Cross-Correlation between the Epoch of Reionization Intensity Mapping Experiments, HERA and SPHEREx

Prepared for:

Daniel Jacobs, Adam Beardsley, & Judd Bowman

Arizona State University

School of Earth and Space Exploration

Prepared By:

Tyler Cox

Arizona State University

School of Earth and Space Exploration

Astrophysics Senior Thesis

December 10^{th} 2019

Abstract

The Subaru Strategic Exploration of Exoplanets and Disks (SEEDS) collaboration is conducting high-contrast observations of exoplanets and disks using the 188 actuator AO system (AO188), classical Lyot coronagraph, and near infrared differential imaging science camera (HiCIAO) on the Subaru Telescope. This work supports the SEEDS project by conducting an analysis of the importance of field rotation for observations acquired in angular differential mode (ADI). ADI suppresses optical speckle features by fixing the telescope point spread function (PSF) with respect to the science camera detector, while allowing the field with any companions to rotate freely. In post processing, the sequence of images are registered and combined to produce a reference PSF that is subtracted from each image. The final images are de-rotated to realign the field with a fixed position angle. We find that increasing field rotation does influence sensitivity and that doubling the amount of field rotation in an observation can reduce the minimum angular separation at which companions can be detected by 0.1" and increase the sensitivity of an observation by factors of 2–4 at separations of 0.2"–0.4". These results emphasize the importance of conducting ADI observations during transit when the rotation rate of the target is maximized.

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Acknowledgements

First and foremost, I would like to thank my research advisors, Adam Beardsley and Danny Jacobs.

To my committee members, Judd Bowman and blah. I can't thank you enough for blah.

I would also like to thank my friends and colleagues, who's endless encouragement and blah helped to. In particular, I would like to thank Shane Bechtel, Lily Whitler, Sam Nigh, and blah for their support over the last three years. Without them, I surely would have dropped out years ago.

Most importantly, none of this could have been done without the love and support of my family. To my sister, thank you for keeping me humble. To my Mom and Dad, thank you for all you've done.

1. Introduction

1.1. The Early Universe

blah asbdfasdf asdfkjasdlfk asffsd lkfsdalkjfdslkfds

1.2. The Epoch of Reionization

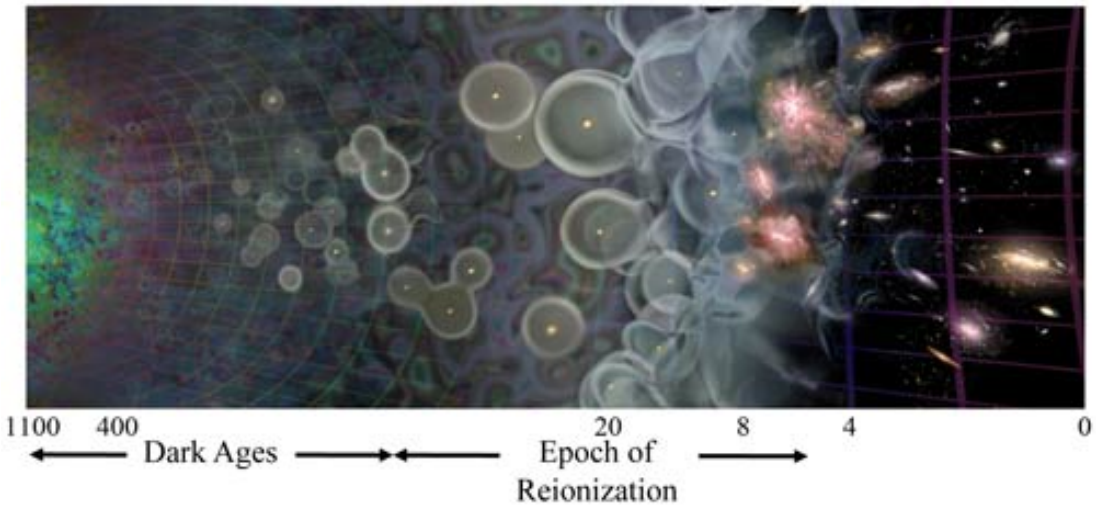

Figure 1. The power spectrum estimated after flagging a contiguous block of two channels.

