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THE BEGINNING OF NEW 24-th CYCLE IN SOLAR AND GEOMAGNETIC ACTIVITY GENERATION

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Abstract. The last prolonged minimum of solar activity (SA) stimulates interest to unusual solar phenomena – relatively slow intensification of "new" active regions of 24-th cycle in present time. Solar wind (SW) in near-Earth cosmic space has typical features, resulting from the configuration of general solar magnetic field. Heliosphere plasma layer (HPL) holds the most flat configuration; high-speed streams from recurrent coronal holes exist in solar wind as main reasons of geomagnetic disturbance in minimal phase of SA. Fractal analysis of SW plasma (Wind data) recognized clearly HPL transitions and fast SW flows, as basic long-lived phenomena in ecliptic plane. Fractal dimension of SW plasma shows the interesting result, connecting with sector structure of interplanetary magnetic field. The deepening into HPL without IMF polarity change points to situation, when heliosphere current layer is not cut in that case.

1. Introduction – solar minimum in 2006-2008

The general solar magnetic field is presented by quasi dipole structure in solar activity minimum. The heliosphere plasma layer (HPL) [Wilcox, 1965, 1983; Winterhalter, 1994] divides the giant solar wind flow into two regions of preferred polarity in connection with the solar hemisphere polarity. The coronal configuration of the last total solar eclipse in 2008 confirms with this description.
On the Earth orbit the polarity alternation is the interplanetary magnetic field (IMF) sector structure variations. Heliosphere current layer (HCL) is situated inside the HPL. Current layer is much more thin; the IMF polarity changes into opposite polarity after this layer transition. HPL and HCL are the long-lived solar activity phenomena. The changing of sector structure boundaries shows the dynamics [Ivanov, 1988] of solar activity in the equatorial belt of the Sun.
The prolonged solar minimum of 23-th solar cycle demonstrates us the most flattening of heliosphere plasma layer. Fig.1 shows the middle and the end of year 2008, Carrington rotations 2073 and 2077 – WSO Source Surface Field charts are similar to each other. Only in the deep solar spot minimum the HPL has the most flattening configuration in heliosphere and near to ecliptic plane.

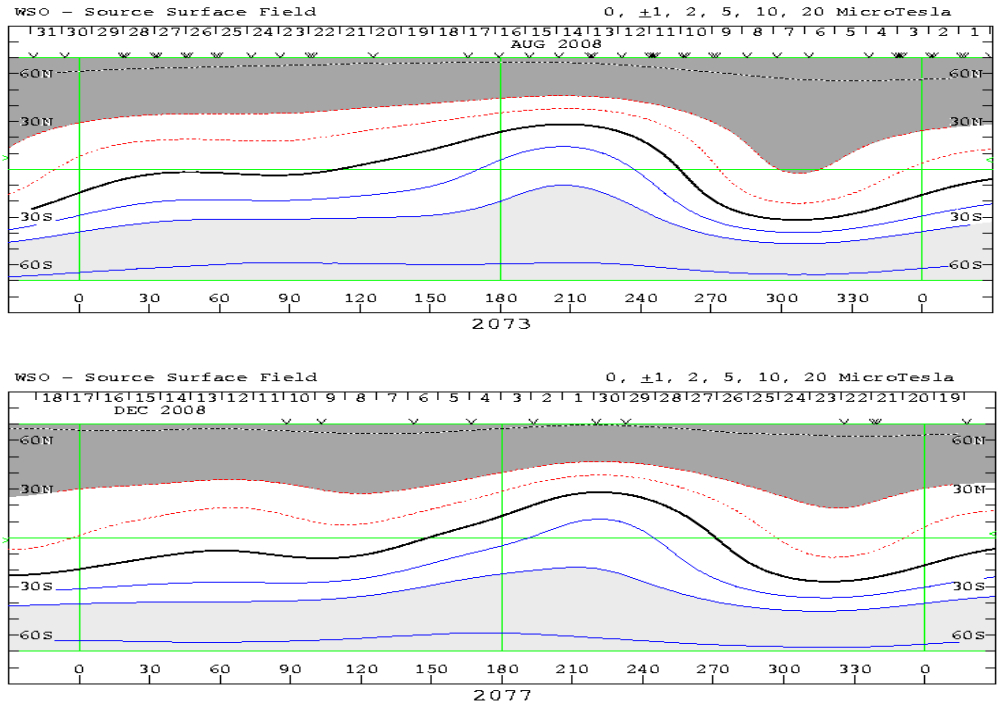

Fig.1. Two Carrington rotations (2073 and 2077) in 2008 show very similar pictures.

