Intensity Mapping Techniques for Radio Observation

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Overview

INTRODUCTION

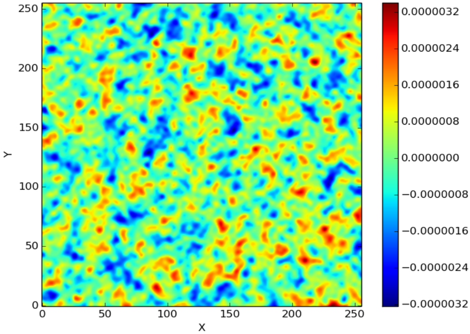


Figure : **Simulated fluctuations in the brightness temperature of 21cm emission from galaxies. Red indicates overdensity and blue underdensity**

INTRODUCTION

1. Intensity mapping is an observational technique which makes use of autocorrelations and low resolution images of the sky to map the distribution of large scale HI structure without localizing individual galaxies.

2. The technique has the advantage of containing spatial information that can be used to further understand the processes of structure formation or as a cosmological probe.

3. However, these signals are subject to Direction Dependent Effects (DDE's) and the most challenge is the primary beam.

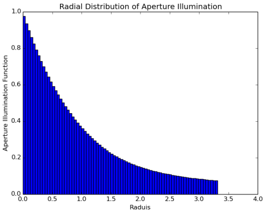
How to Go About Intensity Mapping

1. To achieve this, we produce fully polarized beams and try to corrupt these fully polarized beams and find ways of correcting them. We then observe what comes out of these simulations in terms of foreground that have leaked from intensity polarization.

2. **Key goal:** Determine the effect of polarisation on intensity mapping experiments.

Beam Model:

1. $\phi \sim U(0, 2\,\pi) \longrightarrow$ Dipole Orientation
2. $f(h^{-1}(y))|\frac{dh^{-1}(y)}{dy}| = 1.|(-\lambda)\mathrm{e}^{-\lambda y}| = \lambda \mathrm{e}^{-\lambda y} \longrightarrow$Radial Distribution



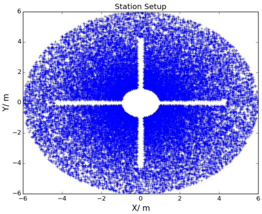


Figure : **Station Layout of Circular Aperture array**

Beam Model: Conversion between Jones and Mueller

- It represents the horizontal and vertical polarization states of the signal.

$$\mathbf{J} = \begin{pmatrix} J_{00}(\nu, t, l, m) & J_{01}(\nu, t, l, m) \\ J_{10}(\nu, t, l, m) & J_{11}(\nu, t, l, m) \end{pmatrix} \tag{1}$$

- Stokes Mueller matrix representation of the primary beam.

$$M_{ij} = U\,(J \otimes J^{*})\,U^{-1} \tag{2}$$

$$U = \frac{1}{2}\begin{pmatrix} 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & -1 \\ 0 & 1 & 1 & 0 \\ 0 & -i & i & 0 \end{pmatrix}, \quad M_{ij} = \begin{pmatrix} I \leftarrow I & I \leftarrow Q & I \leftarrow U & I \leftarrow V \\ Q \leftarrow I & Q \leftarrow Q & Q \leftarrow U & U \leftarrow V \\ U \leftarrow I & U \leftarrow Q & U \leftarrow U & U \leftarrow V \\ V \leftarrow I & V \leftarrow Q & V \leftarrow U & V \leftarrow V \end{pmatrix}$$

Applying Convolution Techniques

$$P_F(\theta_0, \phi_0) = \sum_{\forall\, x_i, y_j \text{ close to } \theta_0, \phi_0} map(x_i, y_j) beam(x_i - \theta_0, y_j - \phi_0) \quad (3)$$

