Chapter 6

Conclusions and Future Plans

This thesis is devoted to the study of solar transients in different solar regions. The role of the magnetic field in the eruption of solar transients is discussed in this thesis. The observational study of coronal jets along with other solar transients e.g., mini-filaments, flares, coronal mass ejection (CME) is the major contribution of this thesis. In this chapter, we briefly conclude and summarize all the derived new results. We also discuss the future aspects of this area of research which can be further continued as a potential scientific research.

6.1 Main Conclusions

[A] We have analyzed observational results of a quiet Sun blow-out jet and its association with twin CMEs as jet-like and bubble-like CME using SDO/AIA and SOHO/LASCO data. The initiation of blow-out jet eruption is triggered by eruption of different sections of a circular filament which is rooted in internetwork region at the base of the blow-out jet. The SDO/HMI line-of-sight (LOS) magnetograms is also analyzed at the base of the jet which indicates collective magnetic cancellation at the northern end of the filament by which this end of filament destablizes and further erupts in two different stages. In first stage northern section of the filament ejects and drives evolution of northern part of blowout jet. This northern part of blowout jet is further extended in collimated plasma beam to form a jet-like CME. In second stage southern section of filament erupts in form of a twisted magnetic flux rope which further forms southern part of blowout jet. This eruption of southern section of filament further drives a bubble-like CME in the outer corona. This observed event is the third event of the twin CME with blowout jet eruption after the observation results of Shen *et al.* (2012) and Miao *et al.* (2018). The plasma blobs at the northern side of the blowout jet is also found which results by Kelvin–Helmholtz (K-H) instability in its twisted magneto-plasma spire.

[B] We have done observational study of recurring jets which are found above a supergranular cell/magnetic network near AR11176 during the period 2011 March 31 17:00 UT to April 1 05:00 UT using SDO/AIA observations. The mini-filaments play important role in eruption of all these recurring jets. Mini-filaments (mini-filament1 & 2) are found at the base of these recurring jets. Mini-filament 1 shows partial eruption in case of first three jets. Mini-filament 2 shows a complete eruption which further drives a full blow-out jet and also triggers a C-class flare. This C-class flare is occurring due to reconnection resulting from the mini-filament field which is moving upward. The eruption of blow-out jet triggers a CME. The plane-of-sky velocities of recurring jets are analyzed which results as $160\,\mathrm{km\,s^{-1}}$, $106\,\mathrm{km\,s^{-1}}$, $151\,\mathrm{km\,s^{-1}}$ and $369\,\mathrm{km\,s^{-1}}$. The analyzed velocity of CME is $636\,\mathrm{km\,s^{-1}}$. The continuous magnetic flux cancellation is observed at the base of all recurring jets which is a driving cause of eruptions of these mini-filaments and recurring jets. At the eruption time of first three jets, the rate of cancellation is low while in the case of mini-filament2 full eruption and triggering of a C-class flare and a CME-productive jet the cancellation rate is high. At the base of first three jets, the mini-filament 1 causes to push the overlying dynamic complex thin loops resulting in the reconnection and drives the jet eruptions. The first three jets are not full blow-out jets, while the fourth jet is the full blow-out jet which further forms a CME. This observational result supports the mini-filament eruption model of Sterling *et al.* (2015).

[C] We have studied an active region coronal jet evolution from southward of a major sunspot of NOAA AR12178 on 04 October 2014. This jet is associated with a GOES C1.4 flare. This jet is termed as a two-stage confined eruption of plasma because this erupts in two stages. In the first stage plasma erupts above compact flaring region and in second stage, this eruptive jet plasma and associated magnetic field lines interact with another set of distinct field lines and creates an X-point region above which second stage of the jet eruption is deflected along curvilinear path in overlying corona. The first stage of jet is followed by a cool surge visible in GONG Hα observation. The magnetic flux cancellation triggers C-class flare which further triggers first stage of the coronal jet eruption. The second stage of the jet eruption is the consequence of an interaction of two distinct sets of magnetic field lines in the overlying corona. The complex evolution of two-stage jet involves flare heating induced first stage plasma eruption, guiding of jet's material above a junction of two distinct sets of field lines and intra-relationship with cool surge. This complex eruption of two-stage coronal jet imposes rigid constraints on the existing jet models.

6.2 Future Plans

Some future works can be further done in this area of research, which are listed below.

1. The observational study of coronal jets with high resolution data of new space-based observatories e.g., IRIS, SDO, Solar Orbiter, etc, can further increase our understanding about these transients and their association and interaction with other solar transients.

2. The coupled behavior of coronal jets and CMEs can be further explained with more observational events and also with numerical modelling results.

3. The combination of high resolution ground based observations (e.g., 4m-DKIST, 1m-SST) and space-borne EUV observations (e.g., IRIS, SDO, Solar Orbiter) will enable to understand the triggering mechanisms of the coronal jets and their association with the cool counterpart of the plasma eruptions from the lower atmosphere. This will shed new light on the formation and energetics of coronal jets.

4. The exclusive high resolution observations will put a rigid constraints and help in the development of the numerical models to understand the origin and kinematics of coronal jets.

5. The association of coronal jets in triggering the Earth directed CMEs may provide more refined statistics and understanding in predicting the space weather.

6. Alongwith imaging observations we will use spectroscopic observations e.g, EIS instrument on Hinode, CDS instrument on SOHO, IRIS etc. to explore more useful information about solar coronal jets and other phenomena (e.g., heating, flow speeds, rotation of the coronal jets or torsional oscillations).