Searching for the Cosmic Dawn

Thesis by
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ABSTRACT

[This abstract must provide a succinct and informative condensation of your work. Candidates are welcome to prepare a lengthier abstract for inclusion in the dissertation, and provide a shorter one in the CaltechTHESIS record.]

PUBLISHED CONTENT AND CONTRIBUTIONS

[Fill this out with my publications]

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Chapter 1

INTRODUCTION

The discovery of the cosmic microwave background (CMB) radiation by Penzias & Wilson (1965) provided the first direct evidence that the universe had a beginning. Arno Penzias and Robert Wilson shared the 1978 Nobel Prize in Physics for this discovery, and astronomers have been studying this radiation ever since. In fact, a second Nobel Prize was awarded to John Mather and George Smoot in 2006 for their work on the Cosmic Background Explorer (COBE) satellite, which was amongst the first experiments to demonstrate that the background radiation was anisotropic (Smoot et al., 1992). These studies of the CMB have fundamentally advanced humanity's understanding of the universe: its origin, evolution, and composition. Still we continue to study the CMB particularly because it illuminates everything in the universe. It is a flashlight for the darkness of space within our expanding universe.

As the universe expands, the wavelength of a photon is similarly stretched or redshifted (so-called because it gradually drifts to longer, redder wavelengths). Photons originating from a star 1000 light-years away will travel through the universe for 1000 years before they are collected by our telescopes. Consequently we observe this star as it was 1000 years ago. However, during its travels, the photon was also stretched by a small factor of 0.000007% due to the expansion of the universe. For nearby stars, this expansion factor is clearly too small to be conceivably measured. However, with the discovery of the first quasar by Schmidt (1963) it soon became apparent that the stretching factor, the redshift z, can be $> 10\%$. Today, the most distant known galaxies are so far away that the wavelength has more than doubled ($z > 1$) due to the expansion of the universe.

list some known galaxies and their redshifts

Due largely to careful and detailed work studying the CMB, Type Ia supernova explosions, and cosmological galaxy surveys, we have a very detailed understanding of the expansion history of the universe.

Given knowledge of the original wavelength of the photon, and the expansion history of the universe, we can calculate how long the photon must have been in flight.

Today the CMB is a 2.7 K sea of photons that permeates the universe. This radiation is constantly cooling due to the inexorable expansion of the universe.

Introduce the 21 cm transition.

Introduce low frequency telescopes.

BIBLIOGRAPHY

Penzias, A. A., & Wilson, R. W. 1965, ApJ, 142, 419

Schmidt, M. 1963, Nature, 197, 1040

Smoot, G. F., Bennett, C. L., Kogut, A., et al. 1992, ApJ, 396, L1

Chapter 2

THE OWENS VALLEY RADIO OBSERVATORY LONG WAVELENGTH ARRAY

(a)

(b)

Figure 2.1: **(a)** A picture of an OVRO-LWA antenna. **(b)** A view of the OVRO-LWA with the Sierra Mountains in the background.

Chapter 3

THE RADIO SKY AT METER WAVELENGTHS: *M*-MODE ANALYSIS IMAGING WITH THE OVRO-LWA

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5.5 UnitfulAstro.jl

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