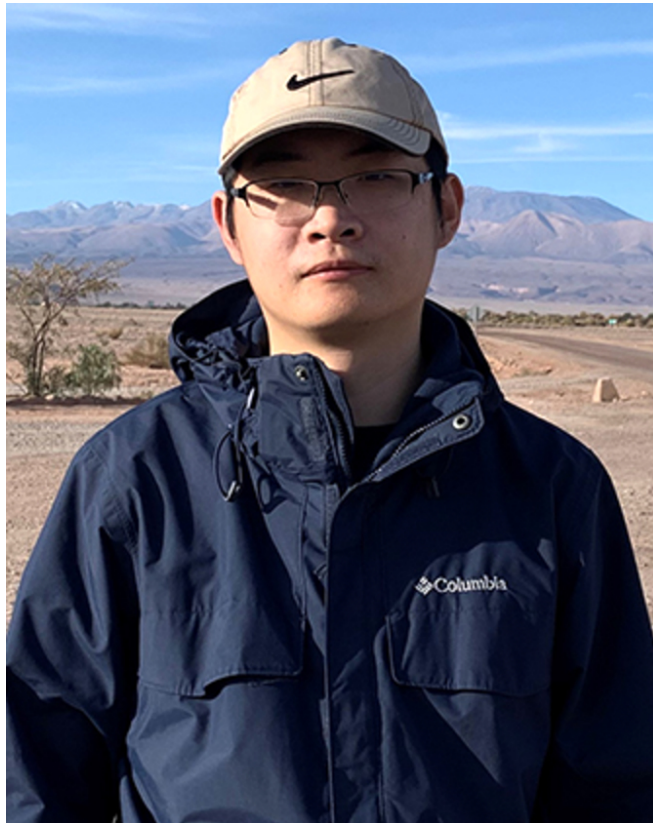


DOCTORAL DEFENSE

Topics in Microwave Astronomy and Cosmology

Yilun Guan



Abstract: Over the past decades, precision measurements of the Cosmic Microwave Background (CMB) have led to remarkable progress in our understanding of the universe in what is known as the standard model of cosmology. In this thesis, we demonstrate the potential of such high precision CMB dataset in improving our knowledge in both cosmology and astronomy.

In the first part of the thesis we show that the upcoming CMB experiments may allow us to detect signals from the primordial magnetic field (PMF), which is the hypothesized magnetic field that exists prior to the decoupling of the CMB photons and may help explain the origin of the ubiquitous magnetic field observed in the universe in galaxies, galaxy clusters and even the intergalactic medium. We show that a signal from PMF may pose as a source of confusion to the signal from the primordial gravitational waves which is highly sought after, particularly if such signal is detected in the large-scale CMB anisotropies. We further show how one can effectively break the degeneracy with the help of precision measurements of the small-scale CMB anisotropies.

In the second part of the thesis, we explore the use of precision measurements of the small-scale CMB anisotropies in constraining physics beyond the standard model. In particular, parity violating physics in the early universe may lead to an effect known as the cosmic birefringence, which can be detected in the CMB. With data obtained from the Atacama Cosmology Telescope (ACT), we search for a cosmic birefringence signal. Our non-detection allows us to place a tightest constraint on such effect at the time which improves the previous limit by a factor of 3.

In the third part of the thesis, we demonstrate that the high angular resolution CMB dataset can also be used for astronomy, particular in galactic science. By combining the CMB datasets from both ACT and Planck, we make a map of the Galactic center region of our galaxy which improves the previous maps in the microwave frequencies in terms of a wider field of view and higher angular resolution and sensitivity in both temperature and polarization measurements. Such map allows us to probe different physical emission mechanisms in the region, study the magnetic field morphology around different radio sources and molecular clouds, and probe the Galactic magnetic field in the microwave frequencies.

In the last part of the thesis, we discuss the prospects of the upcoming data release (DR6) from ACT which will contain a factor of 5 more data than the previous ACT data releases and is expected to improve our constraints on cosmological parameters by a factor of 2. In this chapter I provide a description of the important preprocessing step known as the data cuts pipeline, which identifies data with sporadic pathologies and removes them from the CMB mapmaking. I also show the preliminary results from the pipeline for the ACT DR6 and discuss its prospects for the upcoming Simons Observatory.

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