# Characterization of the Diffuse Radio Sky with **EDGES** and **MIST**



Radio Synchrotron Background Workshop 17 June 2022

# EDGES Global 21-cm Experiment

### Absolute Calibration of Low-Frequency Diffuse Maps

$$M_C = k_1 \times M + k_2$$

Monsalve at al. (2021)

#### **45-MHz Map**: Guzmán et al. (2021)

**150-MHz Map:** Landecker and Wielebinski (1970)

45-MHz Map

#### Monsalve at al. (2021)



#### 150-MHz Map

#### Monsalve at al. (2021)



Linear Fits



At each frequency fitting 2 data sets simultaneously

### Uncertainties of Results

=

Uncertainty of Linear Fit Parameters



Systematic:

- Choice of Data sets
- Instrument Calibration
- Ionosphere

Uncertainty of Corrected Maps

Uncertainty
of Linear Fit
Parameters

quadrature

+



RMS of Fit Residuals Results

#### **Linear Fit Parameters**

<u>45-MHz Map</u> Guzmán et al. (2021)				<u>150-MHz Map</u> Landecker and Wielebinski (1970)		
$k_2$	-160K	<u>+</u>	78K (2 $\sigma$ )	+0.7K	$\pm$	6K (2 <i>σ</i> )

#### Map Brightness Temperature at $(l, b) = (+190^{\circ}, +50^{\circ})$

<u>45-MHz Map</u>			<b>150-MHz Map</b>		
	<u>Guzmán</u>	<u>et al. (2021)</u>	Landecker and Wielebinski (1970)		
Original	3326K	<u>+</u> > 333K	148.9K <u>+</u> >41K		
This Work	3419K	$\pm$ 255K (2 $\sigma$ )	166.3K $\pm$ 14.3K (2 $\sigma$ )		

#### Monsalve at al. (2021)







### 159-MHz Map from Kriele et al. (2022)

SKA Prototype Station: Engineering Development Array 2 (EDA2) Located at Murchison Radioastronomy Observatory (MRO) 256-element interferometer 3<sup>o</sup> resolution



Wayth et al. (2021)

### 159-MHz Map from Kriele et al. (2022)

EDA2 only



### 159-MHz Map from Kriele et al. (2022)

EDA2 + Scaled Haslam



#### High-Band **BLADE** Dipole



#### Mid-Band **BLADE** Dipole



#### High-Band FOURPOINT Dipole



# EGG

Char The

N.T.

### Absolute Calibration of 159-MHz Map

Monsalve at al. (in prep)



### Diffuse Radio Recombination Lines (RRLs)



Expected frequencies for  $C\alpha$  lines



#### **Stacked Analysis**

380 days 2-h LST bins +/- 100 kHz windows



GHA 00 / LST 17.8

0.2

0.0 T<sub>RRL</sub> (K) -0.2 -0.4 -0.6 -0.8 GHA 06 / LST 23.8 GHA 08 / LST 1.8 GHA 10 / LST 3.8 0.2 0.0 T<sub>RRL</sub> (K) -0.2 -0.4 100 Relative Frequency (kHz) Relative Frequency (kHz) Relative Frequency (kHz)

GHA 02 / LST 19.8

GHA 04 / LST 21.8

#### Bowman et al (in prep)



50

0

Relative Frequency (kHz)

-100

100

-50

0

50

-100

-50



# MIST Global 21-cm Experiment

### Mapper of the IGM Spin Temperature (MIST)

Experiment began in 2018







Government

of Canada

Canadian Space Agency

# Standard Prediction for Global 21-cm Signal



# Mapper of the IGM Spin Temperature (MIST)

#### Instruments:

- 2 x single-antenna total-power radiometers
- Wideband **dipole** and **monopole** antennas
- Antennas directly above ground without metal ground plane
- Field measurements of **spectra** and **reflection coefficients** of **antenna** and **LNA**
- High portability for deployment at remote locations
- Low power consumption (~ 15 watts)
- Powered only by batteries

#### Main analysis steps:

- Excision of data with radio-frequency interference
- **Relative spectral calibration** using field measurements of internal standards
- Absolute calibration using laboratory measurements of external standards
- Removal of ground and balun loss

### Instrument

#### **Digital Back-End**

#### **Analog Front-End**







### Plans for Canadian Arctic in July 2022

#### The McGill Arctic Research Station



#### Measured in 2019 10.0 Low freq roll-off from antenna 9.8 9.6 9.4 9.2 -No persistent FM features! 9.0 8.8 8.6 Shortwave floor at <20 MHz (during Arctic summer...) 8.4 20 40 80 100 120 0 60 Freq (MHz)

#### Credit: H. Cynthia Chiang

### Test Field Measurements Done in May 2022









# **Death Valley**



# **Death Valley**

### Shania Twain – That Don't Impress Me Much



### ZZ Top – I Gotsta Get Paid



### ZZ Top – I Gotsta Get Paid



### ZZ Top – I Gotsta Get Paid



# **Death Valley**



# **Death Valley**







# Soil Antenna

# Soil Resistivity Meter

# Soil Resistivity Meter

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and the spectrum and

Cos)

### **Determination of Soil Layers**



### Other Soil-Characterization Efforts

Building 64-electrode soil resistivity meter for 3D tomography



### Sky Blockage by Mountains



### SHAPES code (Neil Bassett et al. 2021)

### **Dipole Observations – Death Valley**



### **Reflection Coefficients**



### Balun and Ground Loss for Dipole Antenna



### **Dipole Observations – Death Valley**



### **Dipole Observations – Death Valley**



# Summary

- 1) With EDGES, provided absolute calibration to 45- and 150-MHz diffuse maps.
- 2) With EDGES, calibrating 159-MHz map.
- 3) With **EDGES**, **detected RRLs**, including at high Galactic latitudes.
- 4) With **MIST**, starting to produce **high-quality data** to study the radio sky.