8.1 Summary

Important results obtained from the present investigation have been described in Chapter 3 to Chapter 7. The results are summarized below:

Observations of Sweep Frequency, Fixed Frequency and Flare Related Radio Bursts (Chapter 3): (i) Optical observations at different wavelengths do follow the black body radiation which proves that optical wavelengths from our sun are thermally generated. However, radio energy does not follow black body radiation, proving the radio energy from our sun is not generated thermally. Our receiving systems linked to two log periodic dipole array can receive solar radio signals in the frequency range from 50 MHz to 300 MHz. Two low noise amplifiers (LNA) are used to reduce the local noises and thereafter the signal is fed to high frequency amplifier to amplify the received signal. A schematic diagram of the whole arrangement is shown in Figure 3.4. The received signal through the amplifier is fed to the digital storage oscilloscope (DSO) connected to the master computer. We observe constantly varying signal voltages along the vertical axis ('Y' axis), against the horizontal time axis ('X' axis). Our time of measurement was mostly from 8 AM (IST) in the morning to 5 PM (IST) in the evening. For the purpose we have divided the total time domain into three parts. Part-1 which is from 08:00 hrs to 11:00 hrs (IST), during which we have not received direct solar signals (IST– 5 hr 30 min = UT), Part-2 which is from 11:00 hrs to 14:00 hrs (IST), during which we receive direct solar signals and Part-3 which is from 14:00 hrs to 17:00 hrs (IST), during which we again have not received direct solar signals. Figure 3.5 shows how the two log periodic dipole array antennas are used for recording data. (ii) We obtained hundreds of CSV (Comma Separated Value) files for showing variation of solar signal per hour. Then using these CSV file we analyze these solar signal variations and manually recorded it for different points of time. We make a note of solar bursts recorded on a particular date, its starting time, peak time and also the end time. When a burst was obtained (solar signal amplitude goes beyond 0.1 volt), we isolate the peak values of the bursts while recording the time of the corresponding values. We did the same for non burst components. Using these data’s, we calibrated and plot a one hour plot of solar radio signal variations as shown in Figure 3.7. We start collecting solar data, using DSO, from 7th February, 2013. As we had lectures to attend, we were unable to collect data on a regular basis. Instead we collected data for 11 days in the month of February, 12 days in the month of March, and 7 days in the month of April. We collected data till 7th April, 2013, a total of 30 days. Out of these 30 days, we obtain bursts for 7 days in February, 11 days in March, and 1 day in April, a total of 19 days. We obtain our first two bursts on 12th February, 2013, and a maximum number of 6 burst on 28th February, and 18th March, 2013.
The numbers of bursts recorded on specific dates are shown in the Table 3.4. We obtained 18 bursts on the month of February, 27 bursts on the month of March, and 1 burst on the month of April, a total number of 46 bursts. Our time of measurement was mostly from 8 AM (IST) in the morning to 5 PM (IST) in the evening. The percentage of occurrence of bursts within this time are divided into 5 intervals as shown in Table 3.8 and also plotted in the histograms of Figure 3.9. The LPDA can receive direct solar signals from 11:00 hrs to 14:00 hrs (IST). From Figure 3.10 we can see that, we received a number of 13 bursts from 10:00 hrs (IST) to 12:00 hrs (IST), and a number of 9 bursts from 12:00 hrs (IST) to 14:00 hrs (IST). Here we can also observe that a small number of 3 bursts occurred respectively between 8:00 hrs (IST) to 10:00 hrs (IST) and between 16:00 hrs (IST) to 18:00 hrs (IST). This was well expected as we do not receive direct solar signals during this interval of time. However we recorded a maximum number of 18 solar radio bursts in the time interval from 14:00 hrs (IST) to 16:00 hrs (IST). From this we can conclude that, the LPDA we used for capturing solar signals, is sensitive enough to receive radio signals even when it is not receiving solar signals directly. (iii) With our instruments we were unable to record any data corresponding to the frequency of the bursts. Therefore, we cannot classify the solar radio bursts that we observed. However, we correlate these bursts with different solar events, X-ray events, and