Advances in Astronomy and Space Physics, **3**, 84-88 (2013)

Fast-growing sunspot groups AR1618, AR1619, AR1620, AR1640 and their features

Yu. A. Fursiak*

Crimean Astrophysical Observatory, 98409, Nauchny, Crimea, Ukraine

The paper considers evolutionary features of fast-growing sunspot groups AR1618, AR1619, AR1620, and AR1640. The study consists of the analysis of magnetic fields, movements of the solar atmosphere at different levels, and other data. In order to obtain the largest possible volume of information about the groups, data from a number of sources, both terrestrial (Kanzelhoehe Solar Observatory, Crimean Astrophysical Observatory), and space (SOHO, SDO, etc.) were used. A comparison of the groups with typical sunspot groups was made.

Key words: Sun: atmosphere, sunspots

INTRODUCTION

The study of sunspots is an important issue, as they are directly correlated with flares, which have a noticeable impact on various processes on the Earth.

Sunspot groups, being a basic element of the active region, may differ significantly from one another. Their classification may be based on morphological characteristics (the total area occupied by a group, the number and size of individual spots, the group dynamics), as well as spatial characteristics (latitude and longitude, latitude drift) or physical characteristics (structure of the magnetic fields, flare activity, etc.).

The development process of a typical sunspot group was well-studied and described in the 40-50-s of the XX century [1]. The present paper considers several fast-growing sunspot groups, which appeared on the Sun in November 2012 – January 2013, and have a number of properties and characteristics of interest.

FAST-GROWING SUNSPOT GROUPS: ANALYSIS CRITERIA AND STATISTICS OF CYCLE 24

The fast-growing sunspot groups have a number of evolutionary characteristics that set them apart from typical active regions. Firstly, it is the rapid growth of their total area, and secondly, the rapid growth of the number of spots in them. It should be noted that large active regions, at a certain stage of their development, have significant rates of growth of the total number of spots and group area. The acceleration of evolution of such groups usually occurs near the maximum stage of the development of an active region (the 5th–8th days of existence of the group), and it is of slightly different character, that distinguishes them from active regions with rapid growth.

For more detailed information about fast-growing sunspot groups, a number of factors were pointed out, which had a significant influence on development and existence of sunspot groups as a whole. First of all, these are general characteristics of the studied active formations[1]. These characteristics may include the variation of the total area of the group, the variation of the total number of sunspots with the passage of time, the complex configuration of the magnetic field [2], and variation of longitudinal extent. A number of other peculiarities can be marked out, among them the presence of strong flares, including flares with coronal mass ejection (CME), interaction with other groups through coronal loops, or photosphere magnetic fields with formation of a large complex of the groups, etc. Each of the studied regions was assayed according to the the above-mentioned criteria. The characteristics of active regions were identified, and general conclusions were made.

It should be noted that this paper considers only four fast-growing groups. Since the beginning of solar cycle 24, more than 10 such active regions have been already registered: two were observed in 2010, 1 – in 2011, 5 – in 2012, and since the beginning of

*yuriy_fursyak@mail.ru

[1] http://www.tesis.lebedev.ru/active_areas.html

2013, 6 groups with accelerated evolution have appeared on the Sun.

DYNAMICS OF ACTIVE REGIONS AR1618, AR1619, AR1620 AND AR1640

The dynamics of the investigated active regions is illustrated in Fig. 1. The horizontal axis shows the days of visibility (moving of the group along the visible hemisphere of the Sun). Vertical axis: left (N) – the number of spots in the group, right: S – the total area of the active region (in millionths of the solar hemisphere, msh), n – the number of flares, associated with this region. Note that all of the studied active regions have a large extent, which is greater than 10° by longitude in the maximum stage of development. It is more typical for large active regions. At the same time, the total area of each group considered does not exceed 460 msh, which is typical for small groups with weak flare activity. AR1618, AR1619 and AR1620 were located in low latitudes, which is common among groups during the solar activity maximum period. The AR1640, being in the latitude 28°, has low activity (only seven flares of C class have been registered). The extremely weak flare activity was also observed in the AR1619, which interacts with near-by regions through coronal loops and photospheric magnetic fields. Note also that the group AR1618, despite the complex $\beta\gamma\delta$-configuration of the magnetic field (Fig. 2), has not caused any X-class flares[2]. This means that the group was less active than anticipated [3]. The same can be said for regions AR1620 and AR1640. It is likely that this is due to a small total area of the groups, the predominance of small spots, and large longitudinal extent. Perhaps the rapid development of the active region has some influence as well.

