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Search for a 152-158 days periodicity in the occurrence rate of solar flares inferred from spectral data of radio bursts

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Abstract. — We have carried out a power spectrum analysis of the daily number of solar flares producing type I, II, III, IV, and V radio bursts for the period 1980 - 1984. The analysis shows that type II and IV radio bursts confirm the existence of a 152 - 158 days periodicity in the rate of occurrence, while type I, III and V radio bursts do not show this 152 - 158 days periodicity. We conclude that only type II and IV radio bursts should be used as a parameter which indicates the solar activity.

Key words: Periodicity — solar radio bursts — solar activity.

1. Introduction.

Rieger *et al.* (1984) first pointed out the existence of a 154-day periodicity in the occurrence rate of Gamma ray flares (>300 keV photons) observed by the Gamma Ray Spectrometer (GRS) aboard the SMM satellite during the interval from February 1980 to August 1983. Rieger *et al.* (1984) also found a 152-day periodicity in the occurrence rate of GOES X-rays flares > *M* 2.5. Kiplinger *et al.* (1984) also found a 158-day periodicity in the occurrence rate of hard X-ray bursts (>30 keV) observed during solar flares in 1980-1985. Bogart & Bai (1985) carried out a power spectrum analysis of the occurrence rate of microwave (MW) bursts observed at 1 GHz and found a 152-day periodicity. Ichimoto *et al.* (1985) found the similar periodicity in Hα flare data from cycle 20 and 21.

Wolff (1985) has attempted a theoretical explanation of this periodicity based on the rotational spectrum of the g-modes of the Sun. Bai & Sturrock (1987) found, however, problems with this approach, which seem to invalidate this model.

In the present paper we have carried out a power spectrum analysis of type I, II, III, IV and V radio bursts. Type II and type IV radio bursts are observed during major solar flares. Urbarz (1983) has carried out a similar study based on monthly rates of bursts of type II, IV and on sunspot numbers for the period 1976-1982. His study shows that there is a distinct peak appearing almost after every 5 months. The present study covers the period around the maximum of cycle 21, i.e. the years 1980 - 1984.

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2. Observational data and analysis.

The type I, II, III, IV and V radio bursts data have been taken from the chapter "Solar Radio Waves Spectral Observations" of Solar Geophysical Data. In this chapter radio bursts of all types observed throughout the world are published with information on the event start and end time and with an indication of the intensity on a 1 to 3 scale. Radio bursts are divided into decameter (10-30 MHz), meter (30-300 MHz) and decimeter (300-3000 MHz) wavelength ranges (Solar Geophysical Data Supplement, 1986). Most of the radio telescopes observe in the meter wavelength range and the majority of solar bursts is manifested at meter wavelengths. Therefore, we have limited the present study to the meter wavelength radio bursts. The present study covers the period of solar maximum cycle 21 (1980-1984). For the calculation of periodicity we have used the daily number of radio bursts, and in counting the daily number of radio bursts, we have taken extreme care in that these bursts should be counted only once. The number of type I, II, III, IV and V bursts and their root mean square (r.m.s.) values are shown in Table 1.

In the present investigation we have carried out a power spectrum analysis of all types of radio bursts separately. Figures 1, 2, 3, 4 and 5, show the plot of frequency *versus* power spectral density of the daily number of radio bursts of type I, II, III, IV and V, respectively. To calculate the most significant peaks in these figures, we have calculated the standard deviation (s) for each set of data. Peaks above the 3s level are considered as significant, the rest as noise.

TABLE 1. *Number of various radio bursts and their root mean square values in the period from 1980 to 1984.*

Type of Radio bursts	No. of Radio bursts	Root mean square values of the number of radio bursts
I	5321	4.26
II	622	1.10
III	29538	22.12
IV	274	0.55
V	3143	3.41

Figure 1 does not show any significant peak around 152-158 days. The value of s is 0.098 in the case of Figure 1. The tick marked peak in Figure 1 corresponds to a period of 152 days but this peak is not significant. The value of s for Figure 2 is 0.12. Only the first of the tick marked peaks is above the 3s value. This peak corresponds to a period around 152 days. The value of s for Figure 3 is 0.09. None of the the peaks is significant. Figure 4 shows a number of peaks. With $s = 0.15$, only three of them, marked A, B and C are significant. They correspond to periods of 365, 152 and 47 days, respectively. Similarly, Figure 5 also shows a number of peaks. With $s = 0.15$, the ones marked A, B, C and D are above 3s level. They correspond to periods 332, 68, 54 and 35 days, respectively. We have indicated by tick marks in Figures 1 to 5 not only the frequency range corresponding to a 152-158 days periodicity but also the location of harmonics.

In summary:

1) The radio bursts of type I, III and V do not show periodicities around 152-158 days.

2) The radio bursts of type II and IV show periodicities around 152-158 days.