other solar observations which were recorded by various observatories around the globe. For this we used the website of SWPC (Space Weather Prediction Centre). Upon comparing our recorded data with that reported by SWPC (Space Weather Prediction Centre), we find that, out of the 46 bursts recorded by us, 33 bursts can be nearly correlated with SWPC’s reported bursts and other events. We have shown these 33 bursts in the Table 3.6. We have assign numbers (Event No.1-33) to the solar bursts recorded by us. In some cases, as for Event No. 31 and 32, we can see that there is only one event reported by SWPC which starts from 5:05 UT and ends at 8:44 UT. Within this time interval we recorded two separated bursts, one starting from 5:41 UT and ending at 5:43 UT, and the other starting from 6:19 UT and ending at 6:27 UT. This is shown in the Figure 3.10. (iv) Though we have obtained bursts on the same date, the starting, peak, and end time difference between our recorded data and the data reported by SWPC may significantly vary. The time differences between the recorded and reported starting, peak and end time are shown in the tables table 3.7, 3.8 and 3.9 respectively. It appears from the Figure 3.11, there are some few cases that a time differences between our recorded data and data reported by SWPC. But starting time and end time show opposite type of time-phase, i.e. when starting time is recorded before that for SWPC then end time of reported burst lead in phase over our data or vice-versa. We observe the peak times for burst are almost the same for both the cases as compared to the peak or end time. (v) With our observations, we observed and verified 33 out of 46 solar radio bursts most of which were correlated with solar flares, X-ray events and other low frequency solar observations.
Radio Emissions of the Sun and Associated Geomagnetic Parameters during Maximum Solar Activity (Chapter 4): (i) Disturbances to the solar wind due to a solar flare can trigger a geomagnetic storm. The solar wind exerts a pressure on the earth’s magnetic field (earth’s magnetosphere). If this pressure changes suddenly with the arrival of a shockwave from a solar flare, earth’s magnetic field changes shape in response. This generates strong electric currents by the dynamo effect, which travels along the lines of the magnetic field of earth, which in turn generates noise on the HF (3-30 MHz) and VHF (30-300 MHz) bands of the radio spectrum. Figure 4.2 shows solar signal amplitude vs. time plot, obtained from the one hour data recorded on February 7, 2013, the day in which no significant bursts were recorded. From the graphical plot, we can see that, the amplitude has an average value of 0.0015 volt, with few peaks at 0.002 volt. This can be considered as the quiet sun component of solar radio emission, which comes from thermal emission from hot ionized gases of the sun. (ii) Figure 4.3 shows the one hour plot obtained on February 28, 2013 and on February 26, 2013, 6:00 AM (UT) and 5:30 AM (UT) onwards respectively. From the plot of February 28, we can see that the amplitude level remained at about 0.05 volt with a sudden increase to about 0.25 volt from 6:18 AM (UT) to 6:21 AM (UT). We considered this event as a burst of duration 3 minutes. Clearly the burst component has amplitude 100+ times greater than the quiet sun component. Similarly, we recorded many more radio burst, having different amplitudes and durations. Some bursts occurred for duration as long as 30 minutes as that on February 26, 2013, 5:30 AM (UT) onwards. We can consider these two as the active sun component of radio emission which are associated with sunspots and flare activity. (iii) Some bursts occurred only for few seconds, as on March 12, 2013 at 7:43 AM (UT). Normally most of the burst component recorded by us, have amplitude about 0.1 volts, however we also obtained bursts having amplitude about 1 volt or above, as that obtained on March 4, 2013 around 9:45 AM (UT). These bursts components have amplitude 1000 times greater than the quiet sun components. These bursts are shown in Figure 4.4. (iv) We have received very strong and longer solar radio bursts on 26th and 28th February, 2013 (Figure: 4.6). The durations the bursts are thirty nine minutes and thirty four minutes respectively. So we consider these types of burst as long bursts. We observe the time sequences of these bursts. When we compare with the time sequences of the geomagnetic activity defined by Ap index, Table 4.4 clearly indicates that Ap value reaches high value (compared to other adjacent days) 34 and 14 on March 1st and 3rd, 2013 respectively. So the time difference between these solar burst and geomagnetic storm in the earth is two or three days. (v) To observe the effect of these solar flares and activities on geomagnetic conditions, we have taken into account the values of different geomagnetic indices starting from January 1, 2009 to January 2014. We have plotted one day average value of $a_p$ index in Figure 4.7. It appears from this figure that geomagnetic condition is more disturbed for the years 2012 and 2013 and it also increase its strength as we go through from 2009 to 2013. The minor storms observed for sunspot cycle 24 are two, three, six and again six in the year 2010, 2011, 2012 and 2013 respectively. In addition to this, in 2012 two major storms were occurred while that number is only one for 2013. To relate the geomagnetic conditions with solar activity, we have plotted Kp and $a_p$ index with the
sunspot number in the same panel (Figure 4.8). Here we have taken 27 days average as this average is more effective due to solar rotational period. For long time observation $a_p$ and Kp index increases due to enhanced sunspot activity when we compare the years 2009 and 2010 with 2012 and 2013. But when we compare for short duration e.g. shaded portions of the panel, the sunspot activity negatively correlated with geomagnetic indices and has a phase difference between them. In Figure 4.9, thirty seven month running average of calculated Ap index is plotted from the year 1991 to January 2014. It is clear from this figure that geomagnetic condition is quiet in cycle 24 (up to 2013) compared to two previous two sunspot cycle, though variation of sunspot activity of those three cycles quite small.

**Observation of a Variable Radio Sources as Derived from Jupiter and its Galilean Satellites (Chapter 5):** (i) Due to interaction of electrons with strong magnetic field radio emission occurs from Jupiter. We have received Jovian radio signals at Kalyani, West Bengal, using a radio telescope at 20.1 MHz based on the design from NASA’s Radio Jove Project. There are two types of signal received on a chart recorder, viz., the L and S bursts. By suitable audio monitoring arrangement, Jovian signal is listened simultaneously which identified the characteristic differences of typical emissions producing L-bursts and S-bursts. The L bursts have been described as having a 'swishing' sound or as 'waves crashing on a beach'. The S bursts occur less frequently than L-bursts. They are considerably shorter in duration; typical durations are less than 10 ms. When heard S-bursts have a 'chuff-chuff-chuff' type of sound with recurrence rates of between 10 and 40 per second. Usually, the bursts tend to occur in groups several seconds in duration. Besides their time duration, the main remarkable characteristic of the two burst types is their frequency drift rate. In the case of S-bursts this drift is apparently owing to the fact that charged particles, originating at Jupiter, spiral out along Jupiter's magnetic field lines and enter into the regions of progressively reducing magnetic field. The cyclotron frequency is directly proportional to the magnetic field strength and the burst frequency changes to reflect the changing field. At 20 MHz, frequency drift rates for S-bursts are around -20 MHz/sec. The negative sign indicates that the bursts start at a high frequency and drift down to a lower one. The frequency drift for L-bursts is related to complex geometric beaming effects associated with the cyclotron action. Diffraction effects imposed near Jupiter give rise to the modulation and other secondary scintillation effects due to the interplanetary medium. Moreover, the Earth's ionosphere is responsible to modulate the emission which appears in the radio frequency spectrum of L-bursts as regions of reduced signal amplitude with drift rates of typically +/- 100 kHz per second. The scintillation effects produce a characteristic amplitude modulation of the bursts on a time scale of seconds. Figure 5 shows idealized radio frequency spectrum of the two types of decametric radio noise bursts received from Jupiter. Figure 5.6, on the other hand, have chosen to present chart records producing L- and S-bursts at Kalyani (22.98°N, 88.46°E) observatory, West Bengal. The short (S) bursts last only a few milliseconds and drift down in frequency with time. The long (L) bursts have durations of seconds and contain modulation lanes which can drift either up or down.
