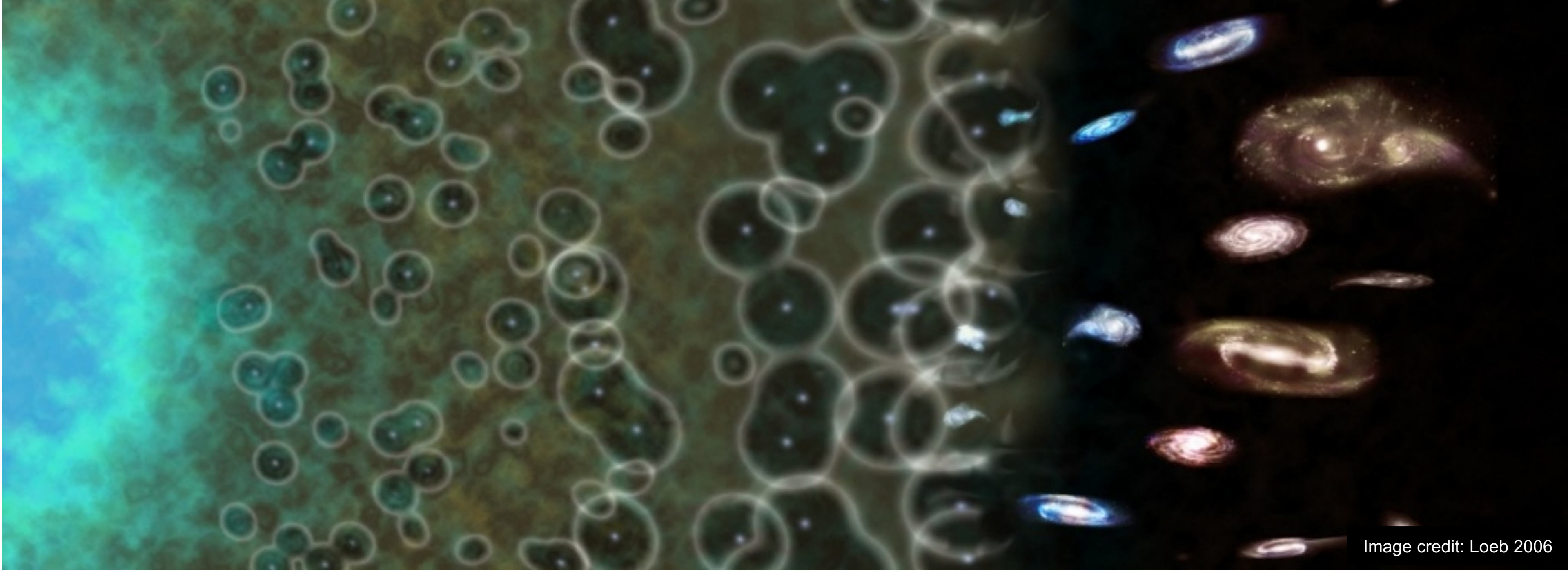

Virtual Research Presentation Conference

Developing the Error Budget for Future Space-Based 21 cm Cosmology Missions

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Program: Spontaneous R&TD

Assigned Presentation # RPC-001

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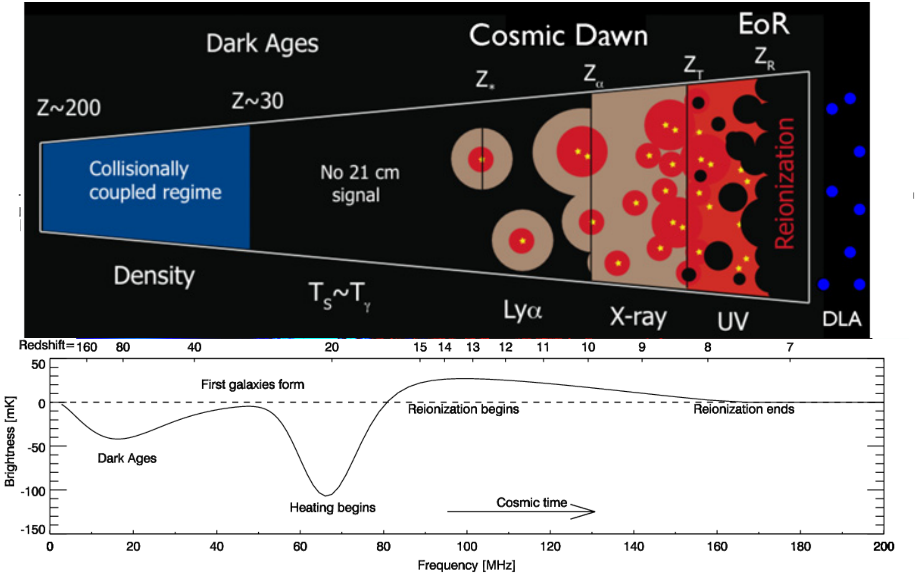
Tutorial Introduction

