THE LWA1 LOW FREQUENCY SKY SURVEY

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OVERVIEW

- Motivation
- LW A1
- Approach
  - Data acquisition
  - Calibration
  - Missing spacing correction
- Maps & Spectral Indicies
- The Low Frequency Sky Model
- Conclusions

Collaborators:

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Overview

• Motivation

• LWA1

• Approach
  • Data acquisition
  • Calibration
  • Missing spacing correction

• Maps & Spectral Indices

• The Low Frequency Sky Model

• Conclusions and Future Directions
MOTIVATION

NASA/WMAP Science Team
MOTIVATION

Pritchard & Loeb (2012)
MOTIVATION

Caswell (1976) - 10 MHz

Rogers et al. (1999) - 22 MHz

Alvarez et al. (1997); Maeda et al. (1999) – 45 MHz
LWA1

256 Dipoles

100 m

5 m
LWA1

LWA1 shielded electronics shelter (100 dB shielding w/ RF tight racks)

~50 km of cables buried
LWA1
LWA1

Outriggers →

500 m

Long Wavelength Array

Google
Astrophysics

**Cosmology**
Observing cosmic dawn through redshift 30 absorption of the 21 cm line. High redshift radio galaxies, containing the earliest black holes

**Acceleration, Propagation & Turbulence in the ISM**
Origin, spectrum & distribution of Galactic cosmic rays, Supernova remnants & Galactic evolution, Pulsars and their environments

**Solar Science & Space Weather**
Radio heliography of solar bursts & coronal mass ejections, Solar magnetic fields

**Exploration of the Transient Universe**
New coherent sources, GRB prompt emission, poorly explored parameters space …

Ionos- & Atmospheric Physics

**Unprecedented continuous spatial & temporal imaging of the ionosphere**

**Test and improve global ionospheric models**

**High-time-resolution Imaging of Lightning**

Your ideas?
All of LWA1 time is open skies. Your observing proposals are welcome!
• Three methods of data collection at LWA1:
  • TBN, TBW, and Beamforming

• Used TBW to gather all of the bandwidth in 61 ms chunks
  • 61 ms is short but not so short as to be uninteresting
    • Confusion limited at degree resolutions
  • Each capture is ~10 GB
  • Use many captures to build up sky coverage
    • Snapshots every 15 minutes over a 24 hour period
    • Multiple epochs to help remove the Sun
Three main problems: flux calibration, imaging, and missing spacings

Multi-part strategy
- Use lab measurements to constrain what we can
  - Front end and analog receiver electronics
- Use simulations for things we can’t easily measure
  - Beam pattern and impedance mis-match loss
- Tie the brightness of “A team” sources to an existing flux scale, like Baars
- Use the LEDA total power system to constrain the total flux
- Used MFS + forward modeling to constraint the missing scales
APPROACH - MOSAICING

- Re-project the snapshots onto a sphere and co-add
- Used HEALpix for the final maps
Maps

74 MHz
UNCERTAINTY
COMPARISONS
FERMI BUBBLES

Gamma Ray + X-ray
Fox et al. (2015)
Ackermann et al. (2014)

Carretti et al. (2013)

velocity
velocity

Polarized Jy/beam
FERMI BUBBLES

38 MHz

60 MHz

74 MHz
CENTAURUS A

38 MHz

74 MHz

408 MHz
SPECTRAL INDEX
SPECTRAL INDEX
LOW FREQUENCY SKY MODEL

Our maps, plus literature maps at:
- 10, 22, 45 MHz
- 408 & 820 MHz
- 1.4 GHz
- WMAP bands

GSM-style principle component analysis
THE LOW FREQUENCY SKY MODEL

74 MHz
• The LWA1 Low Frequency Sky Survey covers:
  • Nine frequency bands between 35 and 80 MHz of
  • The radio sky north of $-40^\circ$ at a
  • 2 to 5 degree resolution
  • MNRAS (2017) 469, 4537-4550

• The sky has been combined with existing data to create
  a new model for the low frequency radio sky
  • Uses new data to create an updated model of the sky below 400 MHz

• The survey maps and the model are available at:
  • https://lda10g.alliance.unm.edu/
    LWA1LowFrequencySkySurvey/
**FUTURE DIRECTIONS**

- Better understanding of the instrument
  - Dipole beam pattern
  - Frequency dependent losses

- Push to lower frequencies
  - Opens up new possibilities for absorption studies, new modeling methods

- Combine data with other instruments, investigate new approaches to imaging

Henning et al. (2010)

MWA (Wikipedia)