The Wolf numbers have typical variations in minimum: the number of days with W=0 growths from one year to the next year. They are 65 days in 2006, 170 days in 2007, 265 days in 2008.

Table 1. Mean monthly W values in 2006-2008.

2008	2.1	9.3	2.9	3.2	3.4	0.5	0.5	1.1	2.9	4.1	0.8	0.8
2007	16.8	10.7	4.5	3.4	11.7	12.1	10.0	6.2	2.4	0.9	1.7	10.1
2006	10.6	4.7	10.8	30.2	22.3	13.9	12.2	12.9	14.5	10.4	21.5	13.6

The minimal W values we look in June-July 2008 in present time. Probably 2008 constitutes a year of minimum in 23-th cycle of solar activity.

2. Active regions with polarity of 24-th cycle in 2008

The sure diagnostics of active regions of new 24-th cycle had place in 2008 – the first AR of "new" polarity generated in April 2008 (N hemisphere), in May 2008 (S hemisphere), both ARs were spotless. In September, October and November 2008 the little spots exist in active regions, all cases in N hemisphere. In December 2008 we look a little spot in S hemisphere. MDI in December 2008 consists new AR in N hemisphere repeatedly (earlier – November 13) in the next CR. It is transformed to flabby AR, at the same time new AR is generated in S hemisphere. On the last MDI from 12.01.2009 11.17 UT we may look faint new AR 2009 in progress. It may be concluded – the start of 24-th cycle is presented.

3. Geomagnetic activity in 2006-2008

Geomagnetic disturbance in 2006 was not high: only one extra-storm (December 14-15 2006), two moderate storms G2 (January 26, August 28), small magnetic storms 17 – in all 20 storms in 2006. The great geomagnetic storm was generated by X-flare (X3.4/2B, 13 December, 2006). About 25 geomagnetic storms (G0-G2) disturbed Earth magnetosphere in 2007. Only one storm G2 January 29-31 was caused by flare and coronal mass ejection, in sum 6 storms G2 were generated in 2007. Great geomagnetic storm was absent in that year. Many works analyzed the statistical and morphological SW characteristics [Yermolayev et al., 1992; Khvijusova et al., 2000] and SW geo-effectiveness. In 2008 magnetosphere activity was small: 15 storms G0-G1, 5 – G2, 1 – G3. They were produced by co-rotating interaction regions (CIR) mainly. The magnetic clouds in the vicinity of leading boundary regions of SW high-speed streams were the general reason of geomagnetic storms.