CHARACTERISTICS OF THE ACTIVE REGION

AR1618 (visibility period: 16.11.2012 – 28.11.2012). The group of sunspots appeared in the form of several pores, surrounded by plages. From the very beginning of development of the active region it occupied a rather large area — 13° in longitude. It should be noted that the p-spot of the group disappeared earlier than the f-spot. The p-spot is usually the more long-lived one [1].

AR1619 (visibility period: 16.11.2012 – 26.11.2012). On the north-east and north-west from the area studied on November 14-18, 2012 there were two more groups (AR1614 and AR1616), which disappeared with the development of AR1619. The magnetograms (Fig. 3) clearly show that the new bipolar magnetic flux AR1619 leads to redistribution of magnetic fields in the entire complex. It indicates the physical relationship of these regions. This group has another feature of interest — interaction through a coronal loop with AR1613, located in the southern hemisphere (see Fig. 4).

AR1620 (visibility period: 19.11.2012 – 01.12.2012) appeared on the eastern limb as a small spot, with several pores surrounded by plages. Active growth of the group begins somewhat to the west of this spot, following its disappearance. Over two days (25-27.11.2012) the area of region AR1620 increased by a factor of 12.

AR1640 (the visibility period: 29.12.2012 – 09.01.2013) developed very rapidly. Over two days the region reached 100 000 km in diameter and kept on growing[3]. Just like AR1619, AR1640 interacts through coronal loops with near-by regions AR1636 and AR1638 (Fig. 5) and has low activity.

RESULTS AND CONCLUSIONS

The analysis of images and data obtained with different instruments makes it possible to draw the following conclusions:

(1) The lifetime of fast-growing sunspot groups is 10-12 days or more.

(2) The rapid development of groups can be explained by the fast output of elementary magnetic flux on the surface of the Sun.

(3) The calculation of time derivatives on the number of spots dN/dt ($dt = 24$ hours) for the fast-growing groups showed that during the period of their growth, this derivative was very stable. Thus all four active regions with accelerated evolution showed approximately the same values of this quantity, comprised within the range from 0.29 to 0.50 spots/h for 24-72 hours. However, neither small sunspot groups, nor powerful growing groups exhibited long-term stable development.

(4) The relatively low activity of fast-growing groups, despite the complex magnetic fields, may be due to their large longitudinal extent at the early stages of development, and due to a small total area.

(5) The active regions with rapid development have a number of properties typical for small groups of sunspots (small total area, weak flare activity). At the same time, complex configuration of the magnetic field, large longitudinal extent, rapid growth of the area and the number of spots are more typical for large active regions.

(6) The general statistics of the fast-growing sunspot groups from the beginning of cycle 24 indicate that they are more characteristic of the period

[2] http://www.spaceweather.com/glossary/flareclasses.html?PHPSESSID=1g4mc4ce7qd9qiqu3g2dgkuma0