3. Discussions and conclusions.

One of the important results from the solar maximum period of cycle 21 was the discovery of the 152-158 days periodicity in the occurrence rate of solar flares. Recently, Verma and Joshi (1987) carried out a power spectrum analysis of strong hard X-ray bursts (photon count rate >10000 counts/sec) and found a 155-day periodicity in the occurrence rate. They did not find any periodicity in the sunspot numbers for the same period. As shown above, type II and IV radio bursts do, however, confirm a 152-days periodicity, while type I, III and V radio bursts do not. We therefore propose that only type II and IV radio bursts should be used as indicators of solar activity along with H-alpha flares, microwave, soft X-ray, hard X-ray and Gamma ray bursts.

The cause of this (152-158 day) periodicity in the solar flare rate is still not clear. However, we are taking the view that a 152-158 days periodicity may occur due to the differential rotation of the Sun. It is well known that the solar activity is concentrated in ±11 to 30 degree of solar heliographic latitude (Verma *et al.* 1987, Verma & Pande 1988). Also according to Smith & Smith (1965) the majority of flares occur in between ±8 to 32 degree of heliographic latitude. The 152-158 days period is about 6 times the solar rotation at 11 to 30 degree latitudes of the active regions producing solar flares.

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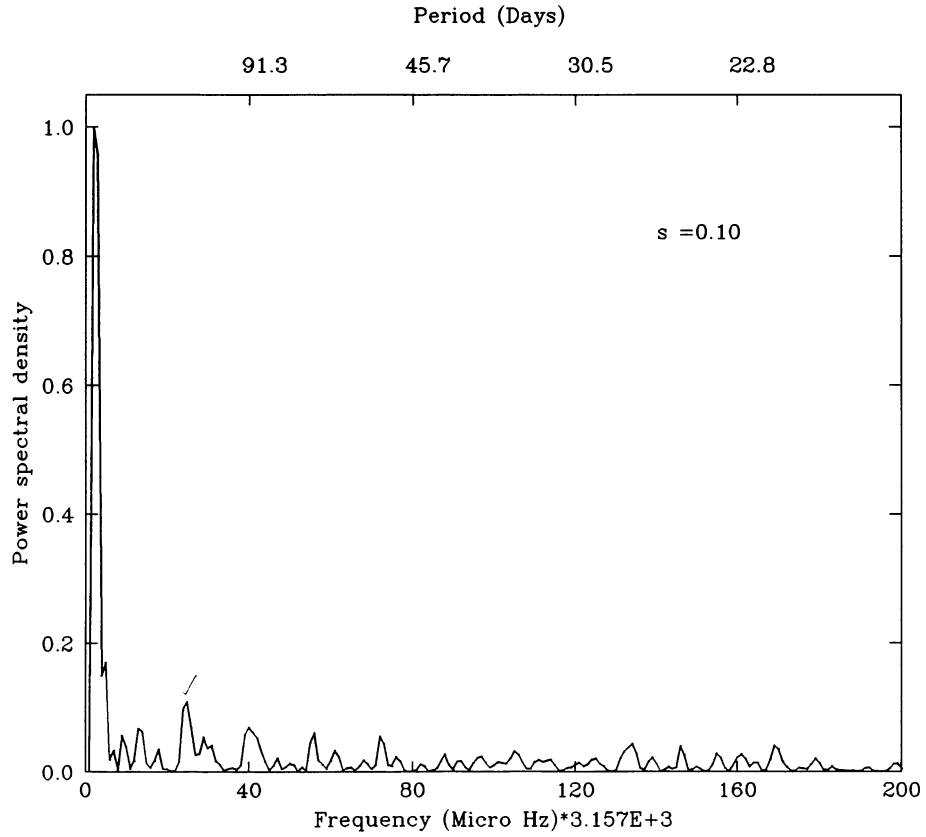

FIGURE 1. Plot of frequency *versus* power spectral density of type I radio bursts for the period of 1980-1984.

