AN ANALYSIS OF EVOLUTION OF THE ACTIVE REGION OF JUNE - JULY 1982

Mogilevsky E.I.[1], Ioshpa B.A.[1], Starkova L.I.[1], Utrobin V.G.[2], Korobova Z.B.[2], Stoyanova M.N.[3], Golovko A.A.[4].

[1]IZMIRAN, 142092, Troitsk, Moscow Region, USSR

[2]Astronomical Institute of the Uzbek Academy of Sciences, 700052, Astronomicheskaya 33, Tashkent, USSR

[3]Main Astronomic Observatory, 196140, Pulkovo, Leningrad, USSR

[4]SibIZMIR, 664697, P.O.Box 4, Irkutsk, USSR

ABSTRACT

Using the observation data for the AR-82 complex (magnetograms, photoheliograms, H-alpha filtrograms), a first step of evolutionary analysis has been carried out. The results obtained in June-July when the complex reached its maximum development were subject to a most detailed analysis. The connection between the complex and the structure of the ambient large-scale magnetic field is considered. We have shown that quasiperiodic variations in the central part (topologic centre) of the AR complex (variations in the number, size and motions of sunspots and pores) to a large extent determine the structure and evolution of the entire AR complex. The spots and pores in AR-82 form global and sporadic (unstable) spiral structures.

АНАЛИЗ РАЗВИТИЯ КОМПЛЕКСА АКТИВНОСТИ НАБЛЮДАЕМОГО В ИЮНЕ-ИЮЛЕ 1982 Г. На основе наблюдательных данных (магнитограммы, фотогелиограммы и Н-альфа фильтерграммы) был сделан эволюционный анализ июньско-июльского комплекса активности. Результаты, которые были получены во время максимального развития комплекса (июнь-июль 1982) были детально анализированны. Была обсуждена свяэ между комплексом активности и структурой окрестного крупномасштабного магнитного поля. Было показано, что структура и развитие целого комплекса активности в большей степени определены топологическим центром и его квазипериодическими вариаци ми (вариящии в числе, размерах и в движении пятен и пор). Пятна и поры в комплексе 1982 г. создавают глобальную и спорадическую (неравновесную) спиральные структуры.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

ANALÝZA VÝVOJA KOMPLEXU AKTIVITY, POZOROVANÉHO V JÚNI A JÚLI 1982. Na základe pozorovacích údajov (magnetogramy, fotoheliogramy a H-alfa filtergramy) bola urobená analýza vývoja júnového až júlového komplexu aktivity. Výsledky, ktoré boli získané pre obdobie maximálneho rozvoja komplexu (jún-júl 1982) boli detailne analyzované. Uvažovaný bol vzťah medzi komplexom aktivity a okolitým veľkorozmerovým magnetickým poľom. Bolo zistené, že štruktúra a vývoj celého komplexu aktivity sú vo veľkej miere určované topologickým centrom a jeho kvaziperiodickými variáciami (v počte, rozmeroch a v pohybe škvŕn a pórov). Škvrny a póry v komplexe z roku 1982 vytvárajú celkovú a sporadickú (nerovnovážnu) špirálnu štruktúru.

1. INTRODUCTION

The present report should be considered as the first step to analyzing the evolution of one of the most complicated and powerful active complexes in the previous solar cycle. This compact complex of active regions was the subject of joint international studies, and a number of publications [1-5] have already been devoted to its analysis. Our work is based on the following observational material: a/ the charts of longitudinal magnetic fields ($B_{\parallel}$) and Doppler velocities (v_D) for 7 days obtained in July 1982 on the Solar Tower Telescope of IZMIRAN (simultaneously, two magnetographs were making records in a photospheric, FeI 5253 Å, and a chromospheric, Ba II 4554 Å, lines); b/ a series of $B_{\parallel}$ magnetograms obtained in June and July 1982 at the Sayan Observatory of SibIZMIR using a panoramic magnetograph; c/ a large series of H-alpha filtrograms taken on the Large Solar Telescope of IZMIRAN with an Opton birefridgent H-alpha filter ($\Delta\lambda$ = 0.25 Å with a band shift of $\pm$3 Å, up to 12 Å during flares); d/ photoheliograms obtained at a routine basis with a photoheliograph at the Astronomical Institute of the Uzbek Academy of Sciences; and e/ high-resolution photoheliograms ($\lesssim$ 1") obtained on the high-altitude solar station of the Pulkovo Observatory at Pamir with the aid of a stationary solar telescope of Saturn type. When treating these data, we also made use of some publications in Solnechnye Dannye and Solar Geophysical Data [6] devoted to the active region under discussion.