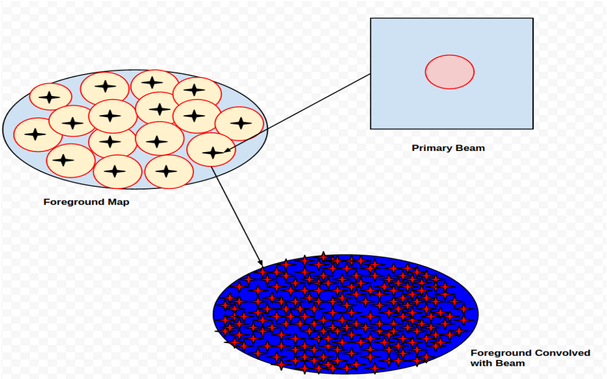


Figure : **Foregrounds convolved with modeled beams**

RESULTS: 4 $\times$ 4 Mueller matrix of the True Beam Model

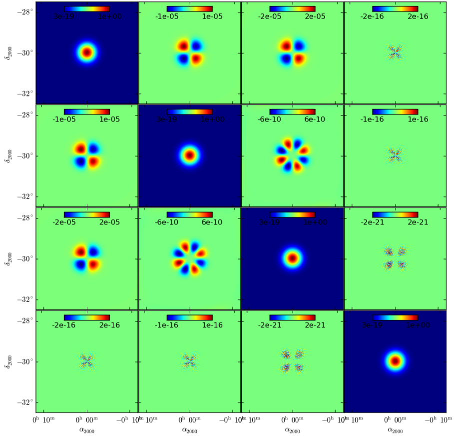


Figure : **Representation of non-distorted primary beams**

RESULTS: Mueller matrix form of Distorted Beam Model

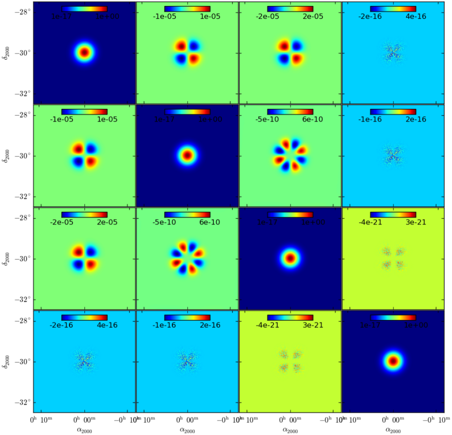


Figure : **Representation of distorted primary beams**

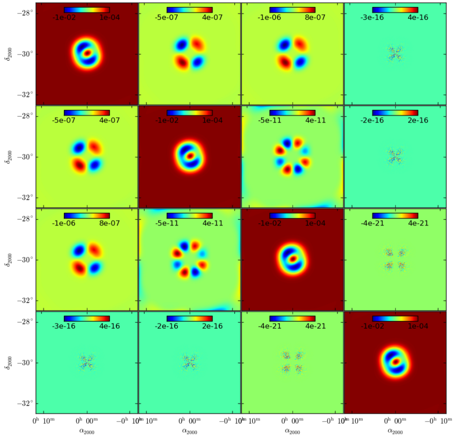


Figure : **Corresponding Beam Errors**

RESULTS: Foreground Intensities

- Provide full-sky foreground intensities with low resolutions of 0.23°

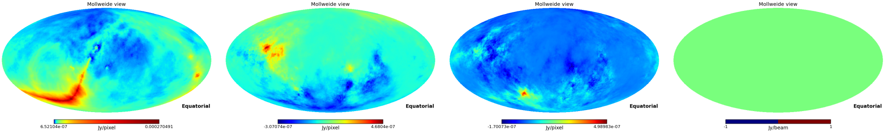


Figure : **Mollweide projections of full-sky synchrotron maps of Stokes** I, Q, U, V

