Contents

List of Figures **xxiii**

List of Tables **xxv**

1 Introduction **1**

1.1 A Brief History of Neutrinos 1

1.2 Neutrinos in the Standard Model 4

1.2.1 The Electroweak Theory 5

1.3 Neutrinos Beyond the Standard Model 8

1.3.1 Neutrino Oscillations 8

1.3.2 Neutrino Oscillation Probability 9

1.4 Review of Neutrino Parameters 11

1.4.1 Solar Neutrino Experiments 12

1.4.2 Atmospheric Neutrino Experiments 13

1.4.3 Reactor Neutrino Experiments 15

1.4.4 CP Violation in the Leptonic Sector 17

1.5 Massive Neutrinos 18

1.5.1 Dirac Mass Term 19

1.5.2 Majorana Mass Term 20

1.6 Seesaw Mechanism 21

1.6.1 Type-I Seesaw 21

1.6.2 Type-II Seesaw 23

1.6.3 Type-III Seesaw 23

1.7 Baryon Asymmetry of the Universe 24
1.7.1 Evidence of Matter-Antimatter Asymmetry 24
1.7.2 Measurements from CMB and BBN 25
1.7.3 Sakharov's Condition 27
1.7.4 Leptogenesis 28
1.8 Outline of the Thesis 29
Bibliography 31

2 Realizing TM_1 mixing in the minimal seesaw model using S_4 symmetry and its implication on resonant leptogenesis 37
2.1 Introduction 38
2.2 Model Framework 40
2.3 Numerical Analysis 43
2.4 Resonant Leptogenesis 45
2.5 Conclusion 49
Bibliography 50

3 A minimal inverse seesaw model with S_4 flavour symmetry 55
3.1 Introduction 55
3.2 The Model 58
3.3 Numerical Analysis and Results 60
3.4 Conclusion 66
Bibliography 67

4 Low-energy CP phases and resonant leptogenesis in radiative seesaw model 73
4.1 Introduction 73
4.2 Scotogenic Model 76
4.3 Resonant Leptogenesis 79
4.4 Neutrinoless Double Beta Decay 83
4.5 Conclusions 84
Bibliography 86

5 Parameter space for resonant leptogenesis within the framework of minimal inverse seesaw model 91

5.1 Introduction 92

5.2 Model Framework 93

5.3 Resonant Leptogenesis in ISS(2, 2) Model 96

5.3.1 Scenario I: R matrix with complex ζ 98

5.3.2 Scenario II: R is a real matrix with $Re(\zeta) = \pi/4$ and $Im(\zeta) = 0$ 99

5.3.3 Scenario III: texture zeros in m_D 100

5.4 Conclusions 101

Bibliography 103

6 Conclusions and Future Outlook 107

6.1 Conclusions 107

6.1.1 Chapter 2 107

6.1.2 Chapter 3 108

6.1.3 Chapter 4 109

6.1.4 Chapter 5 110

6.2 Future Outlook 110

A S_4 group 113

B The Scalar Sector of the Model 117