Our communication has a preliminary character, since we have not yet analyzed the observational data obtained at the solar observatory Einsteinturm (Astrophysical Institute of the Academy of Sciences, GDR), at the Debrecen Heliophysical Observatory and at the astronomical institutions of Czechoslovakia. This is not only due to a cumbersome procedure of data processing and a large amout of calculations required for a detailed analysis. At the first stage, we thought it reasonable to confine ourselves to the above listed data sources and to reveal some essential, in our opinion, structural features in the AR evolution that may afterwards be helpful in a qualitative analysis of flaring active regions. In the complex under consideration that attained a maximum in its evolution during the June and July solar rotations (e.g., rapidly changing sunspots of δ-configuration were observed in July in three parts

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

of sunspot groups SD No. 228-229 and the number of sunspots and pores on some particular days exceeded $\simeq 140$) we shall try a/ to trace the relationship of the AR complex with the large-scale magnetic field characteristics for more than 8 solar rotations (from January to September); b/ to reveal in the process of evolution (particularly at the maximum) the decisive role of the central part of the complex (its topologic magnetic and velocity centre), whose structural changes determine, to a large extent, the highly intricate structure of the entire complex; c/ to find out some particular features in the evolution of global and local (sporadic) spiral-like auto-wave structures in the distribution of sunspots. The changes and decay of the latter are due to the flare activity.

2. SOME GENERAL FEATURES IN THE EVOLUTION OF THE AR-82 COMPLEX AND THE ASSOCIATED LARGE-SCALE MAGNETIC FIELD (LMF)

One of the authors of this paper followed in detail the evolution of this complex (the forming and interaction of three main branches of the changing active regions) [2]. The evolution of the branches from January through July 1982 is represented schematically in Fig. 1. Without going into detail of the

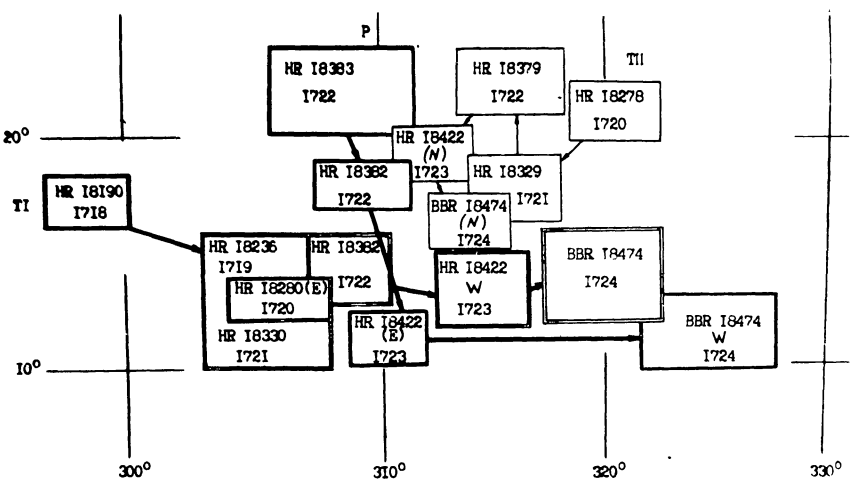

Fig. 1: A scheme of evolution of the branches of an active complex from January to July 1982 in the Carrington reference frame. The number of the AR and the number of Carrington rotation are indicated in the rectangles that mark the locations of AR centres.

