Faraday Synthesis with CHIME: an interferometric component of GMIMS-LBN

Abstract

The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is producing high quality, broadband polarization maps of the northern sky as an interferometric contribution to the Global Magneto-Ionic Medium Survey Low-Band-North (GMIMS-LBN). CHIME covers 400 to 800 MHz in 390 kHz channels with a declination range of 0 to 90 degrees and 40 arcminute spatial resolution. The spatial and frequency coverage of CHIME overlaps with the recently observed DRAGONS (DRAO GMIMS of the Northern Sky) survey, which will provide the absolutely calibrated, single-antenna component of GMIMS-LBN. I report on progress toward calibrating the CHIME polarization maps, studying large-scale Galactic magnetic field structures in comparison with previous GMIMS datasets, exploring discrete magnetized objects in the ISM revealed by CHIME's high spatial resolution, and comparing to the DRAGONS survey with the goal of ultimately combining the two data sets.

With its unique configuration and large field of view, CHIME maps the northern sky on a daily basis, allowing for the sensitivity necessary to achieve the experiment's primary goal of detecting cosmological 21 cm emission (CHIME Collaboration, 2023). The comparatively bright, polarized Galactic foreground is easily mapped with high signal to noise across the bandwidth, making the CHIME data cubes ideal for Faraday synthesis. We have developed a method for independently calibrating the CHIME Stokes Q and U cubes in the 600 to 800 MHz sub-band, yielding Faraday depth spectra with 35 rad/mˆ2 resolution and sensitivity to structures as broad as 22 rad/mˆ2. Eventual inclusion of the lowest frequencies will improve the Faraday depth resolution to 9 rad/mˆ2. Initial comparisons of the Faraday depth moment maps between CHIME and DRAGONS reveal good agreement (Figure 1), and the calibration of the CHIME polarization cubes will improve when the absolutely-calibrated DRAGONS data are incorporated as short spacings for CHIME.

Early science results from CHIME Faraday depth maps are revealing a wealth of information on Galactic magnetic field structures. On large scales, patterns in the first moment of Faraday depth as a function of Galactic longitude agree with the results of Dickey et al. (2022) based on GMIMS High-Band-North, while probing nearer depths as a result of the lower frequency range. This information will provide further constraints on Galactic dynamo models. On smaller scales, CHIME data have revealed new insights into the polarization feature G137+7 (Verschuur, 1969; Haverkorn, 2003; Iacobelli, 2013) suggesting the association of a tail-like structure with the circularly-shaped feature in both polarization angle and Faraday depth (Mohammed et al. 2023, in prep; Figure 2). These early results highlight the utility of low-frequency polarization maps in the GMIMS effort toward understanding the three dimensional structure of the Galactic magnetic field.

References:
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