Technology Developments for Space-Based Intensity Mapping of Carbon Monoxide during the Epoch of Reionization and Galaxy Formation

Sarah E. Church* [(1)], Kieran Cleary [(2)], Kiruthika Devaraj [(1)], Todd Gaier [(3)], Pekka Kangaslahti [(3)], Anthony Readhead [(2)], Lorene Samoska [(3)], and Michael Seiffert [(3)]

(1) Stanford University, Stanford, USA
(2) California Institute of Technology, Pasadena, USA
(2) Jet Propulsion Laboratory, Pasadena, USA

The authors are developing large format focal plane arrays to open a new window on the epoch of reionization (EoR) and galaxy formation and evolution through the spectral-spatial intensity mapping of carbon monoxide (CO) emission at redshifts $3 < z < 10$. Investigating the nature of the reionization process is one of the keys to understanding the process of large-scale structure (LSS) formation, and the nature and formation of the first luminous objects and galaxies, and was highlighted as high priority science by the Astronomy Decadal Survey report in 2011. Planned ground-based observations of highly redshifted neutral hydrogen (HI) will trace the reionization of the neutral intergalactic medium (IGM) but are not sensitive to the photon sources that are responsible for it. CO traces the cold molecular gas in these sources and can provide a complimentary tracer of structure at high redshifts.

The rotational ladder of CO results in multiple emission lines with a well-defined frequency relationship. With sufficient frequency coverage a redshift slice can be mapped in several CO transitions, allowing the signal to be unambiguously separated from other lines and foregrounds via cross-correlation. The 40-80 GHz band is likely to be important because contamination from synchrotron emission will be reduced compared to the lower frequencies and because the band is broad enough to allow at least two lines to be cross-correlated over a redshift range of 3-10 using a single instrument. Since much of the 40-80 GHz band is inaccessible from the ground because of a forest of oxygen lines, a space-based instrument is required. A notional instrument design is a broad-band 100-element focal plane array that can be deployed as a low cost space-based mission on the International Space Station (ISS). Such an array must be light-weight and low power. I will discuss the experimental requirements of such a mission and describe areas of technology developments that will be required, including low-noise amplifiers, compact light-weight feeds and polarizers and low power backends. I will also describe the role of ground-based experiments that are being built at 15-40 GHz. Mapping the entire 15-80 GHz band will provide a wealth of information about the sources of re-ionization and will complement maps of HI.