complex evolution, we should note that it took place within a large-scale unipolar magnetic field of N polarity, whose variations between Carrington rota-

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

tions N 1718 and N 1726 according to McIntosh charts (SGD) are illustrated in Fig. 2. One can see that the large-scale magnetic field (LMF) which initially

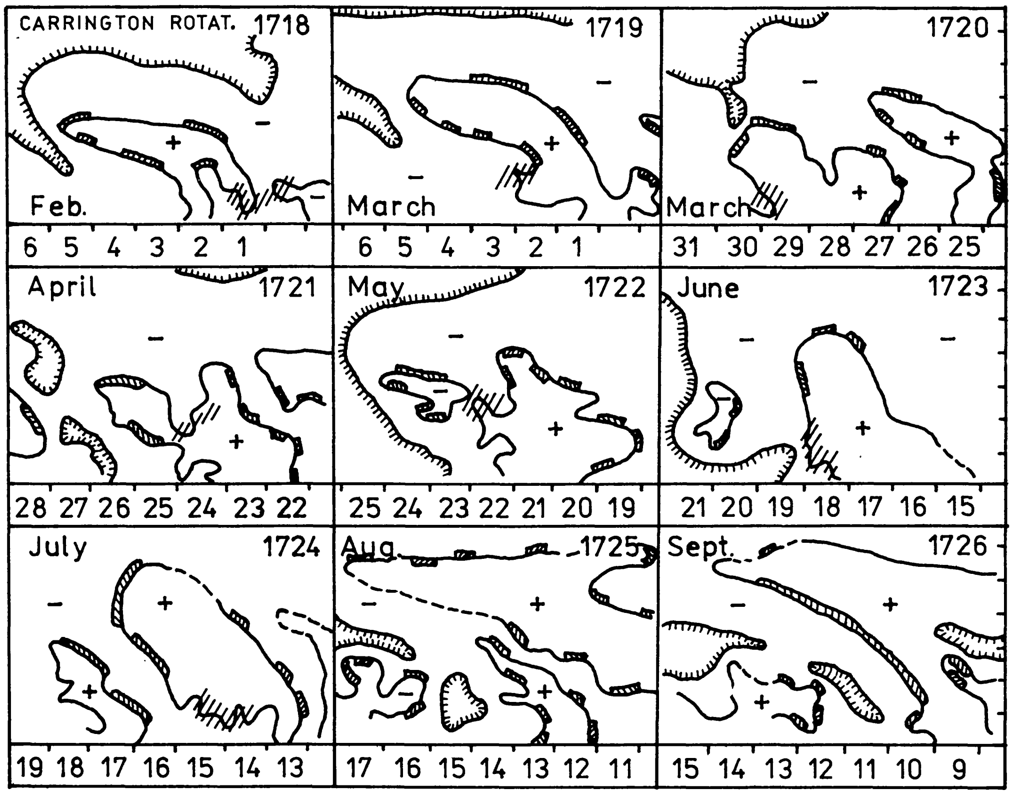

Fig. 2: The structure of a large-scale magnetic field in Carrington coordinates.

had a peninsula-like shape reduced afterwards to an "island" with changing dimensions and contours and then, after the maximum of flare activity in June--July, it recovered its initial structure in August-September. Nearly there was a changed coronal hole. Such a behaviour of the large-scale magnetic field with a complex of flaring active regions was analyzed in other papers [7, 8] . It is typical of large active complexes. As shown by Golub [9], in the AR-82 complex (like in the active regions of August 1972 and July 1974) during the largest flare activity one could observe a near-equatorial chain of LMF "islands" extended for over 180°, with flaring active regions developed in some of them. This confirms one of the main properties of a powerful active complex, i.e. a global character of LMF evolution with active regions extending over a lengthy discrete band of correlated activity (particularly at antipodal longitudes). On the other hand, the insular structure of the large-scale magnetic