(ii) We are recording Jovian radio signal data on a regular basis at the Kalyani University, Physics department by Radio Jove antenna at 20.1 MHz [16]. Our records reveal interesting variations during the events. In Figure 5.7 we have shown typical Jovian radio noise bursts recorded at Kalyani on March 13, 2013 when Jupiter was just rising over Kalyani sky. When we compare top and bottom panel of Figure 5.7 we find that at the time when the Jupiter was just about to appear at the Kalyani sky, the radio signal level has produced significant change in its records. This indicates a contribution of the Jovian radio signal received. (iii) The main problem encountered in deciphering the dynamics of the Jovian magnetosphere is the transport of heavy cold plasma from the Io torus at 6 \( R_J \) to the outer magnetosphere at distances of more than 50 \( R_J \). The precise mechanism of this process is not known, but it is hypothesized to occur as a result of plasma diffusion due to interchange instability. The process is similar to the Rayleigh-Taylor instability in hydrodynamics. In the case of the Jovian magnetosphere, centrifugal force plays the role of gravity; the heavy liquid is the cold and dense Ionian (i.e. pertaining to Io) plasma, and the light liquid is the hot, much less dense plasma from the outer magnetosphere. The instability leads to an exchange between the outer and inner parts of the magnetosphere of flux tubes filled with plasma. The buoyant empty flux tubes move towards the planet, while pushing the heavy tubes, filled with the Ionian plasma, away from Jupiter. This interchange of flux tubes is a form of magnetospheric turbulence. The magnetosphere of Jupiter as viewed from above the North Pole is shown in Figure 5.8. This highly hypothetical picture of the flux tube exchange was partly confirmed by the Galileo spacecraft, which detected regions of sharply reduced plasma density and increased field strength in the inner magnetosphere. These voids may correspond to the almost empty flux tubes arriving from the outer magnetosphere. In the middle magnetosphere, Galileo detected so-called injection events, which occur when hot plasma from the outer magnetosphere impacts the magnetodisk, leading to increased flux of energetic particles and a strengthened magnetic field. (iv) When flux tubes loaded with the cold Ionian plasma reach the outer magnetosphere, they go through a reconnection process, which separates the magnetic field from the plasma. The former returns to the inner magnetosphere in the form of flux tubes filled with hot and less dense plasma, while the latter are probably ejected down the magnetotail in the form of plasmoids. The reconnection processes may correspond to the global reconfiguration events also observed by the Galileo probe, which occurred regularly every 2–3 days. The reconfiguration events usually included rapid and chaotic variation of the magnetic field strength and direction, as well as abrupt changes in the motion of the plasma, which often stopped co-rotating and began flowing outward. They were mainly observed in the dawn sector of the night magnetosphere. The plasma flowing down the tail along the open field lines is called the planetary wind. (v) The reconnection events are analogues to the magnetic substorms in the Earth's magnetosphere. The difference seems to be their respective energy sources: terrestrial substorms involve storage of the solar wind's energy in the magnetotail followed by its release through a reconnection event in the tail's neutral current sheet. The latter also creates a plasmoid which moves down the tail. Conversely, in Jupiter's magnetosphere the rotational energy is stored in the magnetodisk.
and released when a plasmoid separates from it. Dynamics of Jovian magnetosphere mainly depend on internal sources of energy; the solar wind probably has a role as well, particularly as a source of high-energy protons. The structure of the outer magnetosphere shows some features of a solar wind-driven magnetosphere, including a significant dawn–dusk asymmetry. In particular, magnetic field lines in the dusk sector are bent in the opposite direction to those in the dawn sector. In addition, the dawn magnetosphere contains open field lines connecting to the magnetotail, whereas in the dusk magnetosphere, the field lines are closed. All these observations indicate that a solar wind driven reconnection process, known on Earth as the Dungey cycle, may also be taking place in the Jovian magnetosphere. The extent of the solar wind's influence on the dynamics of Jupiter's magnetosphere is currently unknown; however, it could be especially strong at times of elevated solar activity. The auroral radio, optical and X-ray emissions, as well as synchrotron emissions from the radiation belts all show correlations with solar wind pressure, indicating that the solar wind may drive plasma circulation or modulate internal processes in the magnetosphere.

