

Environmental Systematics and the Impact on  
21-cm Epoch of Reionization Measurements

by

Lily R. Whitler

has been approved

Spring 2019

APPROVED:

---

Prof. Daniel Jacobs, Director

---

Prof. Judd Bowman

---

Dr. Adam Beardsley

ACCEPTED:

---

Dean, Barrett, The Honors College

Environmental Systematics and the Impact on  
21-cm Epoch of Reionization Measurements

by

Lily R. Whitler

A Thesis Presented in Partial Fulfillment  
of the Requirements for the Degree  
Bachelor of Science with Honors

Committee:

Daniel Jacobs, Director

Judd Bowman

Adam Beardsley

ARIZONA STATE UNIVERSITY

April 2019

## Table of Contents

<b>List of Figures</b>	<b>2</b>
<b>List of Tables</b>	<b>2</b>
<b>1. Introduction</b>	<b>4</b>
1.1. The Epoch of Reionization . . . . .	4
1.2. The 21-cm Power Spectrum . . . . .	4
1.3. The Hydrogen Epoch of Reionization Array . . . . .	4
1.4. Radio Frequency Interference . . . . .	5
<b>2. Methods</b>	<b>5</b>
2.1. RFI Excision Strategies . . . . .	5
2.2. Calculating the Power Spectrum . . . . .	5
2.3. Modelling HERA Data . . . . .	5
<b>3. Results</b>	<b>5</b>
<b>4. Conclusion</b>	<b>5</b>
<b>5. References</b>	<b>5</b>

## List of Figures

1. Timeline of the universe . . . . .	5
2. HERA as of late 2017 – early 2018 . . . . .	6

## List of Tables

## **Abstract**

## 1. Introduction

### 1.1. *The Epoch of Reionization*

Immediately after the Big Bang, the expanding universe was a hot, but cooling, plasma of fundamental particles. Approximately 380,000 years later, the universe had cooled and expanded enough for electrons to become bound to atomic nuclei, making the universe transparent to light and emitting the cosmic microwave background. Immediately following this period and lasting until  $\sim 400$  million years after the Big Bang was the cosmic Dark Ages, when the universe was quite literally dark—no stars or other sources of light had yet formed. Then, with the **formation** of the first luminous sources, the intergalactic medium (IGM), which had been predominantly neutral until then, was ionized by the energetic radiation from these sources during the Epoch or Reionization (EoR). The EoR ended around a billion years after the Big Bang, and the universe’s structure has continued evolving into what we now see today. This history is summarized in Figure 1. **I should probably have a reference here.**

[Furlanetto et al. \(2006\)](#)

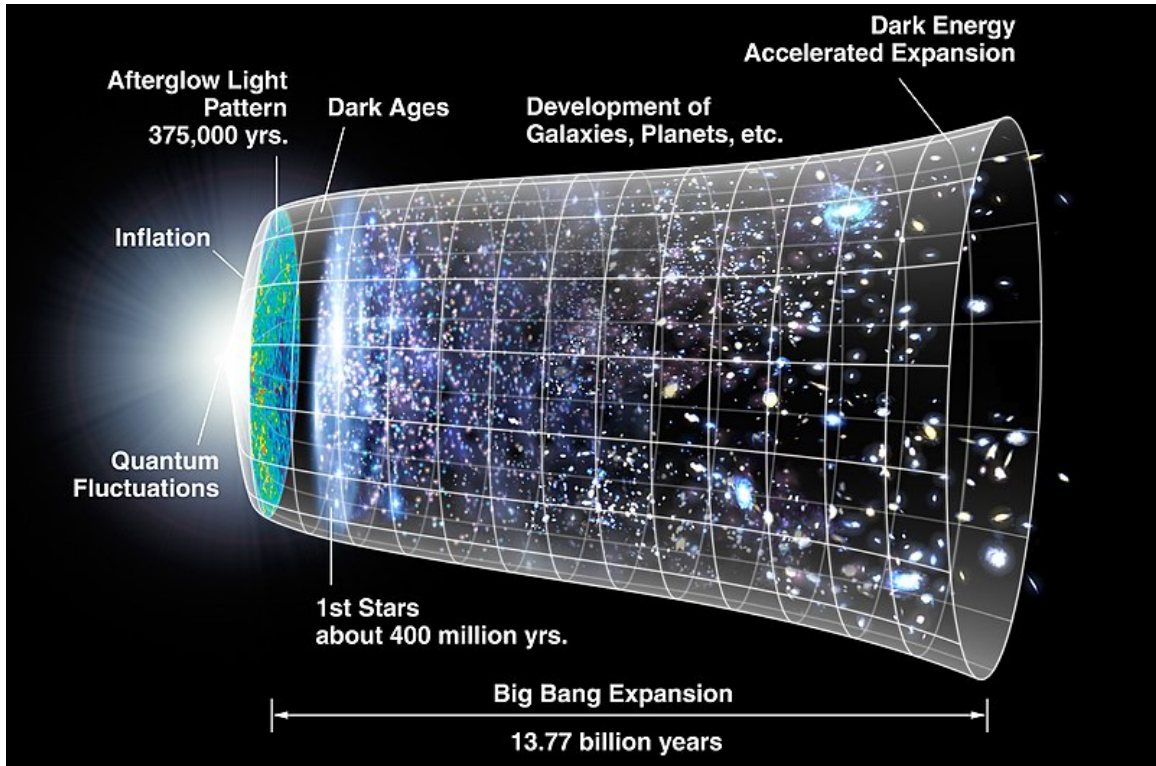
[Morales & Wyithe \(2010\)](#)

[Pritchard & Loeb \(2012\)](#)

### 1.2. *The 21-cm Power Spectrum*

### 1.3. *The Hydrogen Epoch of Reionization Array*

The Hydrogen Epoch of Reionization Array (HERA; Figure 2) is an experiment to study the periods prior to and during the EoR (**from redshifts  $z \sim 6 - 30$** ) via measurements of the redshifted 21-cm line ([DeBoer et al., 2017](#)).



**Figure 1.** Timeline of the evolution of the universe. Image courtesy of NASA.

#### *1.4. Radio Frequency Interference*

## **2. Methods**

### *2.1. RFI Excision Strategies*

### *2.2. Calculating the Power Spectrum*

### *2.3. Modelling HERA Data*

## **3. Results**

## **4. Conclusion**

## **5. References**

DeBoer, D. R., Parsons, A. R., Aguirre, J. E., et al. 2017, PASP, 129, 045001

Furlanetto, S. R., Oh, S. P., & Briggs, F. H. 2006, PhR, 433, 181



**Figure 2.** HERA as of late 2017 – early 2018. HERA will observe large-scale structure prior to and during the EoR via the redshifted 21-cm line from the IGM. Image courtesy of the South African Radio Astronomy Observatory.

Morales, M. F., & Wyithe, J. S. B. 2010, *ARA&A*, 48, 127

Pritchard, J. R., & Loeb, A. 2012, *RPPh*, 75, 086901