Focal field Interferometer: Statistical detection of spectral lines from ensemble of galaxies

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Extended Abstract

We present our progress in building a 'focal field interferometer' capable of measuring the spectral visibility near the focal field of a single dish telescope. Measuring spectral visibility of the focal field will be useful for statistical detection of line intensity fluctuations in the observed sky region.

Existing and next generation radio telescopes with large collecting area have the capability to detect ^{12}CO lines from individual gas rich (gas mass $\gtrsim 10^{10}$ M$_\odot$) galaxies at the Epoch of Reionization (redshift z $\sim$ 6)[1]. However, the sensitivity requirement will restrict observations to a relatively small field of view (FoV). Also, such observations will be incapable of detecting signals from individual faint galaxies.

Telescopes with relatively small collecting area can be used for 'statistical detection'. Statistical detection is a technique proposed to study the universe at the Epoch of Reionization[2]. This technique facilitates studying large-scale structures in early universe by measuring fluctuations in line intensity due to the clustering of unresolved, faint galaxies. These observations are over a larger FoV providing information on the aggregate emission from galaxies. Thus such high-redshift observations complement studies that are capable of detecting lines from individual objects.

The intensity fluctuations from galaxy ensembles at high redshift has been studied through simulation. The expected brightness temperature fluctuations for the red-shifted ^{12}CO 1-0 and 2-1 lines in the most optimistic case are $\sim$ 1 μK at scales of 1 Mpc at z $\sim$ 6[2]. This makes experimental detection very challenging. Several hundred hours of observation over a $5^o \times 5^o$sky area near 30 GHz with angular resolution of $5^{'} - 10^{'}$ and spectral resolution of $\sim$10 MHz will be needed for statistical detection of the ^{12}CO 2-1 temperature fluctuation. A system temperature of $\sim$ 30 K is assumed for the observing setup for these estimations[3]

Currently 'intensity mapping' is used for the statistical detection. Total power observation with a single dish at different sky positions is used for intensity mapping. However, intensity mapping suffers from the disadvantages of gain fluctuations and spectral baseline instability inherent in total power measurements. Measuring the spectral visibility of the focal field offers the stability (both gain and spectral baseline) comparable to interferometric measurements. Further, it increases the FoV of a single dish, thus reducing the total observing time needed for the detection. In this presentation, we discuss the details of the instrument design and the detection technique. We also discuss its application to next generation radio telescope such as the ngVLA (Next Generation Very Large Array).

References

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