**The Stormy Weather of Jupiter and a Comparison to Earth (Chapter 6):**

(i) The moist convection is a main factor in converting heat flow into kinetic energy in the Jovian atmosphere. It was also reported that the lightning preceding the storms was indicating the presence of large amounts of water in the deep clouds. We may use lightning that points to the place where there are rapidly falling raindrops and rapidly rising air columns which can be taken as a source of energy for the eddies. The violent storms (e.g. the hurricanes and cyclones) on Earth are fueled by the warm ocean. The water is heated by sunlight to drive all terrestrial weather. But Jupiter being 5 times farther from the Sun than is Earth and so sunlight is only 4 percent as strong there as on Earth, not enough to generate the observed tempests. Due to the heat reservoir of highly compressed hydrogen at its core, the planet generates about 70 percent more heat than it absorbs from the Sun. Moist convection had been proposed as the mechanism but there was no confirmation yet. The existence of a few long–lived large cyclones has been suggested. In addition to cyclones, Jupiter has some large irregular filamentary patches which demonstrate the cyclonic rotation. One of them is located to the west of the GRS in the southern equatorial belt. These patches are known as cyclonic regions (CR) which are always located in the belts and tend to merge when they encounter each other, similar to anticyclones. The large anticyclones extend only a few tens of kilometers above the visible clouds. (ii) The internal heat has important role for the dynamics of the Jovian atmosphere. As Jupiter has a small obliquity of about 3° and its poles receive small amount of solar radiation than its equator, the tropospheric temperatures do not significantly change from equator to poles. This might be due to the fact that Jupiter's convective interior behaves like a thermostat, releasing greater amount of heat near the poles than in the equatorial region. This contributes a uniform temperature in the troposphere. Again as heat is transported from equator to poles mainly through the atmosphere on Earth, on Jupiter deep convection equilibrates heat and, in fact, the convection in the Jovian interior is thought to be driven largely by the internal heat. (iii)
Shallow models considered that the jets on Jupiter are driven by small scale turbulence maintained by moist convection in the outer layer of the atmosphere, above the water clouds. The moist convection is related to the condensation and evaporation of water and is a major driver of terrestrial weather. The production of the jets in this model is associated with two-dimensional turbulence in which small turbulent structures merge to form a larger one. When the largest turbulent structures get a certain size, the energy starts to flow into Rossby waves instead of larger structures and the inverse cascade stops. On the spherical rapidly rotating planet the dispersion relation of the Rossby waves is anisotropic. The ultimate result of the process is the production of large scale elongated structures parallel to the equator. (iv) The Galileo probe observed that the winds on Jupiter extend far below the water clouds at 5–7 bar and do not show any evidence of decay down to 22 bar pressure level. This implies that circulation in the Jovian atmosphere may be deep. The deep model proposed by Busse was based on fluid mechanics, the Taylor–Proudman theorem. It suggests that in any fast-rotating barotropic ideal liquid the flows are maintained in a series of cylinders parallel to the rotational axis. The conditions of the theorem are met in the fluid Jovian interior wherein the planet's molecular hydrogen mantle is divided into cylinders, each of which having a circulation independent of the others. The latitudes where the cylinders' outer and inner boundaries intersect with the visible surface of the planet correspond to the jets while the cylinders themselves are observed as zones and belts. The deep model conveniently explains the strong prograde jet observed at the equator of Jupiter. However produces a very small number of broad jets and realistic simulations of 3D flows are not possible. The deep flows can be caused both by shallow forces or by deep planet-wide convection that transports heat out of the Jovian interior. (v) Jupiter is 1300 times larger than Earth and is primarily composed of gas while Earth is a solid planet mainly comprised of rock minerals and metal. Further, Jupiter's atmosphere consists of helium and hydrogen, while Earth's atmosphere is composed of oxygen and nitrogen. Despite their various differences, they share a variety of commonalities. Jupiter and Earth have some basic similarities, as they both are within the same solar system and revolve around the sun. But Jupiter's density is 1.326 g/cm$^3$ and Earth's is 5.513 g/cm$^3$, i.e. Jupiter's density only being 0.241 times that of Earth. Further Jupiter's orbit eccentricity is 0.04838624 and Earth's is 0.01671123 which equates to Jupiter's being 2.895 times that of Earth. Periodically, Earth experiences alternating patterns of wind in its stratosphere which occur near the equator. The changing stratospheric wind patterns experienced in Earth are called quasi-biennial oscillations. Jupiter also experiences stratospheric variations in the methane above its equator, which are similar to Earth's quasi-biennial oscillations.