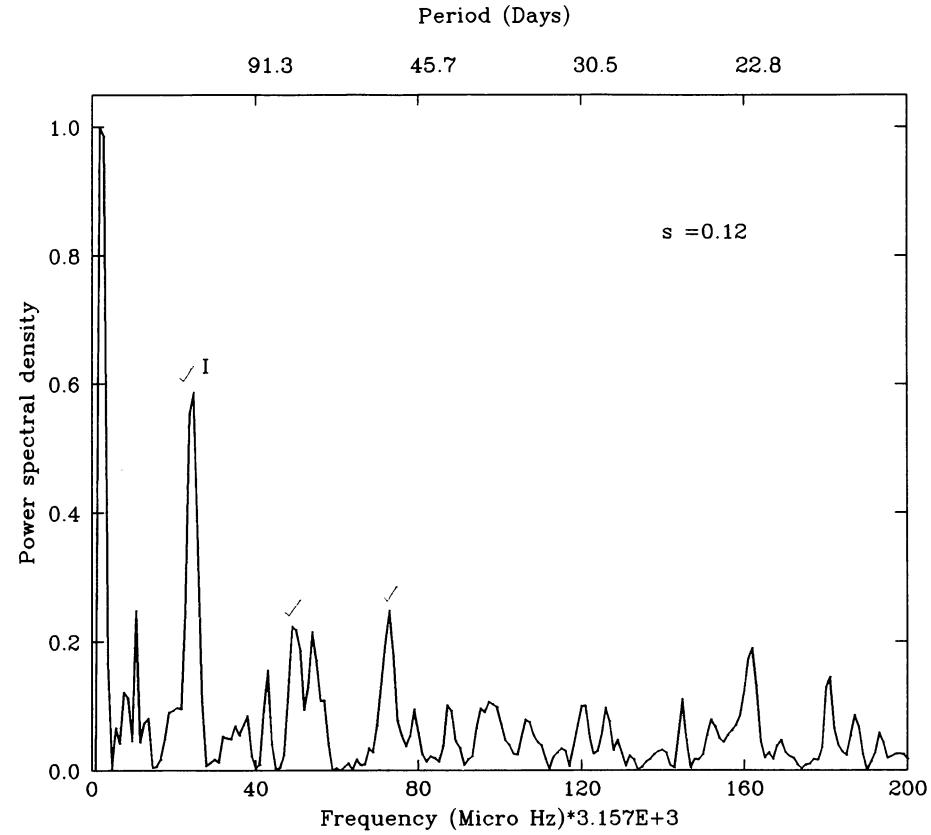

FIGURE 2. Plot of frequency *versus* power spectral density of type II radio bursts for the period of 1980-1984.

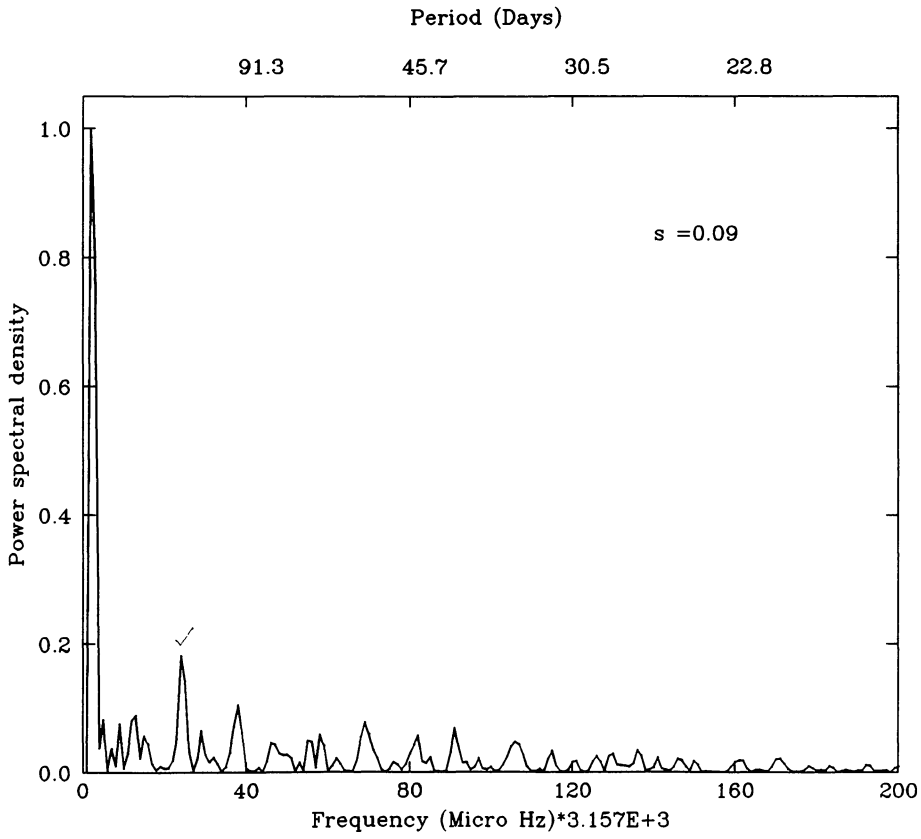

FIGURE 3. Plot of frequency *versus* power spectral density of type III radio bursts for the period of 1980-1984.

