The Peculiarities Of The Initial Phase Of The 24-th Solar Activity Cycle

P A Otkidychev, N N Skorbez
GAS GAO RAN, Kislovodsk, Russia
E-mail: otkid@list.ru

Abstract. A set of peculiarities of the 24-th solar activity cycle is considered on the base of the data of Kislovodsk Mountain Astronomical Station (www.solarstation.ru) as well as NASA/Marshall data. The peculiarities of the 24-th cycle are: the asymmetry between sunspot areas of northern and southern solar hemispheres; the difference between sunspot latitudes in northern and southern solar hemispheres; low activity of the first years of the cycle; large relative amount of single sunspots.

1. Introduction
The Sun observations in white light at the Kislovodsk Mountain Astronomical Station (GAS GAO RAN) carry out from the October 1954 [1]. Thus, the set of GAS GAO RAN observations includes the majority of the 19-th cycle, complete 20–23 cycles and the beginning of the 24-th cycle. At the present time observations carry out on CCD by the instrumentality of the MEADE telescope \((D = 15\,\text{cm}, f = 120\,\text{cm})\).

2. The asymmetry between northern and southern solar hemispheres
There is considerable difference between monthly average areas of sunspot groups in northern and southern solar hemispheres. Adopting the beginning of the 24 cycle as January 2009, we obtain the next mean value of monthly average sunspot areas by Kislovodsk data: 334.0 mhm in the north and 185.7 mhm in the south (here and farther the data are given for the state of August 2012); thus the difference is 1.9 times (although in July 2012, on the contrary, sunspot area in the south was 8.5 times greater than in the north). The correlation coefficient between the north and the south is only 0.29. Sunspot areas shown in the figure 1: the total area (thick line), area of northern (thin line) and southern (dotted line) solar hemisphere.

Wolf numbers in the north also overcome ones in the south. Monthly average meanings of Wolf numbers by Kislovodsk data are: 30.0 in the north and 16.3 at the south. The difference between them is 1.8 times. Wolf numbers shown in the figure 2 similarly to sunspot areas.

The asymmetry exists also in latitude distributions of sunspots. Mean yearly latitudes of sunspot groups by NASA/Marshall data for each year from 2009 are given in the table 1 (calculated as the sum of products of latitudes by sunspot areas, divided by the overall sum of sunspots areas for each year and for each hemisphere). Mean latitudes of sunspot groups in the south are appreciably more than in the north. Besides, mean latitudes at the south in 2012 almost haven’t changed in comparison with 2011. This fact is in disagreement with Sporer’s law. Then, the rate of the change of average sunspot latitude must be about 1.6 degree per year [2].
This condition is approximately true only for 2009-10 years. The data of table 1 represented in the figure 3 (thick line for the North and thin line for the South).

| Year | North | South |
|------|-------|-------|
| 2009 | 22.2  | 25.8  |
| 2010 | 20.4  | 24.5  |
| 2011 | 16.7  | 18.8  |
| 2012 | 15.6  | 18.6  |

Mean monthly latitudes (calculated similarly to mean yearly latitudes) represented in the figure 4 (thick line for the North and thin line for the South too). It is worth paying attention to the fact, that sunspots in southern hemisphere “have switched over” to new cycle only in May 2012.

As for the extremal meaning of latitudes, the least latitude was registered in 24.12.2011 at the group number 11383: 2.3° North, at that one of the sunspots had 1.9° North. Also it should to note group number 11560: for the period 02-06.09.2012 it was crossing the equator, having mean latitude about 3° North. Such low latitudes are typical of the end of the cycle.
3. The initial phase activity of the 24 cycle
The initial phase of the 24 cycle has low activity in comparison with previous cycles. The cycle activity from 20 to 24 cycle is submitted in the table 3: there are mean sunspot area $S_{\text{mean}}$ and Wolf number $W_{\text{mean}}$ for the first year of each cycle and for the first three years (by GAS data).

| Cycle number & beginning | $S_{\text{mean}}$ for the 1-st year | $S_{\text{mean}}$ for the 1-st 3 years | $W_{\text{mean}}$ for the 1-st year | $W_{\text{mean}}$ for the 1-st 3 years |
|------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|
| 20 (1964/10)           | 83.2                                | 564.2                                 | 17.3                                | 61.6                                  |
| 21 (1976/06)           | 158.6                               | 926.5                                 | 18.5                                | 83.4                                  |
| 22 (1986/09)           | 325.2                               | 1279.7                                | 30.7                                | 91.1                                  |
| 23 (1996/05)           | 113.5                               | 567.9                                 | 12.9                                | 51.9                                  |
| 24 (2009/01)           | 30.6                                | 403.0                                 | 5.5                                 | 40.3                                  |

NASA/Marshall data permit to carry out the comparison of the first years of the 24-th cycle with the first years of the weak cycles in the past. From the cycles, which represented in the NASA/Marshall database, 12-th and 14-th are the weakest. The cycle activity of 12-th and 14-th cycles is submitted in the table 3: there are mean sunspot area $S_{\text{mean}}$ (by NASA/Marshall data) and Wolf number $W_{\text{mean}}$ (by Solar Influences Data Analysis Center, Royal Observatory of Belgium) for the first year of each cycle and for the first three years.

| Cycle number & beginning | $S_{\text{mean}}$ for the 1-st year | $S_{\text{mean}}$ for the 1-st 3 years | $W_{\text{mean}}$ for the 1-st year | $W_{\text{mean}}$ for the 1-st 3 years |
|------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|
| 12 (1878/12)           | 33.7                                | 369.8                                 | 5.4                                 | 29.6                                  |
| 14 (1901/09)           | 32.2                                | 237.8                                 | 2.8                                 | 19.1                                  |

The comparison shows that 24 cycle is similar by activity with two weakest cycles from the beginning of the RGO observations, namely with 12 and 14 ones.

The data of tables 3 and 3 has combined in the figures 5, 6 (areas) and 7, 8 (Wolf numbers).

4. The relative quantity of single sunspots
The data of Kislovodsk Station enable to calculate the total and the relative amount of single sunspots (i.e. groups, composed of only one sunspot). The relative quantity of single sunspots (calculated for each year as number of groups, composed of only one sunspot, divided by number of all groups for this year) from 1955 to 2012 represented in the figure 9.

5. Conclusions
As follows from the figure 9, the minima of the relative quantity of single sunspots fall on the cycle minima, with the exception of the minimum between 19-th and 20-th cycles. 24-th cycle demonstrates very high level of the relative amount of single sunspots by comparison with previous years. This fact as well as low cycle activity and spot asymmetry between the north and the south makes this cycle extraordinary. This is the weakest cycle for last hundred years.
Figure 5. Mean sunspot areas for the first year from the cycle beginning.

Figure 6. Mean sunspot areas for the first three years from the cycle beginning.

Figure 7. Mean Wolf numbers for the first year from the cycle beginning.

Figure 8. Mean Wolf numbers for the first three years from the cycle beginning.

Figure 9. The relative quantity of single sunspots.

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References
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