Abstract

The hyperfine spin-flip transition line of neutral hydrogen H I (rest wavelength = 21 cm) has the potential to provide unique information about the state of the intergalactic medium (IGM) and large-scale structure throughout most of the universe (Furlanetto et al. 2006).

Observations of this spectral line can potentially provide unparalleled constraints on cosmological parameters by probing the cosmic structure prior to the formation of the first stars and galaxies.

Space-based observations of the H I hyperfine line will be required at the highest redshifts (z > 20) due to the opacity of the Earth's ionosphere (observing wavelengths > 4 m, observing frequencies < 70 MHz). The importance of the highly redshifted H I line has been recognized in the New Worlds, New Horizons Decadal Survey and the NASA Astrophysics Roadmap.

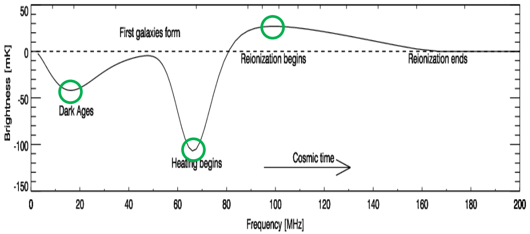


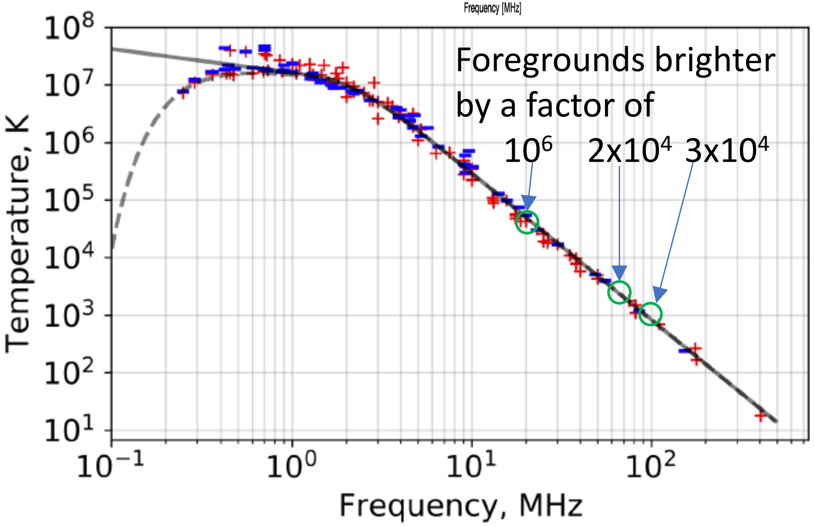
Problem Description

a) Context: Observations of this spectral line are exceptionally challenging, however, because of the strength of the synchrotron radiation foregrounds contributed by the Milky Way Galaxy and other galaxies along the line of sight. A systematically developed error budget is needed.

b) State-of-the-art: many of the terms contributing to the error budget have been identified in the literature, but, to date, there has been no effort to assemble and present them in a comprehensive and systematic manner.

