Contents

1 Introduction **1**

1.1 Present status of neutrino parameters 2

1.2 Standard model 5

1.3 Spontaneous symmetry breaking and Higgs mechanism 8

1.4 Drawbacks of the standard model 10

1.5 Neutrino mass beyond the SM 12

1.6 Seesaw mechanism 17

1.6.1 Type I seesaw 18

1.6.2 Type II seesaw 19

1.6.3 Type III seesaw 20

1.6.4 Inverse seesaw 21

1.7 Cosmological consequences of BSM physics 22

1.7.1 Baryogenesis via leptogenesis 22

1.7.2 Dark matter 29

1.8 Discrete flavour symmetry 31

1.8.1 The group S_4 and its properties 32

1.8.2 The group A_4 and its properties 35

Bibliography **37**

2 Neutrino phenomenology and scalar dark matter with inverse and type II seesaw **45**

2.1 Introduction 46

2.2 Neutrino mass model with various seesaw scenarios 48

2.2.1 Inverse seesaw mechanism 48

2.2.2 Type II seesaw with triplet Higgs 49

2.3 Stabilizing the dark matter 50

2.4 The reactor mixing angle 53
2.5 Neutrinoless double beta decay 54
2.6 Relic density of dark matter 55
2.7 Numerical analysis 58
2.8 Conclusion 64

Bibliography **70**

3 Non-zero θ_{13} and dark matter in an S_4 flavour symmetric model with inverse seesaw **75**

3.1 Introduction 76
3.2 Inverse Seesaw Model with S_4 Symmetry 79
3.3 Origin of non-zero θ_{13} and dark matter 84
3.3.1 Correction to neutrino mass matrix 84
3.3.2 Correction to charged lepton mass matrix 88
3.4 Dark matter 90
3.5 Neutrinoless double beta decay 92
3.6 Results and discussions 94
3.7 Conclusion 102

Bibliography **104**

4 Non-zero θ_{13} and baryon asymmetry of the universe in a TeV scale seesaw model with A_4 flavour symmetry **110**

4.1 Introduction 111
4.2 The model 115
4.3 Resonant leptogenesis 118
4.4 Numerical analysis 120
4.5 Results and discussion 128
4.6 $\mu - \tau$ Symmetric limit of the model 131
4.7 Conclusion 133

Bibliography **136**

5 Neutrino phenomenology with S_4 flavor symmetry in inverse and type II seesaw **141**

5.1 Introduction 142

5.2 Structure of the model 144

5.3 Neutrinoless double beta decay 149

5.4 Numerical analysis 150

5.5 Results and discussions 153

5.6 Conclusion 158

Bibliography **160**

6 Conclusion **163**

6.1 Chapter 2 164

6.2 Chapter 3 164

6.3 Chapter 4 166

6.4 Chapter 5 168

6.5 Future Prospects 168