1.3. The Hydrogen Epoch of Reionization Array

1.4. SPHEREx

blah asbdfasdf asdfkjasdlfk asffsd lkfsdalkjfdslkfds

2. Methods

2.1. 21cmFAST

2.2. 21cm Noise Auto Spectrum

$$\sigma_{21}^2 = \left[P_{21}\left(k,\mu\right) + \frac{T_{\rm sys}^2 V_{\rm sur}}{B\ t_{\rm int}\ n\left(k_\perp\right)} \mathrm{W}_{21}\left(k,\mu\right) \right] \tag{1}$$

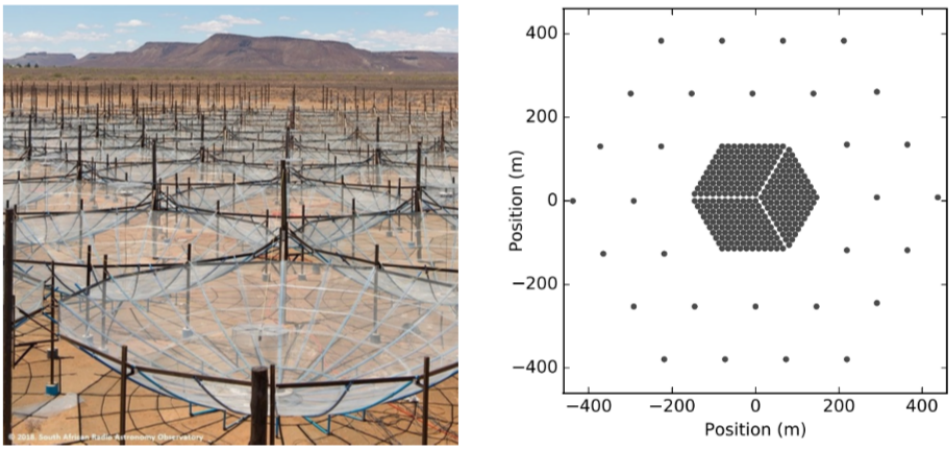

Figure 2. The power spectrum estimated after flagging a contiguous block of two channels.

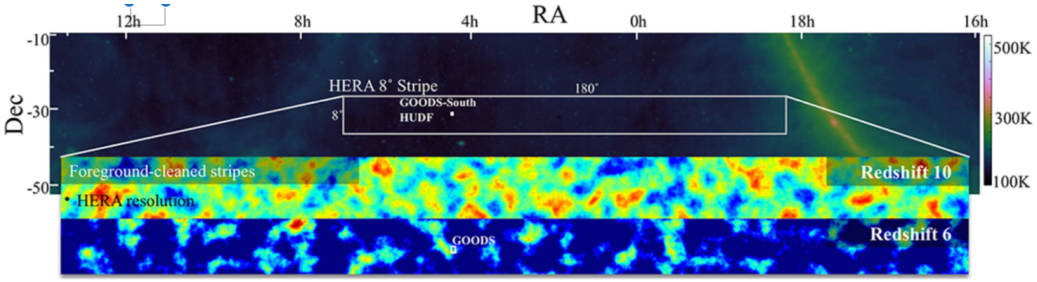

Figure 3. The power spectrum estimated after flagging a contiguous block of two channels.

$$\mathrm{W}_{21}\left(k,\mu\right)=e^{\left(k_{\parallel}/k_{\parallel,\mathrm{res}}\right)^{2}+\left(k_{\perp}/k_{\perp,\mathrm{res}}\right)^{2}} \tag{2}$$

$$V_{\mathrm{sur}}=\chi^{2}\Delta\chi\left(\lambda_{21}\left(z\right)^{2}/A_{e}\right)^{2} \tag{3}$$

$$\frac{1}{\sigma^{2}\left(k\right)}=\sum_{\mu}\frac{N_{\mathrm{m}}}{\sigma^{2}\left(k,\mu\right)} \tag{4}$$

$$k_{\parallel,\mathrm{res}}=\frac{R_{\mathrm{res}}H\left(z\right)}{c\left(1+z\right)}=\frac{1}{\Delta x_{\parallel,\mathrm{res}}} \tag{5}$$

