Table of contents

Acknowledgements xi

List of figures xix

List of tables xxvii

List of symbols xxviii

Abstract xxxi

1 Introduction 1

1.1 Structure Formation and Evolution of the Universe 2

1.2 H I 21- cm signal as a Probe of EoR 3

1.3 Intensity mapping and 21- cm Power Spectrum 5

1.4 Foregrounds 7

1.5 Current status of CD/EoR Experiments 8

1.5.1 Effect of Gain Errors 9

1.6 Aim of this thesis 12

1.7 Technical details 15

2 H I Power Spectrum and Foregrounds 17

2.1 The H1 Power Spectrum and Dark Matter Power Spectrum 17

2.2 Interferometers and visibility measurements . . . 21
2.3 Power Spectrum Estimator . . . 24
2.4 Foregrounds . . . 30
2.4.1 Extragalactic point sources . . . 32
2.4.2 Galactic Diffuse Synchrotron Emission . . . 33
2.5 Foregrounds Mitigation . . . 39
2.5.1 Foreground Avoidance . . . 39
2.5.2 Foreground Subtraction . . . 40
2.5.3 Foreground supression . . . 40
2.6 Discussion . . . 42

3 Radio Interferometric Observations: Gain Errors and Calibration 45
3.1 Interferometric Observation and Gain . . . 45
3.1.1 Time and frequency dependence of the Gain . . . 47
3.1.2 Decomposing the complex gain into antenna-based gains . . . 49
3.2 Calibration . . . 50
3.2.1 Errors in the Calibration . . . 53
3.3 Residual Gain Errors and Its Effects . . . 56
3.3.1 Analytical Results . . . 56
3.3.2 Simulation Results . . . 58
3.3.3 Discussion and Conclusion . . . 62

4 Effect of Time Correlated Gains 65
4.1 Gain error model . . . 65
4.2 Power spectrum estimation and bias . . . 68
4.3 A toy model of baseline pair fractions . . . 72
4.4 Residual Gain Errors in presence of extragalactic point sources . . . 75

4.4.1 Point source sky model 76
4.4.2 Simulation method 77
4.4.3 Results 80
4.5 Discussion and Conclusion 84

5 Analytical Estimates of Bias and Variance of Power Spectrum 91
5.1 Gain Error Model 92
5.2 Analytical Estimates of Bias and Variance of the Power Spectrum 95
5.2.1 Effect of gain errors in visibility correlation 95
5.2.2 Bias and Variance of the power spectrum 96
5.3 Comparing analytical expression of bias and variance with simulation . . 100
5.4 Results: Different effects of gain errors 107
5.5 Discussion and Conclusion 116

6 Effect of Frequency Correlated Bandpass Errors 119
6.1 Time and Frequency-Dependent Gains 119
6.1.1 Bandpass Errors 120
6.1.2 Modelling the Frequency Correlated Gain Grrors 121
6.2 Analytical Estimates of Bias and Variance 123
6.2.1 Type of Baseline Pair Fractions 124
6.2.2 Bias and Variance 127
6.3 Analysing the Results: Effects of Time and Frequency-Dependent Gain Errors 130
6.3.1 Baseline pair fractions for SKA-1 Low 130
6.3.2 Foreground Model and Other Observational Details 131
6.4 Discussion and Conclusion 138

7 Summary and Future Scope 141

References **145**

Appendix A Empirical Fit of the Maximum Baseline Contours **171**

Appendix B Calculation of the Bias and Variance of the Power Spectrum **173**

List of Publications **181**