List of Figures

Figure1.1 The solar structure (Chandra, 2006)

Figure 1.2 a closer image of a sunspot group, where granulation is also visible (Credits: Royal Swedish Academy of Sciences).

Figure 1.3 The temperature of the solar atmosphere decreases from values near 6,000 degrees Kelvin at the visible photosphere to a minimum value of roughly 4,400 degrees Kelvin about 500 kilometres higher in the atmosphere. The temperature increases with height, slowly at first, then extremely rapidly in the narrow transition region between the chromospheres and corona, from about 10,000 degrees Kelvin to about one million degrees Kelvin. (Courtesy of Eugene Avrett,Smithsonian Astrophysical Observatory).

Figure 1.4 The solar corona in white light during a solar eclipse. The upper part of the chromosphere and some prominences are also visible in red colour.

Figure 1.5 EIT images of the Sun at 195Å showing the corona at a temperature of about 106 K, demonstrating the increase in activity as the solar cycle attains its maximum in the year 2000. Source: http: //sohowww .nascom.nasa. gov / gallery/ images/.

Figure 1.6 The Structure of solar eruptions (Forbes, 2000).

Figure 1.7 Solar Cycles (Courtesy: HATHAWAY/NASA/MSFC 2009/07)

Figure 1.8 Polar plots of solar wind speed as measured by the Ulysses spacecraft. The figure on the left coincides with the decline and minimum of solar activity. The plot on the right is for period of enhanced and maximum activity. The bottom panel shows the average monthly and smoothed sunspot number throughout the two orbits (after McComas et al. 2003).

Figure 1.9 On the left: a classic H-alpha (6563 °A, T _ 10,000 K) image of a prominence at the solar limb from the Big Bear Observatory (1970). On the right: an image in EUV (304 °A, T _ 60,000 – 80,000 K) from the SOHO spacecraft, where an erupting prominence is compared to the size of Earth.

Figure 1.10 Top figures: two high-resolution H-alpha images of quiescent solar filaments in which the fine-structure is clearly seen. The top left- and right-hand side images are adapted from Lin et al. (2003) and Lin et al. (2007), respectively, and were both taken by the Swedish Solar Telescope on

La Palma. Bottom figure: the whole body of a filament in H-alpha from the Dutch Open Telescope (2004).

Figure 1.11 On the left: a Hα image of a region of the solar disc where a filament is seen. On the right: a photospheric magnetogram of the same region, in which white and black colours represent opposite magnetic polarities. One can see that the filament is located between two regions of opposite polarity.

Figure1.12 Prominence photographs obtained by Lyot in 1937 with his coronagraph (courtesy Observatories de Paris).

Figure 1.13 Drawing of prominences observed at total solar eclipse (Secchi in Soleil, 1877)

Figure 1.14 Prominence drawing made by Fearnley in Norway, 1872-73 (courtesy Inst. for Theortical Astrophysics, Oslo and O. Engvold).

Figure 1.15 Active Prominences

Figure 1.16 Eruptive prominence

Figure 1.17 Sunspot Prominences

Figure 1.18 Tornado Prominences

Figure 1.19 Quiescent Prominences

Figure 1.20 Zirin's Classification

Figure 1.21 Two models of the magnetic field supporting prominence. The horizontal line at the base indicates the solar photosphere.

Figure1.22 Schematic representations of two possible field configurations, type A and B, in bipolar magnetic regions, responsible for prominence support (Tandberg-Hanssen, 1995).

Fig 1.23: Diagram of the magnetic field configuration during the active region filament formation in parallel (a) and antiparallel (b) converging mass motion; and during the eruption.

Fig 1.24: the two configurations as described by Martin et al. (1993) (a) sinistral (b) Dextral.

Fig 1.25: The formation of prominence in a twisted flux tube-model by Priest et al., 1989.

Fig 1.26: Flux cancellation in a sheared coronal arcade. The rectangle represents the solar photosphere, and the dashed line is the polarity inversion line. (a) Initial sheared field subjecting to converging flows. (b) Reconnection produces a long loop AD and a shorter loop CB, which

subsequently disappear below the photosphere. (c) Overlying loops EF and GH are pushed the inversion line. (d) Reconnection produces the helical loop EH and a short loop GF, which again submerges.

FIG.1.27: Schematic diagrams showing the magnetic topologies of three types of prominence support models; the prominences are shown by the shaded areas. In each case it is assumed that there is a uniform magnetic field normal to the plane of the figure, which changes the topology of the closed field lines in the center and right-hand diagrams to helical field lines forming flux ropes. The normal polarity dip model on the left thus transforms into the normal.

Figure 1.28: Lasco C2 (left) and C3 (right) image of the CME occuring on February 27, 2000. This CME is also known as the `lightbulb' CME. Source: http://sohowww.nascom.nasa.gov/gallery/images/las02.html

Figure 1.29 A time sequence of Solar Maximum Mission coronagraph images showing a coronal mass ejection on August 18, 1980, (from Hundhausen, 1999).

Fig: 1.30 SOHO/LASCO image (with an EIT 195 image superposed) obtained on 2001 December, 20 showing the three-part structure of a CME above the southwest limb (Gopalswamy et al., 2006).

