Investigating Supermassive Black Holes and their variability by using a Structure Function

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Abstract

Investigating Supermassive Black Holes and their variability by using a Structure Function

Our universe is pockmarked with galaxies as far as we can currently observe from our humble planet. The currently accepted theoretical model is that at the center of these galaxies are super-massive black holes holding them together. This has been proven for a majority of these observable galaxies, including our own, and for some the central black hole is actively accreting matter. We call the galaxies hosting these black holes active galaxies. Active galaxies are of particular interest because they are some of the brightest objects in the night sky and yet their emission spectra are incredibly variable. Unfortunately since the data acquired from these objects is generally unevenly sampled, we cannot use a Fourier analysis as it suffers from windowing and aliasing. For these reasons we turn to the structure function which has a similar effect as the Fourier analysis but with the added benefits of remaining in the time domain and sporting a robustness against windowing and aliasing due to uneven sampling.

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Chapter 1

Introduction

1.1 Overview

This chapter will give an overview of the theoretical models used by modern astronomers and physicists to describe black holes. The majority of this thesis is concerned with the analysis of the electromagnetic spectrum emitted by real supermassive black holes at the centers of various galaxies by using a structure function, which will be described in detail.

To begin, this chapter will give a brief overview of galaxies, active galaxies, black holes and their similarities and differences. This chapter will then go into detail on how we can observe these astronomical objects and the model used to explain what we observe from active galaxies. Finally, this chapter will go over what is expected from the work that was conducted and the motivation behind it.

1.2 Galaxies, Active Galaxies, and Black Holes

Before we can dive into the work that was conducted for this thesis we must first understand the objects that were observed and how they are classified. Galaxies are the easiest of these objects to classify and explain.

1.2.1 Galaxies

Galaxies are relatively faint objects in comparison to close stars when being observed with the naked eye. So it comes as no surprise that they were not discovered until telescope technology had advanced to a sufficient degree as to allow a significant enough amount of light in to view very distant objects. In 1845, William Parsons of Ireland built a telescope that would be the largest of it's time. In using this telescope he was able to observe groupings of stars and gas and dust distant from our own Milky Way. Initially Parsons believed galaxies to be nebulae but soon concluded that they were "great clouds of stars" Seeds and Backman (2013). These great clouds of stars are now theorized by modern astronomers and physicists to contain supermassive black holes at their centers holding them together. Supermassive black holes, as their name suggests and as this chapter will explain later are extremely massive.

Properties of Galaxies

Since their discovery, many various types of galaxies have been discovered and classified. Galaxies are classified based on the following properties.

1.2.2 Active Galaxies

Astronomical description of active galaxies(AGN).

1.2.3 Black Holes

Astronomical description of black holes and super-massive black holes.

1.3 How AGN are observed

1.3.1 Orbital X-Ray telescopes

A description of the orbital observatories used and the bands of the EM spectrum they can observe

1.3.2 The Unified Model

A description of the unified model and how, if the model holds, we can observe the inner workings.

1.4 Expected achievements

What is expected to be achieved from this project

Chapter 2

The General Relativistic Description

2.1 General Relativity

An introduction to general relativity and its relation to black holes.

2.1.1 An introduction to Tensors

An introduction to tensors and their mathematical properties

2.1.2 The Metric Tensor

Role of the metric tensor

2.1.3 The Spacetime Interval

Role of the spacetime interval

2.2 The Kerr Spinning Black Hole

Description of the concept of the Kerr spinning black hole and its importance.

2.2.1 The Kerr Solution

The mathematics of the Kerr solution.

2.2.2 Properties of the Kerr Solution

Properties of the Kerr solution.

Chapter 3

Statistical Analysis

3.1 The Structure Function

(Collier and Peterson, 2001) (author1, year1) (**?**) What the structure function is and how it applies to this data sample. Why it was chosen.

3.2 The Data

An overview of the data. This section will contain many figures.

Chapter 4

PROGRAMMING SFA

4.1 SFA USAGE AND DESCRIPTION

A description of what SFA was developed for and its usage.

4.2 THE SFA ALGORITHM

4.2.1 PROCESS

The logical process SFA follows to generate the structure function

4.2.2 COST AND COMPLEXITY

An overview of the general running cost and Big-Oh order of SFA

4.3 EXPECTED OUTPUT

What one should expect for results from running SFA

Chapter 5

Results and Conclusions

5.1 Results

A review of the results of running SFA on observational data

5.2 Conclusions

Theoretical conclusions based on the findings of SFA

Chapter 6

Future Work

Potential future work and applications of SFA

Appendix A

SFA

If you wanted an appendix, it would go in like this. It would be referenced using Appendix A.

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