[3] http://www.spaceweather.com/archive.php?day=22&month=11&year=2012&view=view

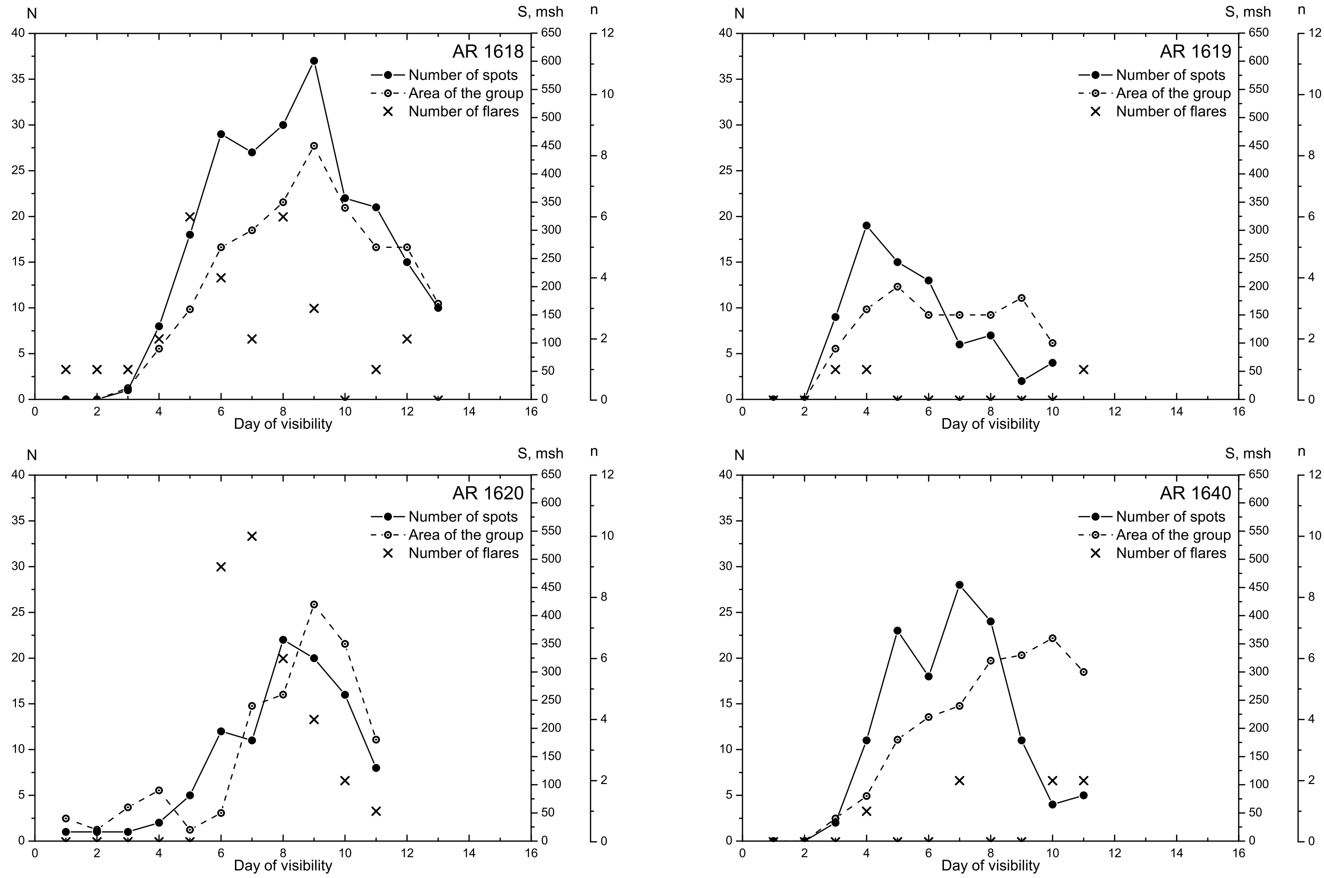


Fig. 1: Evolution of the fast-growing groups considered. The crosses mark the number of flares associated with a particular active region in the days when they were observed.

of maximal solar activity.

ACKNOWLEDGEMENT

The author would like to thank the staff of the observatory, A. N. Babin, A. N. Koval for the helpful comments on this work, the developers of spacecraft SDO and SOHO, and observers of ground-based observatories who obtained necessary data for this work.

REFERENCES

[1] Jager C. 1959, in *'Handbuch der Physik '*, ed.: Flügge S., Springer Berlin Heidelberg, 11/52, 80

[2] Severny A. B. 1988, 'Some problems of Solar physics', Nauka, Moscow (in Russian)

[3] *'Solar activity observations and predictions. Progress in Astronautics and Aeronautics'*, 1972, eds.: McIntosh P. S. & Dryer M., 30, Cambridge: MIT Press

[4] *'The SOHO mission'*, 1995, eds.: Fleck B., Domingo V. & Poland A., Kluwer Academic Publishers, Dordrecht

