STUDY OF PERIODICITIES OF SOLAR NUCLEAR GAMMA RAY FLARES AND SUNSPOTS

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ABSTRACT . Here we have carried out a power-spectrum analysis of solar nuclear gamma-ray (NGR) flares observed by SMM and HINOTORI satellites. The solar NGR flares show a periodicity of 152 days, confirming the existence of a 152-158 days periodicity in the occurrence of solar activity phenomena and also indicating that the NGR flares are a separate class of solar flares . The power-spectrum analysis of the daily sunspot areas on the Sun for the period 1980-1982 shows a peak around 159 days while sunspot number data do not show any periodicity (Verma and Joshi, 1987). Therefore, only sunspot area data should be treated as an indicator of solar activity and not the daily sunspot number data.

1.Introduction

During the solar cycle 21, 152-158 day periodicity was detected in the rate of occurrence of energetic solar flares. This periodicity was first pointed out by Rieger et al. (1984) from the occurrence rate of solar gamma-ray (GR) bursts detected above 300 keV . Rieger et al. (1984) found that soft X-ray bursts also show a 152 day periodicity in the rate of GOES events with classification > M 2.5. Kiplinger et al. (1984) studied larger sample of 6775 solar hard X-ray (HXR) bursts above 30 keV and found a 158 day periodicity. Ichimoto et al. (1985) found similar periodicity from H-alpha flare data observed during solar cycles 20 and 21. Bogart and Bai (1985) carried out a power-spectrum study of microwave (MW) emission bursts observed on 1 GHz for the period 1966-1983 and found a 152 day periodicity. Verma and Joshi (1987) analysed strong HXR bursts and sunspot number data for the period 1980-1984 and found a 155 day periodicity in case of strong HXR events and no periodicity in case of sunspot number data. Wolff (1983) carried out Fourier analysis of the variation of the mean monthly sunspot numbers for the period 1799-1979 and found that the most prominent peak below 200 days is 155.4 days, remarkbly close to the period for flares in cycle 21.

In the present work, we have carried out a power-spectrum analysis of daily solar NGR flares, sunspot area data and umbral area data.

2. Observational Data, Analysis and Results

In the present investigation we have used data of flares observed by SMM satellite during the period 1980-1985 and HINOTORI satellite during 1981-1982. The SMM satellite recorded 92 NGR flares (Cliver et al.,1989). The data for NGR events was taken from column 14 of Table

1 and column 13 of Table 2 (Cliver et al.,1989). The HINOTORI satellite data of the NGR flares was supplied by Yoshimori (1985). Any NGR flares recorded simultaneously by SMM and HINOTORI during the period 1981-1982 were counted only once in the analysis. We also carried out power-spectrum analysis for sunspot area data and umbral area data for the period 1980-1982. The sunspot area data were recorded at Greenwich Royal Observatory , England and supplied to us by courtesy of NOAA, USA.

The power-spectrum for daily NGR flare data is shown in Figure 1. The peak marked I in Figure 1 corresponds to 152 day period . Figures 2 and 3 are the plots of power spectral density versus frequency for sunspot area and umbral area for the period 1980-1982 . The sunspot area data beyond 1982 is available in the literature . The peaks marked A in Figures 2 and 3 have a periodicity around 159 days . The other two peaks marked B and C in Figures 2 and 3 have the periodicity of 52 and 27 days respectively .

3. Discussions and Conclusions

Like the GR emissions, soft X-ray , HXR , strong HXR, MW emission bursts and H-alpha emission flares, solar NGR flares also show periodicities of 152-158 days in their rates of occurrence. Earlier Verma and Joshi (1987) carried out power-spectrum analysis of sunspot number data for the period 1980-1984 and found no peak around 152-158 days. While in the present study we find a prominent peak around 159 days ,very close to 152 -158 days period in case of sunspot area data. Thus , we are of the view that only sunspot area data should be treated as primary indicator of solar activity and not the daily sunspot number data.

