INTERMEDIATE-TERM PERIODICITIES IN THE GREEN CORONA BRIGHTNESS OF THE SUN

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Abstract. We have analysed intermediate-term periodicities in the green corona by dividing $10^\circ$ latitudinal belts for the solar cycles 18, 19, and 20 (1947–1976). Discrete Fourier transform technique was used and three noticeable periodicities (3.48, 2.57, and 2.27 years) were found. The physical origin of these periods is not known, but evidence in our results exclude the possibility that the observed periods are a harmonic due to the method of analysis. The period of 3.48-year is the strongest one. 17.6-month periodicity was found only on around $+40^\circ$ belt while 155-day periodicity was not found in our analysis.

1. Introduction

The variations in the solar output measured by ground-based and satellite observations have period of approximately 11-year and 27-day which are well established. The former being related to the solar magnetic activity cycle, the latter reflecting the modulation imposed on the solar flux at Earth by solar rotation. Establishing the existence of real periods other than 11-year and 27-day, in solar observational data has long been of interest, for the clues this may provide to the mechanism of solar variability. Furthermore, solar irradiance is the main driver for the energy budget of Earth's atmosphere, thus these investigations may improve our understanding of the solar-terrestrial relationship.

The sunspot Wolf number has been commonly used to investigate the temporal variation of solar activity, but the frequencies of other solar parameters are also excellent indicators. The magnitude of the solar activity based on some solar parameters, such as calcium plages, flare and X-ray indices, reveals periodicities other than the most pronounced 11 years one. Many authors have studied this subject with various parameters (Rieger et al., 1984; Ichimoto et al., 1985; Bai and Sturrock, 1987; Özgüç and Ataç, 1989, etc.).

There is, generally, even less confidence in the reality of intermediate-term solar periodicities longer than at 155 days, because of the brevity of the time series and the presence of considerable non-oscillatory power (Hudson, 1987), their existence has been speculated from the analysis of ground-based and satellite observational solar activity data. Intermediate-term periodicities of the solar corona belong to the fields of solar physics which have not been studied sufficiently. However, the real physical origin of these periods has been doubted (Hudson, 1987), partly because in some cases the investigated data sets are not long enough to get any statistically significant result and these long periods may originate from the computational techniques used (e.g., from the way of detrending and smoothing the data). On the other hand, the existence of these
periods depends strongly on the time interval that has been investigated. This rather would indicate a quasi-periodic or time-varying behaviour, rather than a real cyclic behaviour of various solar data. However, because of the importance of showing the real origin of the longer periodicities, further studies are required on this topic.

In this paper we investigate the existence of periodicities in ground-based records of solar corona during the past three solar cycles (18, 19, and 20). We analyse temporal latitudinal variations of the brightness of the green corona for the period of 1947 to 1976. Our primary focus is the intermediate-term periodicity. If these periods, for example, in solar flare occurrence or in other solar phenomena are, as speculated by some authors (Bogart and Bai, 1985; Ichimoto et al., 1985; Akioka et al., 1987), associated with complexes of solar active regions, then it may be detected in at least some of the coronal brightness, unless it is a feature at the lower layers of the solar atmosphere activity alone.

2. Data Base and Analysis

As a main data base for this study we have used the green emission corona (Fe XIV 530.3 nm) brightness published by Sýkora (1983). The data set contains time-latitude distributions of the averaged green coronal brightness which were calculated for each 5° of latitude between ± 60°, for each of the 402 Bartels rotations over the period from 21 January, 1947 to 8 October, 1976. The calculation of the data set was very well described by Sýkora (1983), so we do not mention the details of their calculation. Although the data set contains 5° latitude brightness values, but we have chosen 10° latitude values between ± 60°. So we obtain thirteen time series. Figure 1 demonstrates the time-latitude variations of these thirteen time series.

In order to study existence of some intermediate-term periodicities in these time series we have performed a harmonic analysis by employing the Discrete Fourier Transform (DFT). Before employing DFT the mean of the series were subtracted from the time series. Then both ends of the series have been modified by applying 5% cosine tapering using a split bell cosine window (Bloomfield, 1976). The power spectra were calculated at 500 equally spaced frequencies between 9.1–100 nHz (4–50 rotations) with 0.2 nHz intervals. In Figures 2(a) and 2(b) the power spectra of twelve time series which belong to six opposite sign latitude belts of the corona, have been plotted as a function of frequency. In this figure dashed lines correspond to 3σ deviation (99% confidence level) from the mean. We consider that the peaks above these confidence levels are significant.

The significant peaks, above 99% confidence levels for all the latitudinal belts in the northern and in the southern hemispheres are listed in Table I. The three most prominent intermediate-term periodicities between 1947 and 1976 years in the data which we used, are at 3.48, 2.57, and 2.27 years. A peak at 3.48 years is the strongest feature in the periodograms of the two hemispheres. Now let us examine the power spectra of the twelve time series comparing with the opposite sign latitude belts. A + 60° belt shows two significant peaks (3.48 and 2.57 years) while a − 60° belt shows only one peak at about 3.48 years. The + 50° and the − 50° belts show almost the same periodicity peaks except 3.0-year peak which is seen only in the − 50° belt. The most prominent