List of Figures

4.1 Variation of mass difference between the doubly and singly-charged scalars, for various values of the parameter $h$. ............................. 53

5.1 Variation of mass difference between (left panel) $H_1^{++}$ and $H_2^{++}$ and (right panel) $H_1^{++}$ and $H_2^+$ with phase of triplet $\alpha$ for BP 1 of scenario 1 and BP 3 of scenario 2 for $\alpha = 30^\circ$, BP 4 of scenario 2 for $\alpha = 60^\circ$ .............................. 80

5.2 Invariant mass distribution of same sign di-leptons for (left panel) $\alpha = 60^\circ$ and (right panel) $\alpha = 65^\circ$ for BP 4 of Scenario 2 .............................. 87

5.3 Invariant mass distribution of same sign di-leptons for chosen benchmark points. In the top (left panel) BP 3 and (right panel) BP 4 of Scenario 2 for $\alpha = 30^\circ$. In the middle (left panel) BP 3 and (right panel) BP 4 of Scenario 2 for $\alpha = 45^\circ$. In the bottom, BP 4 of Scenario 2 for $\alpha = 60^\circ$ .............................. 88

7.1 Relic density $\Omega h^2$ vs. dark matter mass $M_\chi$, keeping $\alpha_{\Sigma\nu_s}$ fixed at $2.8$ TeV$^{-1}$, $2.9$ TeV$^{-1}$ and $3.0$ TeV$^{-1}$. $M_\chi$ is varied by changing the remaining parameter $\alpha_{\nu_s}$. We use $M_\Sigma = 1$ TeV, $\alpha_\Sigma = 0.1$ TeV$^{-1}$, $M_{\nu_s} = 200$ GeV. The blue band corresponds to $3\sigma$ variation in relic density according to the WMAP + Planck data. 112

7.2 Contour plot in $\alpha_{\Sigma\nu_s} - \alpha_{\nu_s}$ plane for fixed values of $M_\Sigma = 1$ TeV, $M_{\nu_s} = 200$ GeV, $\alpha_\Sigma = 0.1$ TeV$^{-1}$. In (a) DM relic density is projected onto the plane, whereas in (b), we project DM mass (in GeV). In both plots the red solid line represents $\Omega h^2 = 0.1198$ and the dashed red lines correspond to the $3\sigma$ variation in $\Omega h^2$. Darker region corresponds to lower values of $\Omega h^2$ or $M_\chi$. .............................. 113
7.3 (a) WIMP-nucleon cross section vs. dark matter mass $M_\chi$ keeping $\alpha_\Sigma$ fixed at 0.1 TeV$^{-1}$. $M_\chi$ is varied by changing the remaining parameters. In such a scenario, DM annihilates via self-annihilation only. $M_\nu_s$ is varied between 150 and 1000 GeV. (b) WIMP-nucleon cross section vs. dark matter mass $M_\chi$ keeping $\alpha_\Sigma$ fixed at 0.1 TeV$^{-1}$. $M_\chi$ is varied by changing the remaining parameters. Here coannihilation between the DM candidate with the charged components of the triplet $\Sigma^\pm$, the neutral eigenstate of higher mass provides the dominating contribution to relic density. In both the figures different direct detection experimental bounds are indicated and the red points correspond to the $3\sigma$ variation in relic density according to the WMAP + Planck data.

7.4 (a) WIMP-nucleon cross section vs. dark matter mass $M_\chi$ keeping $\alpha_\Sigma$ fixed at 0.01 TeV$^{-1}$. $M_\chi$ is varied by changing the remaining parameters. Here self-annihilation of the DM candidate provides the dominating contribution to relic density (b) WIMP-nucleon cross section vs. dark matter mass $M_\chi$ keeping $\alpha_\Sigma$ fixed at 0.01 TeV$^{-1}$. $M_\chi$ is varied by changing the remaining parameters. Here coannihilation between the DM candidate with the charged components of the triplet $\Sigma^\pm$, the neutral eigenstate of higher mass provides the dominating contribution to relic density. In both the figures different direct detection experimental bounds are indicated and the red points correspond to the $3\sigma$ variation in relic density according to the WMAP + Planck data.
List of Tables

4.1 Charged scalar masses. ............................... 61
4.2 Neutral scalar masses. ............................... 62
4.3 Decay branching ratios and production cross sections for doubly-charged scalars. ............................... 63
4.4 Cuts used for determination of ratios of events $r_1$ and $r_2$. The subscript $T$ stands for ‘transverse’ and $\eta$ denotes the pseudorapidity. ......................... 64
4.5 Ratio of events $r_1, r_2$ for two-triplet and single-triplet scenario respectively for benchmark point 3. ......................... 64
5.1 Charged scalar masses for phase $\alpha = 30^\circ$. ............................... 80
5.2 Neutral scalar masses for phase $\alpha = 30^\circ$. ............................... 81
5.3 Decay branching ratios and production cross sections for doubly-charged scalars for phase $\alpha = 30^\circ$. ............................... 82
5.4 Charged scalar masses for phase $\alpha = 45^\circ$. ............................... 83
5.5 Neutral scalar masses for phase $\alpha = 45^\circ$. ............................... 83
5.6 Decay branching ratios and production cross sections for doubly-charged scalars for phase $\alpha = 45^\circ$. ............................... 84
5.7 Charged scalar masses for phase $\alpha = 60^\circ$. ............................... 85
5.8 Neutral scalar masses for phase $\alpha = 60^\circ$. ............................... 85
5.9 Decay branching ratios and production cross sections for doubly-charged scalars for phase $\alpha = 60^\circ$. ............................... 86
5.10 Number of same-sign dilepton events generated at the LHC, for the benchmark points corresponding to Figure 3. The integrated luminosity is taken to be $2500 fb^{-1}$, for $\sqrt{s} = 13 TeV$. ............................... 87