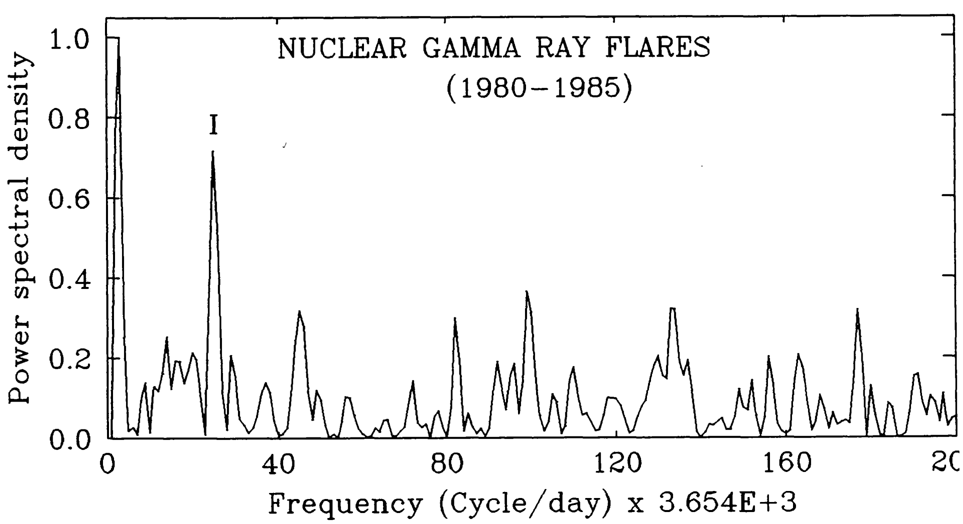

Fig. 1 Plot of frequency of solar NGR flares and power-spectral density.

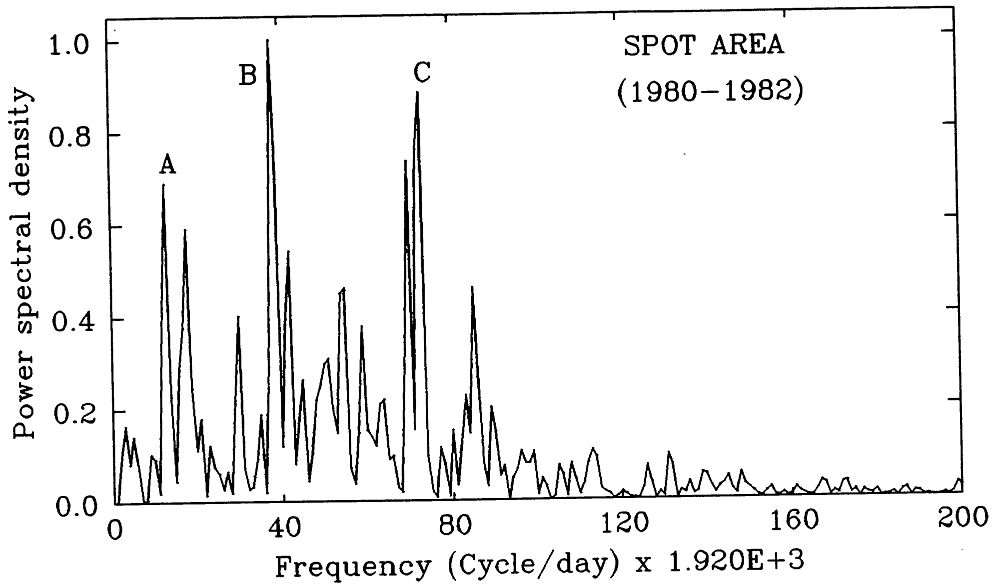

Fig.2 Plot of frequency of sunspot area data and power-spectral density.