Significant Changes of Jupiter's Little and Great Red Spot as Recorded by Spacecrafts (Chapter 7): (i) The atmosphere of Jupiter is full of spots with variety of shapes. In this survey, we have considered properties of over 500 spots during a 70-day period from the continuum band images of Cassini. The relation between the spots and mean zonal wind profile and interactions between spots and the GRS provide valuable information regarding their characteristics. During the 70-day period, nine large spots (major diameter more than
that were absorbed by the GRS from the east were identified. The large spots absorbed by the GRS originate from the CR’s in the SEB west of the GRS. They are entrained into the westward jet to the south of the SEB and encounter the GRS from the east. (ii) By the word “Life cycles” of the concerned spots we mean their appearances and disappearances as well as mutual interactions and interactions with the zonal jets. Making a comparison of the observed life cycles with those produced in numerical models we may get a better understanding of the dynamics of Jupiter’s atmosphere. We may divide appearances into three types: (1) development of contrast in an otherwise featureless region, (2) development of a coherent structure in an otherwise turbulent region, (3) sudden appearance of a bright point followed by rapid expansion in size. In Figure 7.2 we have illustrated the different types of appearances following reported results. Figure 7.2(a) displays an example of a spot forming in a relatively calm area (Type I). This is, in fact, most frequent form of appearance among the three types. The gradual appearance of the spot in the photograph is not due to the change in resolution. In the first two sub images we find that the embryo did not have elliptical shape and we observe much smaller scale features than the embryo itself. Figure 7.2(b), on the other hand, reveals a spot which emerged from the turbulence in a CR (Type II). This is the second most frequent form of appearance while Figure 7.2(c) presents a very bright spot which grows rapidly (Type III). This is the least frequent form of appearance and is probably a convective storm. (iii) We may also divide disappearances into three types: (1) disappearance for a merger between two spots, (2) destruction by the turbulence, usually in a CR, (3) gradual fading. Figure 7.3(a) presents a small spot destroyed by a CR. The range for every frame is (46°N–57°N, 90°–117°). The time of the first sub image shown in the display is Nov 25, 2000. The spot sits in an anticyclonic band and meets the left side of a turbulent structure in the CR. Figure 7.3(b), on the other hand, shows a spot that lost contrast and faded away. Occasionally, this case resembles that shown in Figure 7.3(a), absorption by turbulence. The fitting lines from the origin (Figure 7.4) suggest that long-lived spots and dark spots have smaller NS/EW ratios than short-lived spots and bright spots. The two-parameter fit provides a different result as it is more sensitive to spots having extreme low and high ratios than the fit from the origin. It appears from the figure that all the long-lived spots have major diameters larger than 2000 km while the short-lived spots have major diameters ranging from below 1000 to over 6000 km. No correlation between lifetime and size for the short-lived spots is found. (iv) Time gap between the appearance and disappearance of a spot is called as its lifetime. Figure 7.5 presents a histogram of lifetimes, constructed using the spots having a complete life history during Cassini’s 70-day observation window. The distribution of lifetimes of spots having complete life cycles during the 70-day period have been noted carefully in this analysis. In the figure each point represents the average number of spots in a lifetime bin 1 day wide. The upper panel shows the probable convective storms while the lower panel is for all other spots. From the analysis it is further seen that the exponential functions provide a good fit to the distribution of lifetimes, with time constants of 3.5 days for probable convective storms and 16.8 days for all other spots.