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

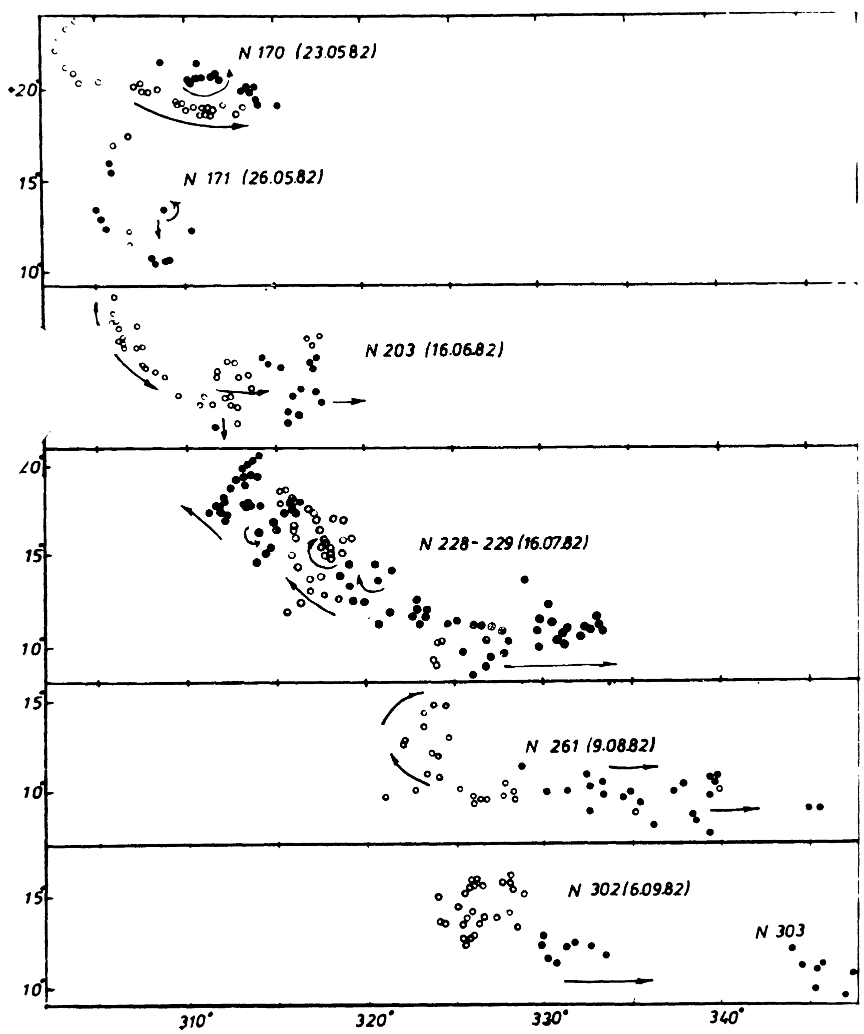

Fig. 3: The locations of sunspots of the leading (.) and the following (o) polarities in the recurrent groups of 1982. The arrows show the direction of proper motions of the sunspots.

field with a powerful AR complex changes in size and configuration, thus implying a dynamism of the turbulent convection zone of "islands" during the release of extra energy that is spent on AR forming and evolution. This shows that general vortex and shear motions in LMF in these periods are more structurized than in the quiet "laminar" phase of evolution, i.e. there acts a certain synergetic law of self-organization [12]. Fig. 3 illustrates changes in the general view of the structure (the distribution of sunspots of different polarities) during five solar rotations from May to September 1982. The differential rotation being taken into account, one can see characteristic

