black holes. I know that the ”Einstein Toolkit” is already written with parallelization options. This is done to speed up the computation and visualization steps which could take a significant portion of the software time.

For both my code and the ”Einstein Toolkit” code I intend to conduct timing studies for different initial parameters. Mainly looking at how the timing changes for different initial mass ratios (mass ratio of black hole 1 and 2). I expect the ”Einstein Toolkit” will significantly outperform my software. Although depending on the numerical methods used in its calculations it may take longer but provide more accurate results. Likely it will provide significantly more accurate results.

3 Benchmark & Optimization

I intend to benchmark my code, which implements the linear model for simulating a binary black hole system. I know this type of model can take advantage of parallelization, given the ”Einstein Toolkit” uses parallelization. At the very least I can parallelize the visualization and data reduction after the simulation has completed running. I expect parallelizaton with OpenMP or MPI would significantly speed up these steps. I should be able to run my simulation code in serial and in parallel, ideally there will be some time saving when run in parallel, but without having written my code I can't form an accurate prediction of what sort of time savings to expect.