8.2 Scope for Further Investigation

From the analysis of radio frequency distribution and relative intensity of emission it is explained that the mechanism of radiation is synchrotron radiation in the magnetic field related with coronal mass ejection from the negatively charged electrons accelerated by solar wind shock driven by the CME. The emission is not visible in dynamic spectra of the solar radio event. In fact, as the limited dynamic range of the radio images, the emission would not have been visible if much brighter plasma emission sources situated in the lower corona are not exposed as the flare region is beyond the limb. The direct imaging of regions of acceleration arise by CME driven shocks generate various types data. More data are needed to calculate the relationship between the accelerated electrons observed in radio images and the energetic proton posing a threat to satellite operations and astronauts and the accelerated electrons observed in the radio images. But imaging at further low frequency with modern facilities, can detect bright sources of plasma radiation. This is very promising new scope of space weather and solar radio investigations.

Type I bursts have very short duration (of the order of seconds) and also have small bandwidth occurring in a drifting chains of 10-20 MHz. But noise storms are a significant sign that energy can release from other wavelength ranges too. This emission of energy can stay for a long duration, but the lack of presence of diagnostics at other different wavelength range turns them tough to investigate. The very bright solar burst at low frequency broadband continuum is not so easy for classification. They occur with fast halo CME and a slower solar proton event near the centre of disk. It is further linked with a principal interplanetary radio burst and the emission observed all the way out to this earth’s orbit. So, this type I burst has significant space weather effect. ‘Moving type IVs’ is a subclass of type IV burst which move in images at velocities identical to that of CME. They are hard to be distinguished from stationary type IV bursts by only their spectral characteristics. As they are mostly low frequency (less than 100 MHz) bursts and occur not so frequently, it is difficult to identify and study them. So more research is required on this moving type IV and also on the linkage between CME and particle acceleration, type II bursts, the space weather applications etc.

Combination of imaging with broadband spectroscopy across various wavelength ranges (dm, cm and mm) is necessary to answer basic questions about particle acceleration, transport (trapping, magnetic connectivity, pitch angle, scattering etc.), energy release (site, means, and nature). So, the most wanted requirement is a solar-devoted instrument which can perform high resolution imaging spectroscopy over dm and cm-wavelength, bands and observe X-ray and optical phenomenon. The less studied area of radio diagnostics and the flare phenomena can also be explained by this. To make such an instrument should be a goal of future researchers. Other facilities like satellite-borne coronagraph instrumentation provide many features invisible at other wavelengths. These processes are very important in studying radio astronomy and space weather physics. In the past decades, solar and space
science had significant progress. We expect parallel observation and imaging at all wavelengths (practically) can give inner mechanism of the subject. Their huge benefaction will help to understand solar bursts and solar flares in near future.

Jupiter produce very strong radio bursts at decametric wavelengths from regions of temporary radio emissions in its magnetosphere. Our present work reports identification and characterization of Jovian signal at Kalyani (West Bengal) at a frequency of 20.1 MHz besides the listening of Jupiter songs by audio monitoring arrangement. The present study has special importance from the point of view of radio astronomical observations on Jupiter over a tropical station in India. The probability of detection can still be fairly low (< 30%) and so observation may need to be made over time to detect a real magnetic storm. However more data, long term monitoring of Jovian noise burst and correlating the observations with other Radio-Jove project may provide valuable information in this area.

Some theories on geomagnetic activity and solar burst are not yet properly developed. Upgraded and sophisticated measuring instruments and new theories will reset some old theories and understanding and may prove some of them wrong when new theories with supporting data will be further developed. They would also enhance investigation on the bursts of dm waves and longer waves. Quantitative study of the electron acceleration is also mostly expected.