Chapter 6

Conclusions and Future Scope

In this thesis, we studied H I column density statistics of the Galactic cold neutral medium from the absorption studies against the extended background sources, nature of the magnetic field disturbances in the supernova remnants of the Cassiopeia-A and H I absorption studies of the Galactic CNM against background sources Tycho's Supernova remnants and a point source. In our study, we used radio interferometric observations. To solve the long-standing puzzle related to the physical properties of the Galactic CNM, studies of the scale-invariant structures are essential. As a first, we studied and demonstrated the analytical formalism to measure the two-point statistics of the optical depth using the radio-interferometric observations. Observationally, there are not sufficient studies that can solve the puzzle related to the physical properties of the CNM phase of the Galactic ISM. Our study shows that how we can directly access the two-point statistics of the Galactic H I column density from the two-point statistics of the optical depth measured against the extended background sources. We found that accessing the slope of the power spectrum of H I column density from the power spectrum of the optical depth does not depend on the physical properties of the CNM. Our study also finds that only the study of the optical depth fluctuations will not tell much about the fluctuation in the spin temperature and column density and hence physical properties of the ISM. We would need multiwavelength observations to probe much about the fluctuation in the spin temperature and column density. The applications of conclusions from our study on real observations can solve the long-standing questions, 1) If there is a singular cascade responsible for turbulence in the ISM from mpc to kpc scale or, 2) Scale-invariant H I structures observed over a wide range of scales in our galaxy is just because we have only few measurements of the H I column density power spectrum. To answer such questions, mapping the structures in the different directions of our galaxy is required, and it will be studied in the future using the H I absorption against supernova remnants spread in different directions and part of our galaxy. The radio-interferometric observations of the supernova remnants are also used to access the magnetic structures i.e. magnetohydrodynamic turbulence in the SNRs. We use the two-point statistics of the synchrotron intensities to access magnetic energy spectra in the supernova remnants Cassiopeia-A. We found that the nature of the magnetic field disturbances in the proximity of the shocks for this SNR follows the 2/3 power law. This is the condition of the trans-Alfvenic magnetohydrodynamic turbulence. We validated our findings using the numerical value of the Alfven Mach number on the global scale. On the basis of our results, we predicted that SNR Cassiopeia-A might have an additional subshock in addition to the reverse and forward shocks. Such a study are important to test the validity of the theoretical predictions of the magnetohydrodynamic turbulence where there is debate regarding the shape of the magnetic energy spectrum in supernovae remnants, and diffusive shock acceleration theory predicts that supernova remnants can accelerate cosmic rays up to knee energy ($\sim$ P eV) through diffusive shock acceleration mechanism. In the future, such a study will be carried out on other supernova remnants too. We also studied the H I structures in the direction of the Tycho's SNR and a point source close to the line of sight of this SNR. Such studies are important to trace the density and spin temperature of the clouds in the different directions and locations of the Galaxy. It is also important in the sense that H I in the interstellar medium of the galaxies works as the reservoir of the stars of the next generation. In our study, we found that there is an asymmetry in the distribution of the H I densities across the face of the Tycho's SNR. There is more H I densities in the direction of the eastern part of the Tycho's SNR than its western part at $\sim$ -48.5 km/s. We also found that there is the correlation between the clouds in the direction of the eastern part of the Tycho's SNR and point source. We proposed a model of the extended H I cloud that overlaps the line of sight of the Tycho's SNR and point source. Based on our calculations, we find that the locations of the Tycho's SNR should not be in the uniform cloud of H I i.e. it should be behind the Galactic Local arm and somewhere at the near edge of the Galactic Perseus arm. Such studies are also important to reveal the possible interaction between the ISM clouds and remnants of a supernova that may affect the evolution of supernova remnants at an early stage.

To solve the long-standing puzzle, 1) Whether there is a singular turbulence cascade present in the Galactic ISM which produces the scale-invariant structures from mpc to pc length scales, or 2) it is only because we have only a few measurements of the column density power spectrum in different directions of our Galaxy, we will carry out more observations of the Galactic supernovae remnants to measure the power spectrum of the optical depth fluctuations in different directions of the Galaxy.