4. Sector structure and SW streams in 2007-2008

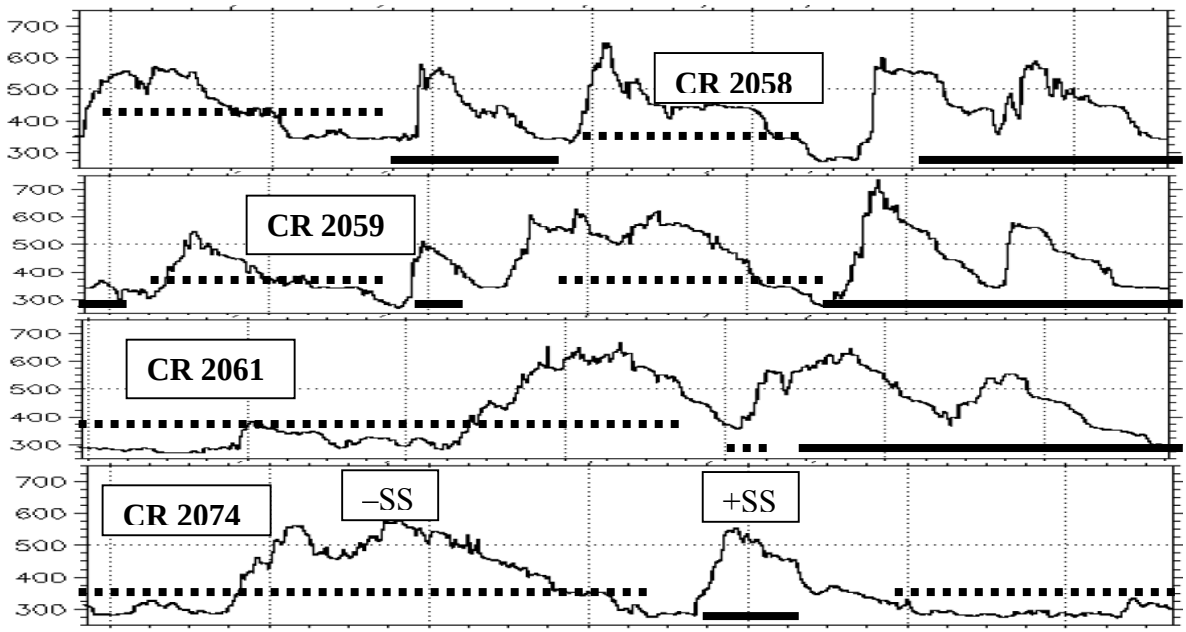

Fig.2. SW speed (km/s) and SS changing in four selected Carrington rotations illustrate the tendency to the flattening of HPL. Sector structure transformations in 2007-2008 show the transition from 4-th SS to 2-th SS with

consequent diminishing of positive sector IMF up to two days in CR 2074. Dotted and firm lines determine intervals of (–) SS and (+) SS accordingly; (+/–) and (–/+) variations exist in days without marking.

HPL transformations in 2007 change from 4-th (–/+/–/+) SS in CR 2052-2058 to 2-th SS in CR 2059-2061. In the last CR 2061(–/+) positive sector, existing in the middle of CR 2052-2058 (see Fig.2) and diminishing up to one day in CR 2059, disappears completely on the old place in the time extension of next Carrington rotations. Further in CR 2062-2068 overall duration of positive sector grows. In CR 2069-2071 variations are present, then the dominance of negative polarity extends constantly up to CR 2074, see Fig.2, where one may look only two days of positive polarity in September 2008. This anomalous situation transforms in the end of 2008, 4-th SS reconstructs.
High-speed streams [Val'chuk et al., 2002, Val'chuk et al., 2004] in 2007-2008 with $V_x \sim 700$-500 km/s are the most outstanding phenomena in all CR in this time of minimum. Above-mentioned situation of positive sector disappearance is connected with the transformation local magnetic situation on the solar disk. Equatorial coronal hole of positive polarity was disappeared in CR 2052-2059. The reason of transformation is the active regions of "old" polarity, which were generated in April, CR 2055, see Fig.3 (inverted pictures, black – positive polarity). Resulted coupling of two negative sectors gave 2-th SS of interplanetary magnetic field up to CR 2076. SS variations exist in the situation of quasi-dipole general magnetic field of the Sun in minimum.

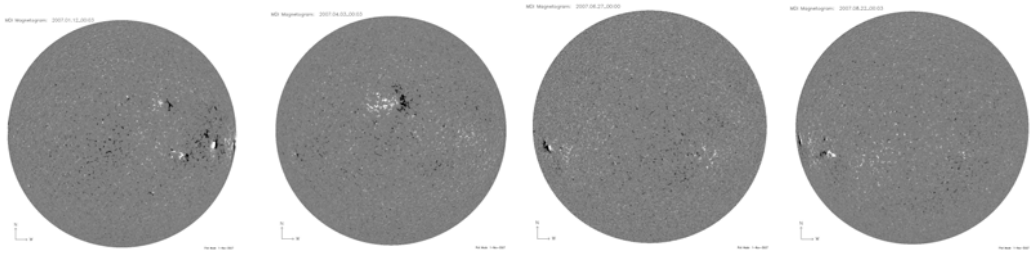

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Fig.3 MDI magnetograms: 1– in CR 2052, 12 January 2007, equatorial (+) CH (black color); 2 – CR 2055, April 2007 - generation "old" AR, SW speed deceleration; 3 – CR 2058 – the region of (+) polarity is seen in the center of disk as yet; 4 – CR 2060 – only negative polarity (white color) in near-equatorial region.