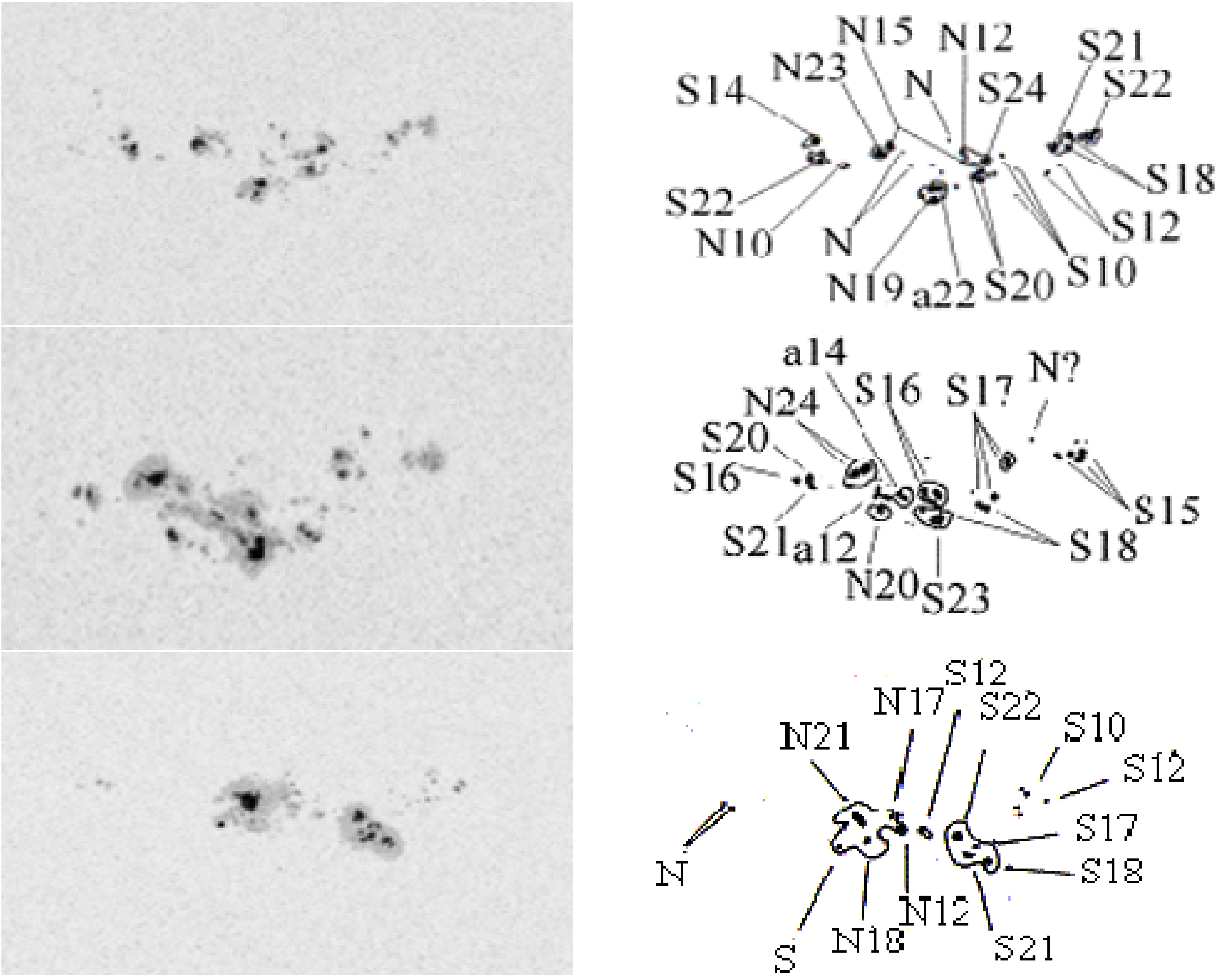


Fig. 2: The images (left) obtained with HMI/SDO[6] and sunspot magnetic fields of NOAA AR1618 (data from TST-2[7] of the Crimean Astrophysical Observatory) on November 20, 2012 (above), November 21, 2012 (centre), and November 23, 2012 (below).

