Occurrence of type-I radio bursts and their association with solar cycle

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A minimum between solar cycle 22 and 23 has been defined earlier on the basis of type-I radio burst only. In the present paper a re-visit to the occurrence of type-I radio bursts in relation to general level of solar activity (sunspot number) is made covering the minima of cycle 21 to complete cycles 22-23. The study shows that, it is not appropriate to speculate solar cycle minima on the basis of type-I radio burst only.

Keywords: Type-I radio burst, Solar cycle, Solar activity, Sunspot number

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1 Introduction

The aim of the present study is to re-visit the analysis done by Ramesh and Sundaram, because it has been found that the minima between solar cycles cannot be identified on the basis of type-I radio bursts only. Plasma oscillations, caused by fast electron streams and gyro-synchrotron radiation from energetic electrons trapped in suitable magnetic field configurations, have been proposed as sources for different spectral types of solar radio emissions. Solar radio burst from the active sun is a complex phenomenon and originates from different heights of solar atmosphere. Solar radio bursts are of different types. Spectral type-I radio bursts are the prominent feature of solar activity at metre wavelength having narrow band width (5-30 mega cycles per second), lasting from a fraction of a second to a few minutes. The large solar flares are frequently accompanied by type-II radio bursts at metre wavelengths (lasting from 5 to 30 min). Spectral type-III radio bursts are the fast drift bursts in the metre and decametre range. It is also found that essentially all of the proton events are preceded by groups of type-III bursts and coronal mass ejections (CMEs). The radio bursts which are followed by emission, covering all wavelengths from microwaves to metre wavelengths and lasting an hour or so, known as type-IV radio bursts. These bursts are connected with emission of plasma from deep atmosphere of the sun. The source model of solar type-IV bursts consists of two interacting loops with one spatial order of magnitude scale difference. Spectral type-V radio bursts are the broadband emission of metre wavelengths lasting a few minutes and are in the form of synchrotron radiation.

Out of various types of bursts, type-I radio burst is the only type of burst, which has not been specifically associated with solar flares. Their association with sunspots and high brightness temperature signifies that the radiation is not thermal in origin. The emission apparently originates in the corona in regions above large sunspots. The chances that a sunspot is associated with a noise storm increase with the area of the spot. This is expected, because there is a close relationship between the size of sunspots and their associated magnetic field. The noise storms are more frequent and intense during the maximum of the solar cycle, and are rare and weak during the minimum of the solar cycle. During solar cycle 23 (minima between 22 and 23), two periods of low solar activity were identified in 1996 – one in the month of May and the other in October. Also, in the month of October 1996 there were a minimum sunspot number, sunspot groups and 10.7 cm radio flux. Earlier, it was reported that October 1996 was the most probable time of sunspot minimum during which no type-I radio bursts were observed. This result has been drawn on the basis of single solar minimum. To test its appropriateness, the study has been extended for three solar cycles.
2 Collection of data

Type-I radio burst data have been taken from the spectral observations of solar radio emission published in the Solar Geophysical Data (covering minima of cycles 21, 22 and 23). The reporting stations were Bleien (47°N, 9°E), Potsdam (52°N, 13°E), Ondrejov (49°N, 14°E), San Vito (41°N, 18°E), Izmiran (55°N, 37°E), Learmonth (22°S, 114°E), Hiraiso (36°N, 140°E), Culgoora (30°S, 150°E), Palchua (21°N, 204°E) and Sagamore Hill (42°N, 289°E). The longitudinal distribution of the different observing stations is such that there is a continuous observation of the sun over a period of 24 h.

3 Results and discussion

Generally, sunspot numbers have been used as a representative solar activity index for various studies. Later on, other type of solar indices like 10.7-cm solar flux, grouped solar flares, solar flare index, sunspot area, grouped sunspot numbers, coronal index, etc. arbitrarily have been used, mostly without assigning any physical reason for the choice of a particular index or the combination of indices. Solar flare index (SFI) has been shown to be a better index for the study of long-term variation of cosmic rays. It has been recognized that the sunspot number and 10.7-cm solar flux are highly correlated even on monthly average basis. Hence, the variations of these two indices have been considered as standard way of representing the solar activity. The solar indices like sunspot number and 10.7-cm solar flux positively follow the minima and maxima of the solar cycle. Ramesh and Sundaram have shown that type-I radio burst and sunspot number are minimum during the minima between solar cycles 22 and 23. Based on the data of spectral observation of type-I radio burst, it has been concluded that minimum between solar cycles 22 and 23 occurred in October 1996.

In the present analysis, to test the earlier findings, the study has been extended for the minima of solar cycles 21, 22 and 23. For this purpose, a graph between smoothed sunspot number and smoothed number of type-I radio burst has been sketched (Fig. 1). It is clearly apparent from Fig. 1 that the number of type-I solar radio burst does not necessarily follow the solar cycle (sunspot cycle) on monthly average basis. It is also evident from Fig. 1 that the nature of the correlation is different for different phases of both the solar cycles (22 and 23). The peaks of the type-I radio burst are found to be at random and do not coincide with the peak of the sunspot number in different solar cycles. Hence, it is not appropriate to define the phases of solar cycle only on the basis of type-I radio burst.

The occurrence of type-I radio burst has been further examined during the minima of last three solar cycles. In order to ascertain the exact time of minima, the histograms of monthly sunspot numbers and total number of type-I bursts observed each month for the year 1976, 1986 and 1996 (minima of cycles 21, 22 and 23, respectively) are plotted. Figure 2 (top panel) shows the total number of radio bursts observed each month in the year 1976 along with monthly sunspot numbers. It is observed that sunspot number is minimum during the month of July, whereas number of type-I radio burst is minimum (zero) in the month of February 1996, which contradicts that both sunspot numbers and type-I radio bursts are minimum during the time of solar cycle minima. Similar analysis has been performed for the year 1986 (minima of cycle 22). Again from Fig. 2 (middle panel) it is clear that numbers of type-I radio bursts observed are minimum (zero) in the months of June, August, September and December during the year 1986, while sunspot number is minimum in the month of June 1986.

As such, it is evident that the minima of any solar cycle cannot be decided only on the basis of the type-I radio burst, as the number of bursts are minimum (zero) four times in the same year. Since no bursts were observed during the month of minimum sunspot activity (October 1996), primarily it gave an idea that the occurrence of type-I radio burst follow the minima of solar cycles (Fig. 2, lower panel). However, the
The present results based on the observation of three consecutive solar cycles show that the minima of solar cycles cannot be made only on the basis of number of type-I radio burst. It may be a mere coincidence that type-I radio burst and sunspot numbers both are minimum during October 1996. Therefore, it is concluded that type-I radio burst cannot be used as a solar activity parameter to define the minima or maxima of solar cycles. Recently, it has been shown that sunspot number can safely be used as a measure of general level of solar activity for any study of solar-terrestrial relationship, unless there is some specific reason to use another parameter. Present investigation confirms that sunspot number is a most suitable index to define the minima or maxima of solar cycles.

References