Distinguishing between comsic strings and glitches using a neural network

Marlinde Drent[1], Marc Duran Gutierrez[1], and Bo Ribbens[1]

[1]*Department of Physics, Utrecht University*

January 15, 2025

Abstract

The detection of cosmic strings is important because reasons . The search for these comsic strings is being held back by detector glitches. These glithces can strongly resemble comsic strings. It is therefore very important to develop a method of distinguishing between a cosmic string signal and a glitch. In the work we focus on using a neural network for this task.

1 Introduction

The first detected gravitational wave (GW) signal was GW150914[1] in 2015. These GW signals can originate from several sources, one of which is cosmic strings. Since the first observed GW many technological advancements have been made, yet one thing that still plagues detectors is the presence glitches. These are bursts of non-Gaussian noise that look like a signal . These glitches can be mistaken for a signal, so it is important to find a way to distinguish between a signal and a glitch. In this work we focus on the use of machine learning to distinguish between a glitch and a signal.

1.1 Cosmic strings

Cosmic strings are one-dimensional topological defects and originate form field theories [2]. These defects could have formed from spontanious symmetry breaking in the early universe [3]. These cosmic strings are of interest since they affect our understanding of physics, and can help confirm or rule out centrain physics models.

Cosmic strings appear at cosmological scales as thin strings with large densities, and their motion is well described by the Nambu-Goto action [4]. Cosmic stings can both be open strings or closed loops, and two cosmic strings are able to interact with eachother.

To detect cosmic strings we first need to understand what a GW signal with a cosmic string source looks like. Cosmic strings can produce GW signals in multiple ways. Examples include the formation of cusps and kinks [5]. Here we will focus on the cusps. A cusp is a singularity, where a point traveling along the curve would have to turn around. When this occurs, the physical string snaps into a cusp shape, and is instantaniously accelerated to the speed of light at that point. A burst GW is then emitted in the direction of acceleration [2]. Such a signal can be seen in figure **??**.

1.2 Machine learning

2 Method

2.1 Data

2.2 Neural network structure

3 Results

3.1 Accuracy

3.2 Efficiency

4 Discussion

5 Conclusion

References

[1] B.P. Abbott et al. (LIGO Scientific Collaboration and Virgo Collaboration). Observation of gravitational waves from a binary black hole merger. *Phys. Rev. Lett.*, 116:061102, Feb 2016.

[2] Quirijn Meijer, Melissa Lopez, Daichi Tsuna, and Sarah Caudill. Gravitational-wave searches for cosmic string cusps in einstein telescope data using deep learning. *Physical Review D*, 109(2), January 2024.

[3] Kai Schmitz and Tobias Schröder. Gravitational waves from cosmic strings for pedestrians, 2024.

[4] Mairi Sakellariadou. Cosmic strings and cosmic superstrings. *Nuclear Physics B - Proceedings Supplements*, Volumes 192–193, 2009.

[5] R. et al Abbott. Constraints on cosmic strings using data from the third advanced ligo–virgo observing run. *Phys. Rev. Lett.*, 126:241102, Jun 2021.