# ASTR3800 Final Project Writeup

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**Abstract**

Through a combination of data science, statistical analysis, machine learning and intuition, I analyzed data collected by LIGO. Throughout the project, I analyzed the Event Demographics of the LIGO data as a whole, the neutron star - neutron star merger GW170817, and discovered hidden correlations between variables within the data set. This helped me to understand the limitations of LIGO, how standard sirens, often sources of LIGO GW signals, are used to calculate the hubble constant, and the correlation between the Signal to Noise ratio and Luminosity Distance.

## 1 Gravitational Waves and LIGO

Gravitational waves are ripples in gravity that are caused by massive merger events, as well as supernovae. Such events can range from neutron star - neutron star mergers to black hole - black hole mergers. Extremely massive objects oribiting each other in a binary system, resulting in gravitational waves propogating out from the merger event. Gravitational waves are detectable based on their 'chirp' in which the steady mythodical waves generated by an extremely massive binary system increase in amplitutde and frequency as the objects grow closer together. This 'chirp' is also relational to the fraction of the total mass of the system that is converted back into energy.

The Laser Interferometer Gravitational-Wave Observatory, or LIGO, is the facility that is used to detect gravitational waves. In a similar way that we use the oscilation of electrons to measure electro-magnetic fields, LIGO measures the dimensionless strain of mass, to detect gravitational waves. A caviat of this measurement is that the dimensionless strain is only $10^{-21}$ m, which is less than the size of a proton over a kilometer. As suxh, detecting dimensionless strain caused by gravitational waves is extremely sensitive to enviromental changes. A truck driving by, a Person walking within the facility, and even minute siesmic activity can through off the accuracy of LIGO's measurements. LIGO has accounted for a number of these systematic erros in the design of its interferometer used to detect GWs. LIGO uses 2 4km arms equiped with mirrors and test masses to detect gravitational waves. Due to the extremely small change over such large distances, the longer the arms, the better chance

of detecting gravitational waves, thus the mirrors change the effective travel distance within the interferometer from 4km to 1200km.

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## 1.1 In-text citations

This journal uses a style based on the APA system (see https://openhumanitiesdata.metajnl.com/about/submiss
The following are some basic citation commands in LaTeX:

| → jensetmcgil
| → australiashealth
| → shree-a
| → fabricius-hansen2012b
| → (eckhoff2018a)
| → (eckhoff2018a; fabricius-hansen2012b; shree-a)

### 1.1.1 Other simple functions

To add bullet points:

- Some point
- Another point

Or numbered points:

- bme numbered point \item[2.] Another numbered point\end{itemize}\noindent This is an exam

is a simple table:
Please refer to your table using: Table **??**.

To add a figure, upload the figure into the `images` folder, and then embed it:
To resize the figure:
Please refer to your figures as: Figure **??**, Figure **??**, etc.

# 2 Dataset description

Here you can provide, if applicable, information about the dataset(s) whose creation, collection, management, access, processing or analysis have been discussed in this paper, following this schema:

**Object name** Typically the name of the file or file set in the repository.

**Format names and versions** E.g., ASCII, CSV, Autocad, EPS, JPEG, Excel, SQL, etc.

**Creation dates** The start and end dates of when the data was created (YYYY-MM-DD).

**Dataset creators** Please list anyone who helped to create the dataset (who may or may not be an author of the data paper), including their roles (using and affiliations).

**Language** Languages used in the dataset (i.e., for variable names etc.).

**License** The open license under which the data has been deposited (e.g., CC0).

**Repository name** The name of the repository to which the data is uploaded. E.g., Figshare, Dataverse, etc.

**Publication date** If already known, the date in which the dataset was published in the repository (YYYY-MM-DD).

# 3 Method

Describe the methods used in the study.

# 4 Results and discussion

Describe and discuss the results of the study.

# 5 Implications/Applications

Provide information about the implications of this research and/or how it can be applied.

# Acknowledgements

Please add any relevant acknowledgements to anyone else that assisted with the project in which the data was created but did not work directly on the data itself.

Table 1: A caption.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| a | b | c | d |
| e | f | g | h |

images/image.jpeg

Figure 1: JOHD's logo.

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Figure 2: JOHD's logo.

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Figure 3: JOHD's logo.