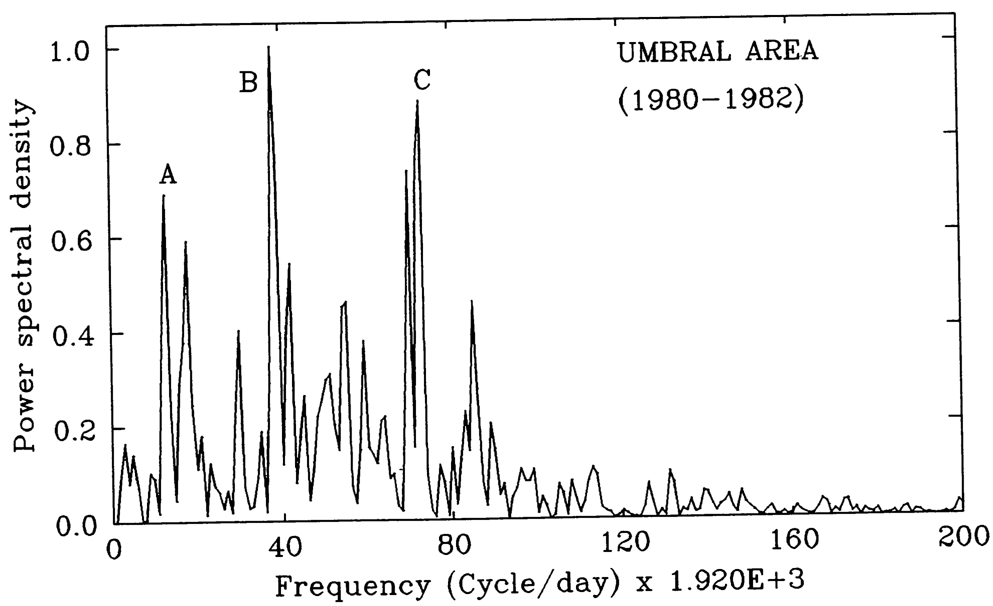

Fig.3 Plot of frequency of umbral area data and power-spectral density.

The cause for the 152-158 day periodicity in the solar flare rate is still not clear. Wolff (1983) carried out a Fourier analysis of mean monthly sunspot numbers for the period 1749-1979 and noticed that the most prominent peak below 200 days is 155.4 days. According to him the periodicity may result from the beating between the rotation of an l=2 and l=3 mode, where l is the spherical harmonic index. Recently Bai and Sturrock (1987) tested Wolff (1983) model by investigating longitudinal distribution of the flares produced during the peak of the 152 day period in the system rotating at the rates w1 and w2. Bai and Sturrock (1987) did not find any pronounced concentrations of flares along some specific longitudes.Therefore Bai and Sturrock (1987) concluded that the beating of g-modes solar oscillation of l=2 and l=3 is not the cause for 152-158 day periodicity. Most recently Verma et al. (1991) interpreted the 152-158 days periodicity in the occurrence rate of solar flares on the basis of differential rotation of the Sun. According to Smith and Smith (1965), Verma et al. (1987) and Verma and Pande (1988), most of the solar activity is mainly concentrated between ± 8 to±32 degree of heliographic latitudes. Verma et al. (1991) calculated diffrential rotation rate for 8 and 32 degree latitudes , which comes out as 14.37 deg/day and 13.65 deg/day respectively. Further , at 8 degree latitudes the period of rotation will be P = 25.04 days and at 32 degree latitude , the period of rotation will be P = 26.38 days. Verma et al.(1991) have also assumed that 6 solar rotations is a duration for energy build up time for active region to produce energetic flares . Finally , they have calculated that at 8 degree latitude, the period of occurrence rate of flares is P x 6 = 25.04 x 6 = 150.3 days and at 32 degree latitude , the period of occurrence rate of flares is P x 6 = 26.38 x 6 = 158.3 days. The above interpretation of Verma et al. (1991) satisfies the periodicity ranges of 152-158 days in the occurrence rate of solar flares.

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