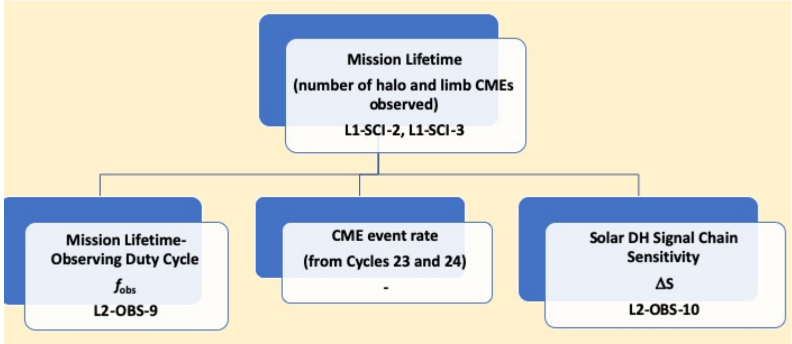
c) Relevance to NASA and JPL: An error budget structure that can account for foreground contamination of the signal, as well as instrumental effects, is needed to advance proposals for space observatories.





Methodology

- The approach is to decompose the error budget into a hierarchy of contributions.
- This approach worked to great effect in the Concept Study Report and Site Visit for the Sun Radio Interferometer Space Experiment (SunRISE).



Results

a) Accomplishments:

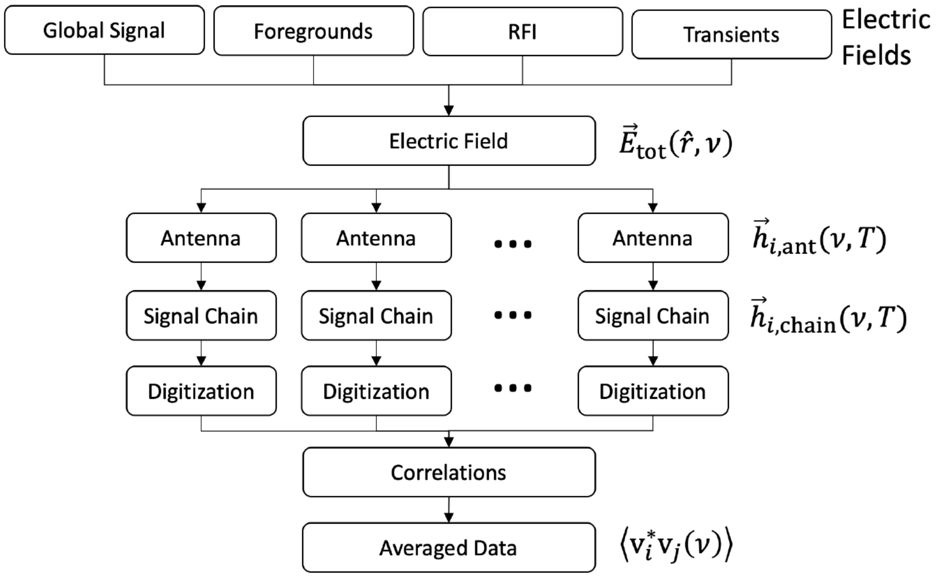
- Developed a hierarchical flowdown of contributions.
- Found that the clearest way was to follow a forward-modeling approach that goes from all electric field contributions down to the visibilities used to image the low frequency sky with an array.
- Initial simulations indicate antenna uncertainties require nuisance parameters be included in every acquisition since the smooth foreground spectrum can change at the level of the signal.

b) Significance:

- We have nailed down a structure for an error budget that will be useful to the development of space-based observatories.

c) Next steps

- Populate the various contributions (of which there are many).
- Develop plans for how to mitigate foregrounds and instrument systematics enabling robust detection and characterization of the global 21 cm signal with a future space-based observatory.



Publications and References

REFERENCES

[1] Furlanetto, Steven R.; Oh, S. Peng; Briggs, Frank H., (2006), Cosmology at low frequencies: The 21 cm transition and the high-redshift Universe, Physics Reports, Volume 433, Issue 4-6, p. 181-301.

[2] Liu, Adrian; Pritchard, Jonathan R.; Tegmark, Max; Loeb, Abraham (2013), Global 21 cm signal experiments: A designer's guide, Physical Review D, vol. 87, Issue 4, id. 043002