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Calibrating CHIME for 21 cm Cosmology

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The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is a radio interferometer that is designed to measure the power spectrum of the 21 cm emission from neutral hydrogen between redshifts 0.8 and 2.5 [1]. The imprint of Baryon Acoustic Oscillations (BAO) on the power spectrum will enable precise constraints on the angular diameter distance versus redshift relation and time evolution of the expansion rate during the epoch when dark energy begins to dominate the energy density of the Universe.

CHIME is located at the Dominion Radio Astrophysical Observatory (DRAO) near Penticton, British Columbia. It consists of four 100 x 20 meter cylindrical dishes oriented in the north-south direction. The focal line of each dish is populated with 256 dual-polarization antenna feeds that are sensitive to 400–800 MHz and have a system temperature of approximately 50 K. CHIME maps the northern half of the sky each day with a synthesized beam resolution of 20–40 arcminutes.

The primary challenge facing CHIME is the removal of astrophysical foregrounds, which are several orders of magnitude brighter than the cosmological 21 cm signal of interest. In order to properly remove these foregrounds, we must characterize the instrument at sub-percent level accuracy. Radio-bright point sources are used for absolute calibration of the complex receiver gains, and a combination of broadband noise source and temperature sensor data is used to correct for drift in the gains with time. The antenna beam pattern is described by an empirical model, which has has been fit to CHIME observations of the sun and holographic observations of radio-bright point sources made in conjunction with the John A. Galt 26 m telescope. I will provide an overview of the strategies used for both complex gain and beam calibration, and evaluate their effectiveness by examining the residuals after foreground removal. I will conclude by discussing the systematic errors that dominate our measurement of the 21 cm power spectrum after acquiring over 2 years of data.

References

[1] L. B. Newburgh, G. E. Addison, M. Amiri, K. Bandura, J. R. Bond, L. Connor, J.-F. Cliche, G. Davis, M. Deng, N. Denman, M. Dobbs, M. Fandino, H. Fong, K. Gibbs, A. Gilbert, E. Griffin, M. Halpern, D. Hanna, A. D. Hincks, G. Hinshaw, C. Höfer, P. Klages, T. Landecker, K. Masui, J. M. Parra, U.-L. Pen, J. Peterson, A. Recnik, J. R. Shaw, K. Sigurdson, M. Sitwell, G. Smecher, R. Smegal, K. Vanderlinde, and D. Wiebe. Calibrating CHIME: a new radio interferometer to probe dark energy. In *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, volume 9145 of *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, page 4, July 2014.