RESULTS: After Convolving with True Beams

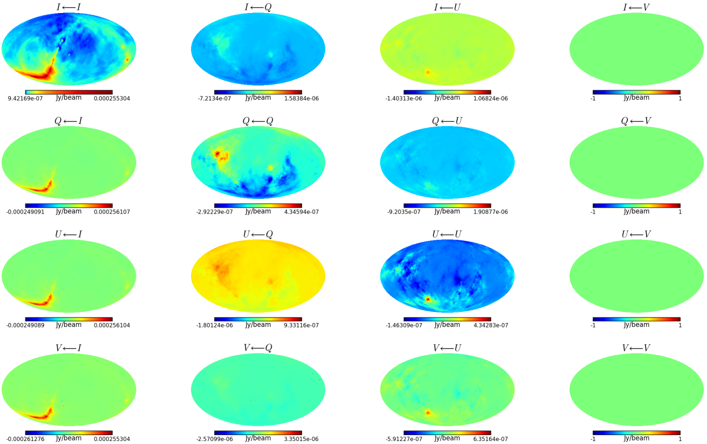


Figure : **Representation of foregrounds convolved with fully polarized beams**

RESULTS: After Convolving with Distorted Beams

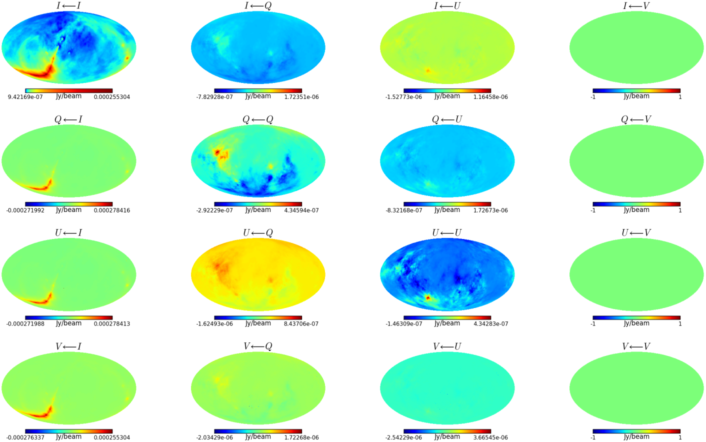


Figure : **Representation of foregrounds convolved with fully polarized beams**

RESULTS: Polarisation Leakage in I, Q, U, V

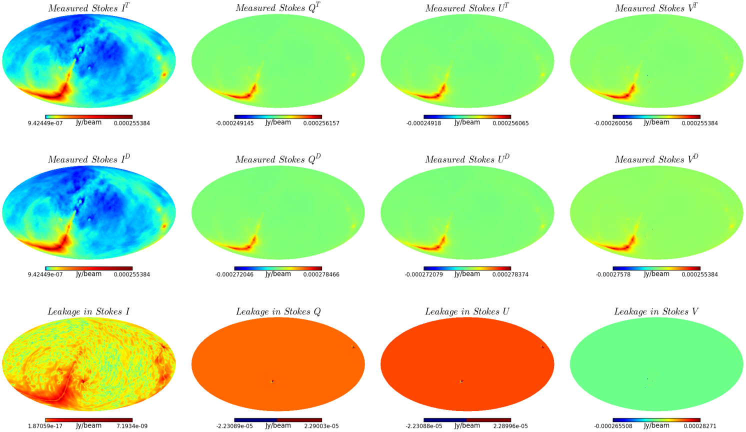


Figure : **Representation of corresponding measured foregrounds of the Sky**

RESULTS: Power Spectrum

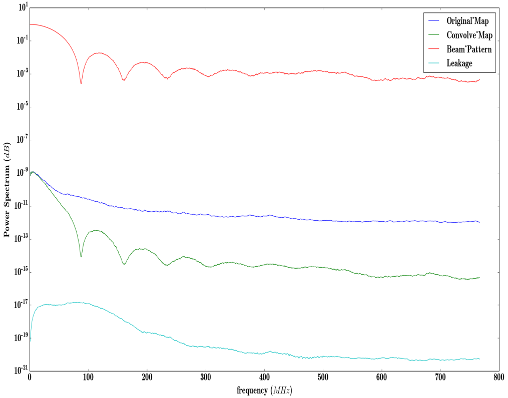


Figure : **Power Spectrum Estimation**

CONCLUSION:

- We can effectively measure the polarization leakage of a signal with the presence of these fully polarised beams.

The End! Thank You!