Long wavelength astrophysics

by

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Abstract

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Acknowledgements

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Chapter 1

The Canadian Hydrogen Intensity Mapping Experiment

1.1 Chapter Overview

In this chapter we will introduce in detail the Canadian Hydrogen Intensity Mapping Experiment (CHIME).

1.2 Introduction

CHIME is a Canadian collaboration between the University of British Columbia (UBC), the University of Toronto (UofT), McGill University, and the Dominion Radio Astrophysical Observatory (DRAO). It is located at DRAO, Canada's national radio observatory, and it consists of two stages: A pathfinder instrument, known hereon as the CHIME Pathfinder, which is two 20x37 m cylinders; and the final instrument, called either full CHIME or just CHIME, which is four 20x100 m cylinders. The Pathfinder was first "on sky" in November 2013, however it has only been observing in full capacity, i.e. with all of its feeds mounted, since XX 2015. Full CHIME is meant to be fully instrumented before the end of 2016.

CHIME's primary science goal is to map out the Universe's neutral hydrogen, mapping out the large-scale structure (LSS) and constraining dark energy's equation of state. However, it was noticed early on that CHIME was an ideal instrument for a large swath of time-variable radio science. Digital radio telescopes like CHIME can run multiple experiments in parallel, since data can be siphoned off and split between different backends. In light of this, an effort was made, successfully, to acquire funding for two new experiments to piggy-back on CHIME. One is a pulsar backend that will time large numbers of sources, observing ~ 10 pulsars 24/7. Another is an FRB backend that will search 1024 FFT-formed beams for dispersed transients.

1.3 CHIME Science

1.3.1 21 cm Cosmology

1.3.2 Pulsar

1.3.3 FRB Survey

1.4 The instrument

CHIME is a novel telescope that caters new analysis techniques to its instrumental ingenuity. CHIME is a novel telescope that pairs its instrumental ingenuity with analysis techniques that have been catered to its design. It is a cylindrical radio interferometer aligned in the north-south direction. CHIME is a transit telescope with no moving parts. It looks at the meridian as the earth rotates and the sky passes overhead, and will have an on-sky duty-cycle of 100%. Since its reflectors are parabolic cylinders, light is only focused in the east-west direction, with a transverse beamwidth given by $\frac{\lambda}{D} \approx 1^{\circ}$. In the north-south direction the dish effectively acts as a mirror. This results in a very large declination beam that can see nearly the whole north-south sky, barring the feed's beam and cosine projection at low-elevation. To gain north-south spatial resolution, CHIME's focal line is populated with broad-band, dual-polarization antennas that we call "clover" feeds due to their likeness to four-leaf clovers. The signals from these feeds can then be interfered either in beamforming or by traditional interferometric correlation.

The clover feeds are separated by ~ 30 cm, constrained by their physical size and the requirements of a 400-800 MHz feed. This is problematic for the top of our band. Since we observe at 37.5-75 cm, wavelengths shorter than twice the physical separation of our feeds will not be properly Nyquist sampled. Therefore below ~ 60 cm (above ~ 500 MHz) we do not uniquely measure the electric field in the north-south direction and our signal will be aliased. In other words, without external information, a point source's declination will be ambiguous at high frequencies.

1.4.1 Beams

1.5 Pathfinder analysis

1.6 Conclusion

Acknowledgements

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