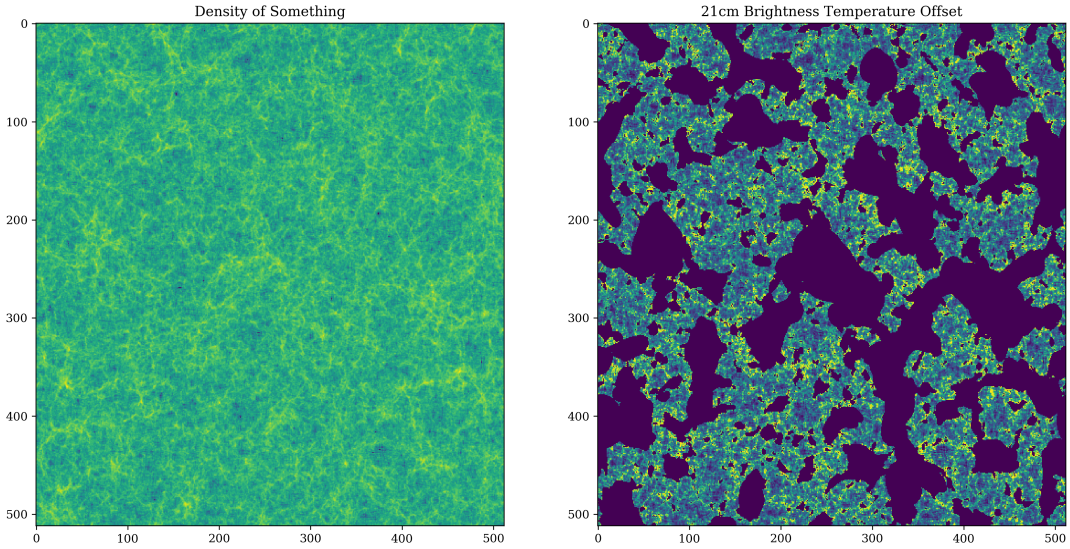

Figure 4. The power spectrum estimated after flagging a contiguous block of two channels.

$$k_{\perp,\mathrm{res}} = \frac{1}{\chi(z)\,\theta_{\mathrm{min}}} = \frac{1}{\Delta x_{\perp,\mathrm{res}}} \tag{6}$$

$$x_{\mathrm{pix}} = \left(\lambda_{21}(z)/l_{\mathrm{max}}\right)(\pi/180)/60 \tag{7}$$

Foreground wedge equation below

$$k_{\parallel} = k_{\perp}\frac{H_0 D_c E(z)\,\theta_0}{c(1+z)} \tag{8}$$

2.3. Lyα Noise Auto Spectrum

$$P_{N,Ly\alpha} = \sigma_{\mathrm{N}}^2 V_{\mathrm{vox}} \tag{9}$$

$V_{\mathrm{vox}} = A_{\mathrm{pix}} r_{\mathrm{pix}}$

$$\sigma_{Ly\alpha}^2 = \left[P_{Ly\alpha}(k,\mu) + \sigma_{\mathrm{N}}^2 V_{\mathrm{vox}} \mathrm{W}_{Ly\alpha}(k,\mu)\right] \tag{10}$$

ν_{res} (kHz)	l_{max} (cm)	T_{sys} (K)	t_{int} (hr)	B (z=8) (MHz)	A_e (z=8) (m^2)	$n_\perp$
3.9	10^5	400	1000	8	925	0.8

3. Results

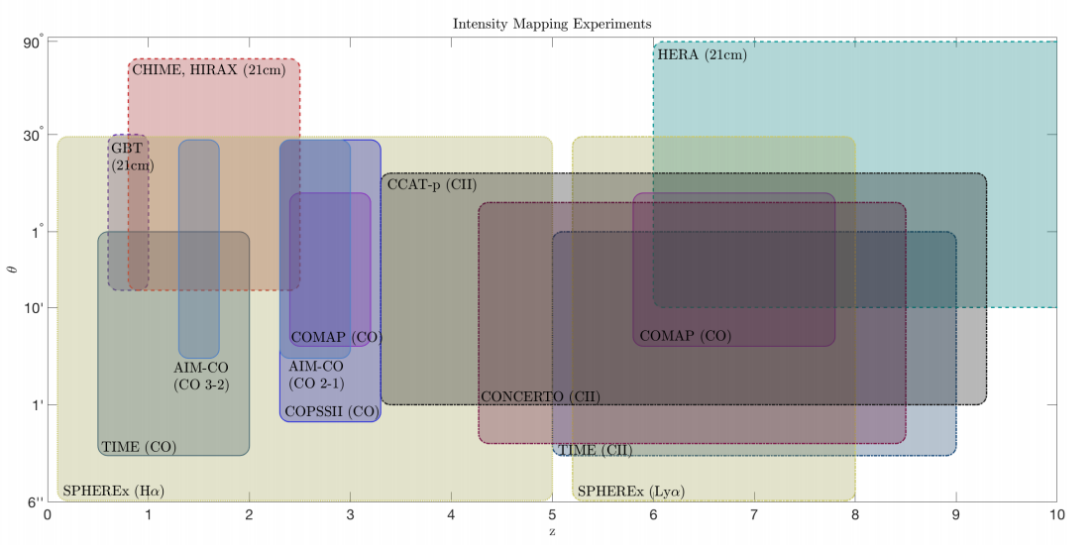

Figure 5. The power spectrum estimated after flagging a contiguous block of two channels.

4. Summary

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Appendix

This is where appendix-y things go