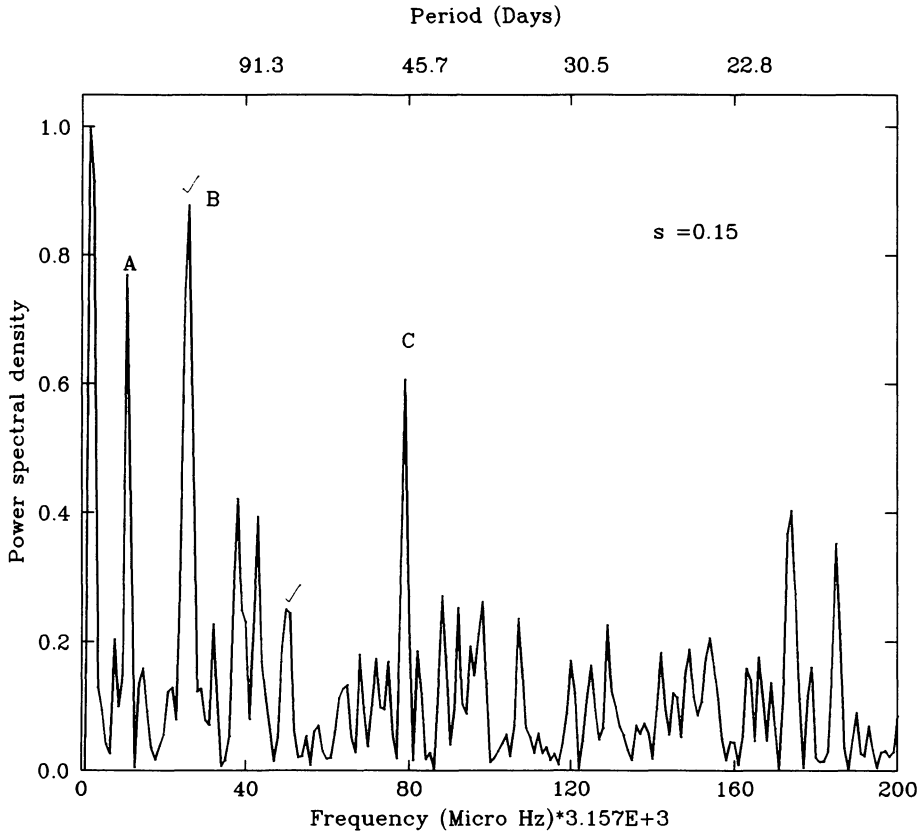

FIGURE 4. Plot of frequency *versus* power spectral density of type IV radio bursts for the period of 1980-1984.

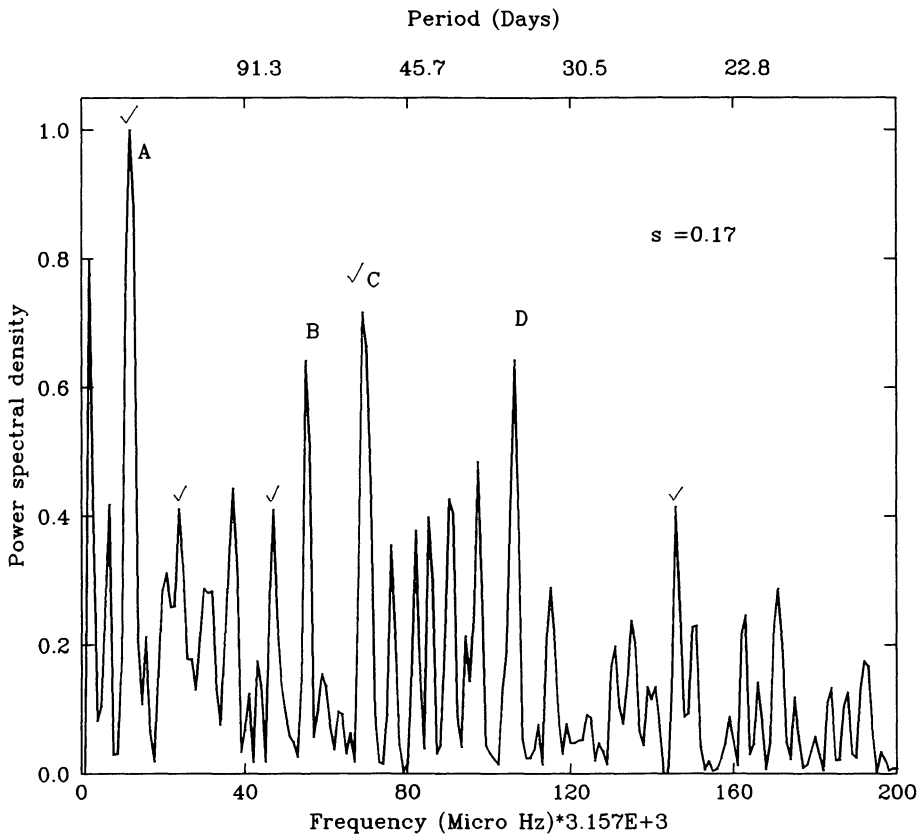

FIGURE 5. Plot of frequency *versus* power spectral density of type V radio bursts for the period of 1980-1984.