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Solar soft X-ray variations in 22^{nd} and 23^{d} solar cycles

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Abstract. The oscillations in solar daily soft X-rays (SXR) have been analyzed for 22^{nd} and 23^{d} solar cycles. The SXR in the 1–8Å passband have been recorded by the GOES-6,8 satellites from January 1986 to April 2003 year. For 22^{nd} cycle the revealed periodicities 24, 43, 54, 65 and 73 days coincide with the 23^{d} cycle ones within data uncertainty (1 day) and their values may be explained by the differential rotation of the solar chromosphere and corona.

GOES data and processing technique. For 22^{nd} and 23^{d} cycles we employ the full-disk soft X-ray flux recorded by GOES satellites in the 1–8Å passband to analyse the oscillations of the solar soft X-Ray emission. The daily averaged soft X-ray data were extracted from Space Physics Interactive Data Resource service (http://spidr.ngdc.noaa.gov) for the periods January 1986 – August 1994 and January 1996 – April 2003 of the GOES-6,8 measurements accordingly.

To reveal the hidden periodicities in the data series the normalized spectral density periodogram (NSDP) was applied (Jenkins & Watts (1969)). The selection of the most confidence revealling NSDP harmonics is carried out by means of the study of primary data high frequency component (HFC). This HFC is a result of linear filtering of the data by Blackman-Tukey high frequency filter (Alavi & Jenkins (1965)). The cut-off frequency ($T_{cut-off}$) determines the time structure in the filtering component. The NSDP is applied to HFC with the different cut-off frequencies and then all periodograms are superposed. This technique allows to distinguish the fine and weak NSDP features in the interval of the high frequencess especially, so the trend was subtracted from the data by linear filtration.

Results and discussion. The solar SXR consist of background and flare emission. They are a manifestation of chromospheric and coronal magnetic structures. The first is a long-life objects about some solar rotations and the second one is short-life structures less then one solar rotation. In SXR the flare deposite exceeds the background more then some powers of value, so the sidereal solar period and multiple periods generated by short-life and intensive flare emission have to prevail among the another periods. This phenomenon must be manifested at solar maximum especially. These main strong periods must be modulated by the faint synodic solar period caused by the SXR background. Besides the rotation of the northern and southern solar hemispheres is different (Schroter & Wohl (1975)) therefore the most strong and narrow NDSP peaks must be broadened and splitted up two or three satellites.

Figure 1 shows solar SXR during the 22^{nd} cycle from 1986 yr. to August 1994 yr. (panel a) and during the 23^{d} from 1996 yr. to April 2003 yr. (panel b) consequently. The NDSP of the data observed in 22^{nd} solar cycle are represented on the panel c for

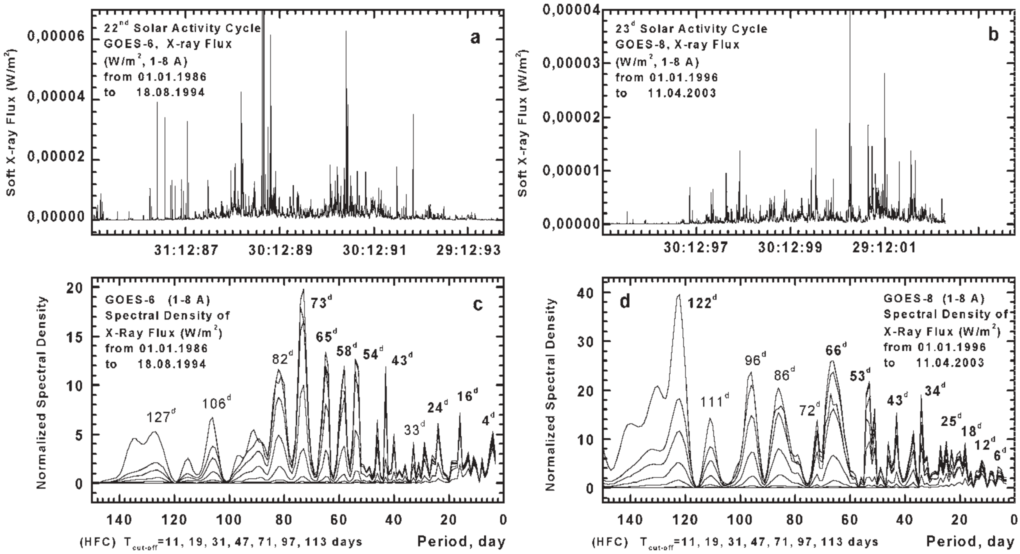

Figure 1. The periodicities in solar daily averaged soft X-ray flux recorded by GOES-6,8 satellites in 1–8Å passband during 22^{nd} and 23^{d} solar activity cycles

different cut-off frequencies. The main periodicities marked by bold types are 4, 16, 24, 43, 54, 58, 65, and 73 days. Their confidence level is greater then 3σ. And the remaining components marked by normal types have the confidence level about 2σ. The same 3σ confidence level periodicities 6, 12, 18, 34, 25, 43, 53 and 66 days were revealed in SXR registered in 23^{d} solar cycle (panel d).

Among of all these periods 24 (25), 54 (53), 73 (72), 106 (111) and 127 (122) days oscillations can be explained by sidereal rotation of Ca-plages and bright points in active regions in the MgX continuum (Ternillo (1986), Donahue & Keil (1995)) at 5000 – 11000 km above the solar photosphere and sidereal rotation of radio emission sources at altitude in the solar corona at 40000 – 60000 km above photosphere (Vats *et. al.* (1980), Vats *et. al.* (1998)).

As to another periodicities, according to Allen (1973), the life-time of usual facular plage is about 15 days, whereas the lifetime of large plags determined solar activity variation is about 82 days and e-folding time of plage square is about 43 days. The lifetime of the usual solar spot group is about 6 days, the lifetime of the large spot groups is about 45 days and e-folding time of large spot square is about 11 days (Allen (1973)). These periodicities are manifested in NDSP represented in figure 1 (panels c and d).

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