5. Fractal dimension of SW plasma as characteristics of SW structure

The plasma and IMF data in 2007-2008 were treated by method [Higuchi, 1988] with the aim of detailed examination of HPL [Korzhov, 1977; Lepping et al., 1996] character in the initial phase of new solar activity grows. Solar wind plasma is the fractal medium [Mogilevsky, 2001], reflecting in fractal dimension (FD) the sector structure transitions [Val'chuk, 2006]. The control of HPL variations from one Carrington rotation to another CR helps to identify the connection between solar wind parameters and solar activity phenomena. The transition of HPL is revealed as the FD diminution (down to 1.5 in the most cases). The sharp decrease of the FD is the feature of another fractal structure in HPL region, Fig. 4. The 4-th sector structure transforms into 2-th sector structure in CRs 2059-2061, Fig.2. The last interesting FD result is connected with the coupling two sector boundaries in the middle of Carrington rotations №2060-2064 in the end of 2007. The possible explanation may be proposed: the Wind trajectory is sink into the thickness of HPL, but HCL is not cut. It is the situation of two-sector structure of IMF, but the typical FD diminution is repeated in these CRs on the old places of the sector boundary coupling. It is the situation of HPL flattening. The situation of 2-th sector structure exists from CR 2059 up to CR 2076 near the end of 2008.

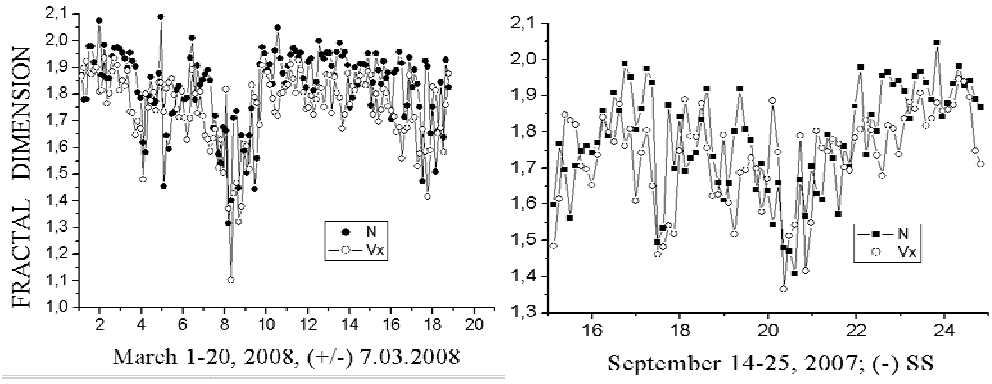

Fig. 4 a) Typical FD variation in the case of HPL transition and SS change. HPL divides (–) and (+) high speed streams; **b)** diminishing FD in plasma layers, SS is stable negative, CR 2061 – after disappearing early present positive sector IMF.

6. Conclusions

The geomagnetic disturbance is not valuable in the minimum of solar cycle №23. Co-rotating recurrent interaction regions (CIR) were the general reasons of geomagnetic disturbances in 2007-2008. The leading boundaries of HSS disturbed moderate geomagnetic activity. Extra magnetosphere storm, similar to great geomagnetic storm 13-14.12.2006, is absent in two last years. The transformations of sector structure from 4-th SS to 2-th SS pick out the last year 2008, as the minimum of 23-th solar cycle. Fractal dimension calculations [Mogilevsky, 2001; Val'chuk, 2006] distinguish a structure of SW flows: high-speed streams, HPL transitions, boundary regions of HSS, deepening into HPL without IMF polarity change. Only in the minimum of solar activity one may look the unusual picture SS with gradual growth of preferred sector polarity from one Carrington rotation to another up to several days opposite polarity (CR 2074). Then the picture transforms to more regular 2-th sector structure. The initial active regions of 24-th cycle are not intensive, it is usual in the end of prolonged solar minimum, but they are revealed now.

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