Abstract

Advancements in space and ground-based observations have helped us put together a model for the evolution of the Universe. The standard cosmological model based on a simple homoge- neous and isotropic Friedmann-Lemaître-Robertson-Walker (FLRW) metric allows a complete description of the evolution of the Universe. Such a universe can be described using a hand- ful of cosmological parameters. The precise measurements of Cosmic Microwave Background (CMB) have validated the standard cosmological model. The CMB anisotropy measurements help us probe the early Universe and deduce a number of parameters such as the evolution of the Universe and formation of large-scale structures (Hinshaw et al., 2013; Planck Collab- oration et al., 2016). Galaxy redshift surveys like the two-degree field galaxy redshift survey (2DFGRS) (Colless, 1999), Sloan Digital Sky Survey (SDSS) (York et al., 2000), and Galaxy And Mass Assembly survey (GAMA) (Driver et al., 2009) provide information on the spatial distribution of galaxy distribution. Galaxies and clusters of galaxies trace the underlying matter distribution. The combination of information from CMB anisotropy measurements and galaxy redshift surveys provides insights into the growth of large-scale structure, galaxy formation, star formation history and evolution of the intergalactic medium (IGM). In the standard cosmological model, the early Universe was significantly denser and hotter. The model also explains the observed black-body spectrum of CMB: the observations indi- cate that matter and radiation were in thermal equilibrium in the early universe. This thermal equilibrium is maintained through interactions such as scattering of photons by electrons, ab- sorption and re-emission of photons by ions and atoms, etc. A small mean free path for scatter- ing makes the early universe opaque until the Universe expands and cools to a temperature of about 3000 K. At this stage matter in the Universe rapidly transitions from a plasma to a neutral atomic state and becomes transparent to radiation. This transition is called recombination and happened at redshift z ' 1100, when the age of the Universe was close to 0.38 Myr. The relic radiation from this early state is seen as the CMB. The early universe was also much smoother in that the amplitude of any perturbations was minimal, as reflected in the amplitude of CMB anisotropies. Recombination leads to a period called the “Dark Ages” without any sources of photons (e.g. stars, galaxies, etc.): only CMB photons traverse the Universe at this stage. The dark ages ended with the formation of first stars. These stars form out of cold gas in collapsed halos: the halos in turn form by collapse of dark matter and normal matter via gravitational instability from small density perturbations present in the early universe. It is believed that the first stars, also called population III stars due to the absence of processed elements, formed at redshift z □ 20 − 30. The UV radiation from these first stars ionizes the surrounding “Inter-Galactic Medium” (IGM). The photo-ionization regions in the vicinity of galaxies grow until these cover almost the entire IGM. This transition from a neutral to an ionized IGM starts with the formation of 1first stars and ends at redshift z ' 6. This period in the timeline of the Universe is called the “Epoch of Reionization (EoR)”. The redshifted 21 cm hyperfine transition line of neutral hydrogen is considered as the most promising method proposed for probing the dark ages and the EoR. Further, intensity mapping of the redshifted 21 cm line in the post-reionization era is an independent probe of the large- scale structure and the evolution of galaxy properties. Several existing, upcoming and future facilities, e.g., GMRT (Paciga et al., 2011), LOFAR (van Haarlem et al., 2013), MWA (Tingay et al., 2013), PAPER (Ali et al., 2015), HERA (DeBoer et al., 2017), CHIME (Bandura et al., 2014), OWFA (Subrahmanya et al., 2017), HIRAX (Newburgh et al., 2016) and SKA aim to detect the redshifted H I signal from different epochs using the line intensity mapping technique. The redshifted 21 cm signal is extremely faint with the expected brightness temperature (T b □ mK) as compared to the bright astrophysical foregrounds which are several orders of magnitude brighter. These foregrounds comprise diffuse and free-free emission from our own Milky Way and, extra-galactic point sources. The most crucial step in the signal extraction process is to remove these foregrounds with high accuracy to obtain a reliable estimate of the signal of interest. Therefore, a detailed understanding of the properties of these foregrounds is

required to subtract them from the observed sky signal. Approaches adopted to disentangle the cosmic signal from these bright foregrounds are based on our understanding of the statisti- cal nature of these foregrounds. Understanding and characterising Galactic and extra-galactic foregrounds are also critical aspects of designing H I intensity mapping experiments. In this thesis, we examine the statistical properties of foregrounds at low frequencies (< 500 MHz). We have studied the diffused galactic foregrounds to determine the domain in which the statistics of these are consistent with a Gaussian random field. Further, we have determined the angular clustering of the extra-galactic radio point sources, which are a dominant source of astrophysical foregrounds at small angular scales, contaminating the cosmic H I signal. Follow- ing sections describe the thesis work in more detail.