Searching for Axions in Dark Matter

Alexander Spencer London[1], Keir Rogers[2], Renée Hložek[2], Alex Laguë[1 2 3]

[1]Department of Astronomy and Physics, University of Toronto, [2]Dunlap Institute for Astronomy and Astrophysics, [3]Canadian Institute for Theoretical Astrophysics

UNIVERSITY OF TORONTO

Introduction

Dark Matter, which comprises 85% of the matter in the universe, is shrouded in mystery. Although dark matter does not interact with light, we can observe its gravitational effects on the largest scales of the universe known as the **large scale structure (LSS).** The LSS consists of regions of higher density (galaxy clusters and filaments) and regions of lower density (voids).

There are many possible components of dark matter, one of which is a hypothetical particle known as an **axion.** Through cosmological simulations, we can study the physical effects that different types of axion dark matter would have on the LSS.

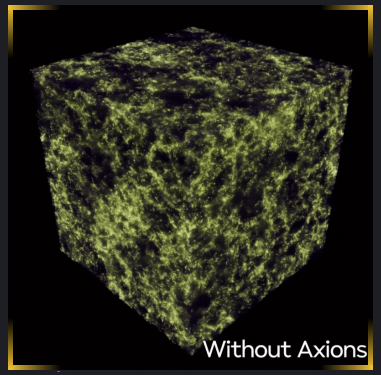


Figure 1: A 3D visualization of the simulated dark matter halo catalogues, generated using Blender.

Click here to view the animated version of this image!

Methodology

We generated 3-dimensional catalogues of simulated **dark matter halos**, One set with axions and one without axions.

Although halo catalogues yield valuable information, **voids** are an often unexplored avenue that may provide new insights into the LSS of the universe, since:

1. Non-linearities may erase the signature of axions, and the utilization of voids can mitigate this issue.

2. We can study more than just the clustering of overdense regions by looking at relationships between underdense and overdense regions.

3. Once we are given a halo catalogue, the void information comes along with it for free!

The correlation function quantitatively measures the amount of clumpiness of a distribution of halos and voids.

The higher the correlation, the more clumpy the distribution is.

Positive values mean clustering, negative means separation.

Results

Figure 2: Mass Histogram of Halos and Voids.

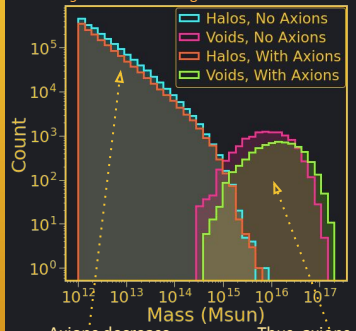


Figure 3: Halo-Halo correlation.

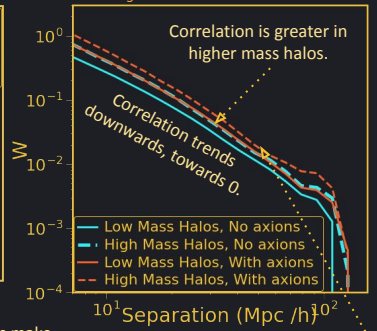


Figure 4: Void-Halo correlation, for catalogues without axions

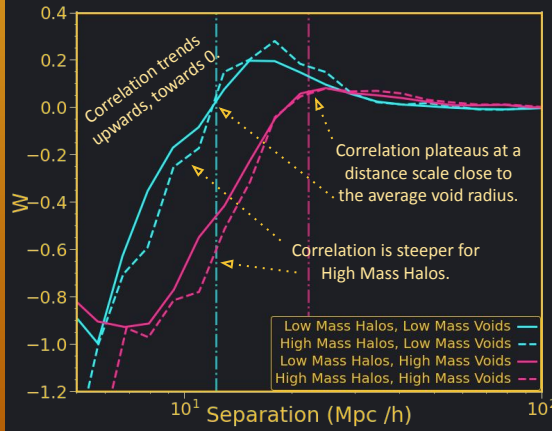
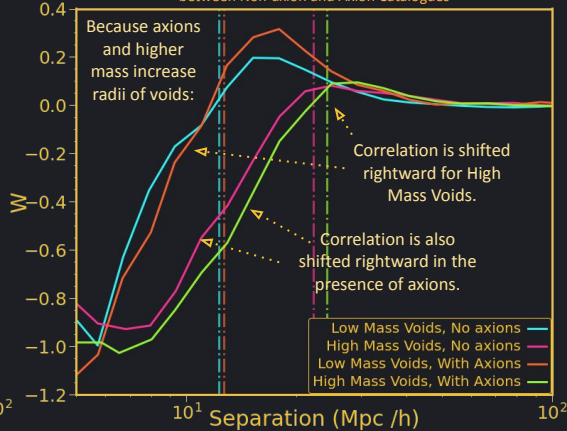


Figure 5: Void-Halo correlation, showing differences between Non-axion and Axion Catalogues



Future Steps

- Generating additional halo catalogues with a wider range of mass fractions and particle masses will allow us to study the overall nature of axion dark matter.
- In addition to halos, we may use simulated galaxy catalogues for the correlation function, which can be compared to the 3D map of the LSS.
- We can also compare halo correlation results to 2-dimensional maps of dark matter, although less accurate.
- Comparing our results with theoretical predictions will allow us to better understand the underlying physics behind our results.