Figure 1.31: Schematic of break-out model (Antiochos et al., 1999). The first sketch shows magnetic field configuration at an early stage and the second at a later stage of eruption. A force-free current is created by shearing the arcade (thick lines) at the equator but a current layer horizontal to the solar surface is also created as the sheared region bulges outward. The process of reconnection of magnetic field lines in this layer allows opening of the sheared field line outward to infinity.

Figure 1.32: The different manifestations of flux-rope model.

Figure 1.33: Standard model for the magnetic field explosion in single-bipole eruptive solar events (taken from Moore et al., 2001). The dashed curve is the photospheric neutral line; bright patches are ribbons of flare in the chromosphere at the feet of reconnected field lines. The diagonally lined feature above the neutral line in the top left panel is the filament of chromospheric temperature plasma.

Figure 1.34 Coronal mass ejections (a) pre-eruption, (b and c) eruption, and (d) post eruption states depicted by the mass-loading model, (from Low, 2001).

Figure 2.1 SOHO space mission

Figure 2.2: Nobeyama 45m single-dish radio telescope.

Figure 3.1: Evolution of the NORH prominence (upper two rows), The 17 GHz Nobeyama Radio heliograph images at 02:05:02 UT, Dec 7, 2001, showing the extended helical wave-like nature and at 02:55:02 UT, showing the semicircle nature and LASCO C2 images (bottom row). North is up; west is right.

Figure 3.2: The height-time profiles of the CMEs (red star), the prominence (black star).

Fig-3.3: The smoothed height-time profile and NORH data (dots), Velocity profile, and acceleration profile of the prominence.

Fig-3.4: Variation of Kinetic energy and mass of prominence 7 Dec 2001 associated CMEs with respect to time.

Fig-3.5: Variation of kinetic energy and mass of prominence with respect to height.

Fig-3.6: Variation of acceleration with velocity and K.E. with mass of prominence associated with CMEs. There is non-linear relation between them.

Figure4.1. Various type of prominence trajectories observed in our data. The height- time measurement fit to (a), (b) deceleration phase and (c) straight line.

Figure 4.2. Maximum heights reached by the prominences: all events (top); radial events (middle); transverse events (bottom). The heights are measured from the disk center.

Figure 4.3. Histograms of the maximum heights reached by prominences: events associated with CMEs (top); events not associated with CMEs (bottom).

Figure 4.4. Average speed to maximum of the prominence eruption events: all events (top); radial events (middle); transverse events (bottom).

Figure 4.5. Histograms of the maximum speed reached by prominences: events associated with CMEs (top); events not associated with CMEs (bottom).

Figure 4.6. Relation between the average speed of prominences and their final height. As expected, the T events are below the straight line. This straight line is a fit to the data points.

Figure4.7 (a) Eruption of the 2004 may 6 microwave prominences from the west limb (top panel). (b) SOHO/LASCO images at several instances (middle panel). Height-time plots of the Prominence and CME, respectively (bottom panel).

Figure4.8. Shows the comparison between microwave and white-light images corresponding to the 2002, June 6 prominence eruption event (Top panel). The prominence rises from the northeast limb and then moves northward (parallel to the limb) before fading out (Middle panel). LASCO C2 running difference images showing no changes along the position angle of the prominence and the same in SOHO/LASCO EIT images in the bottom panel. In the last graph the height-time plots of the prominence eruption are shown**.**

Figure4.9. Show the latitudinal distribution of the prominences and corresponding CMEs (A) and (B).

Figure4.10. (A) Another view of the plot in Fig4.9, but showing the solar cycle variation of the latitude of prominence eruption. (B) Latitude of the CMEs corresponding prominence as a function of time.

Figure4.11. (A) Comparison between the onset times of the prominence and CME events. Negative numbers mean that precede PE onsets. (B) Solar cycle variation of the onset time differences.

Figure4.12. (A) Positional relationship between CMEs and PEs as a difference in CPAs. (B) Solar cycle variation of the P.A. offset.

Fig5.1. Histogram shows the speed distribution of all prominences and the associated CMEs during 1997-2006.

Fig5.2. Annual average and median speeds of prominences and the associated CMEs from 1997-2006.

Fig5.3. Histograms show the width distribution of PEs and the associated CMEs during 1997-2006. In (b), last bin shows halo CMEs whose width is 360 degree.

Fig5.4. Variation of annual average and median widths of PEs and the associated CMEs during 1997-2000.

Fig5.5. Histogram shows the latitudes of all type Latitudes of PEs and the associated CMEs from 1997 to 2006.

Fig5.6. Annual average latitudes of prominence and the associated CMEs from1997to2007

Fig5.7. Histogram of acceleration of PEs and the associated CMEs from 1997 to 2006. (a) Shows clear bias towards deceleration. (b) Shows clear bias towards acceleration.

Fig5.8. Acceleration as a function of speed of all types of PEs and the associated CMEs from 1996 to 2006. “r” is the correlation coefficient of the distributions.

Fig5.9. Annual variation of mean sunspot number and the number of PEs associated CMEs.