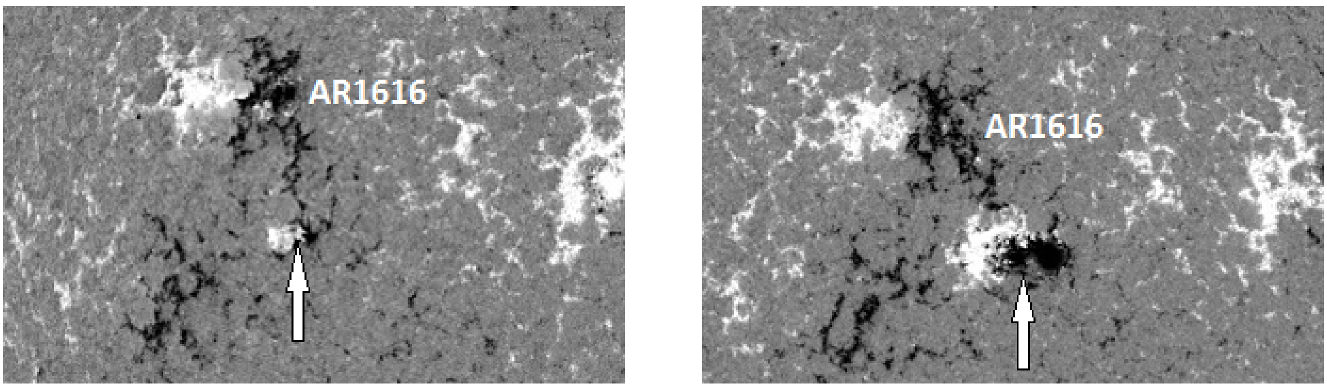


Fig. 3: The interaction of magnetic fields of active regions AR1616 and AR1619 (the location indicated by the arrow). Data from HMI/SDO. Left — magnetogram dated 17.11.2012 16:30 UT, right — dated 18.11.2012 16:30 UT.

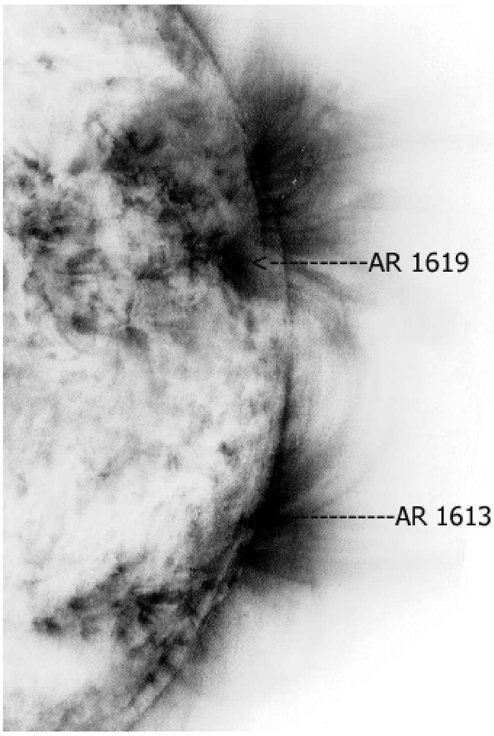
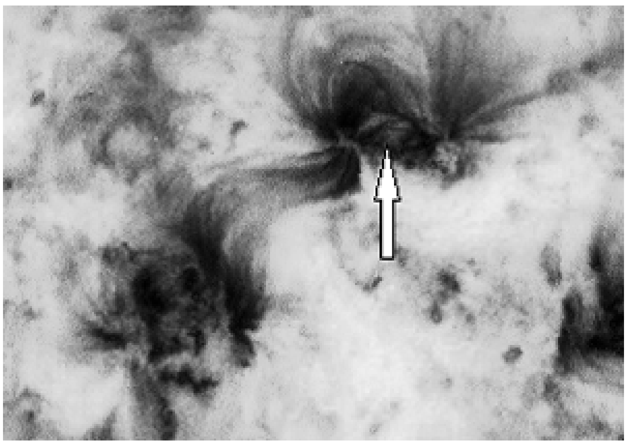


Fig. 4: Coronal loops of AR1619/AR1613. The image of the Sun at the wavelength 171 Å, obtained with EIT/SOHO [4] on November 21, 2012.



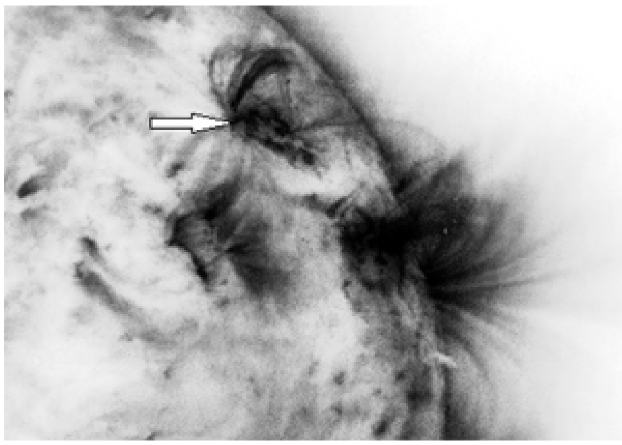


Fig. 5: Coronal loops of AR1640/AR1638 (left) and complex AR1640/AR1638/AR1636 (right). The image of the Sun at the wavelength 171 Å obtained with EIT/SOHO on November 21, 2012. The group AR1640 is indicated by the arrow.