THE LWA1 LOW FREQUENCY SKY SURVEY

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OVERVIEW

• Motivation

• LW A1

• Approach
  • Data acquisition
  • Calibration
  • Missing spacing correction

• Maps & Spectral Indices

• The Low Frequency Sky Model

• Conclusions

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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

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

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

~50 km of cables buried
LWA1

Outriggers →

500 m

Long Wavelength Array

Google
# LWA SCIENCE

## 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 …

## Iono- & Atmospheric Physics

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

### Test and improve global ionospheric models

### High-time-resolution Imaging of Lightning

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**Your ideas?**

All of LWA1 time is open skies. Your observing proposals are welcome!
Approach - Data

- 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)
FERMI BUBBLES

38 MHz

60 MHz

74 MHz
SPECTRAL INDEX
Spectral Index
Our maps, plus literature maps at:

- 10, 22, 45 MHz
- 408 & 820 MHz
- 1.4 GHz
- WMAP bands
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)