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

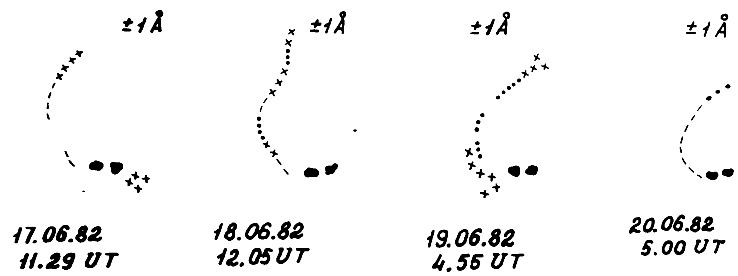

Fig. 4: A scheme of motions in the active filament in June 1982: x - sinking, . - rising, --- trajectory of the filament.

general shears, kinematic features and the structure of the complex. Preferential directions of sunspot proper motions are indicated with arrows. In spite of a great complexity (especially in the July rotation), it is evident that some structural and kinematic features in the complex persisted for several rotations. As noted before [1], the distribution of sunspots and pores in June had the form of a single-thread spiral with a very large and complicated central spot comprising several umbrae. The second branch of the spiral began to form after passage through the central meridian (June 17-18). One can see it on the magnetic chart (Fig. 12) and in Fig. 4, where, besides the contours of the main spots, are also shown fragments of a large active filament near the polarity reversal line, $(NL)_{B_{\parallel}=0}$, that stretched northwards far beyond the active region. As seen from the Figure 4, the up-and downward line-of-sight velocities in some parts of the filament were rather large ($\simeq \pm 40$ km/s). Their variability and sign reversal indicate that a periodic disturbance propagated from the AR centre ("origin" of the spiral) along the neutral line $(NL)_{B_{\parallel}=0}$. In Fig. 5, the same part of the active filament is represented on individual days of observation in July. The character of propagation of periodic disturbances from the AR centre was the same, but the filament itself sometimes bifurcated.

Fig. 6 illustrates some fragments of a large filament and a system of fibrils copied from H-alpha filtrograms. They outline the magnetic field transverse component, $B_{\perp}$, at the centre and near the leading part of the active region. One can see that in July, the fibrils delineated two systems of helical field structures beyond the location of the main spots in AR. It will be clear below that while in June the active region was mainly shaped like a single-thread spiral, in July the global distribution of sunspots and the chromospheric structure took the form of a joint double-thread spiral, which is characteristic of active regions producing large two-ribbon flares. Considerable changes in the number, size, proper motions and location of sunspots and pores in the July rotation made the structure of the complex much more

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

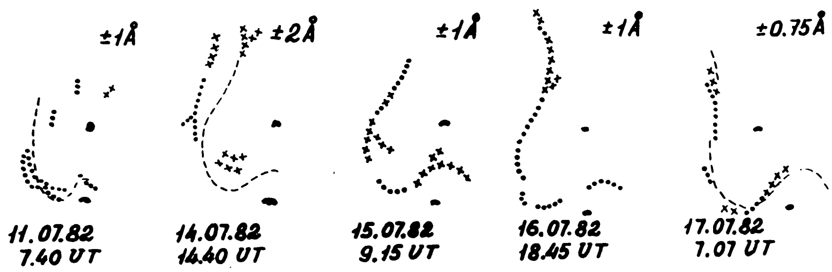

Fig. 5: A scheme of motions in the active filament in July 1982:
x - sinking, . - rising, --- trajectory of the filaments.

Fig. 6: A scheme of the filament and the structure of fibrils in July 1982.

intricate. In this structure four kinematic elements could be singled out, including a typical central part.

3. EVOLUTION OF THE AR CENTRAL PART IN JULY

When analyzing complex active regions, a number of authors paid attention to some characteristic properties of their central part. For example, V. Bumba [7] called it a topologic centre of the active region. Disposing of detailed magnetic charts, a large number of heliograms with high spatial resolution and H-alpha filtrograms for the period of July rotation, one can make an attempt, in spite of a greate complicacy of the active region, to trace the evolution characteristics of the central part and its influence on the structure of the active region as a whole.

Fig. 7a shows the contours of the main umbrae in the AR central part for

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

Fig. 7a: Outlines of the umbrae in the central part of the active region.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

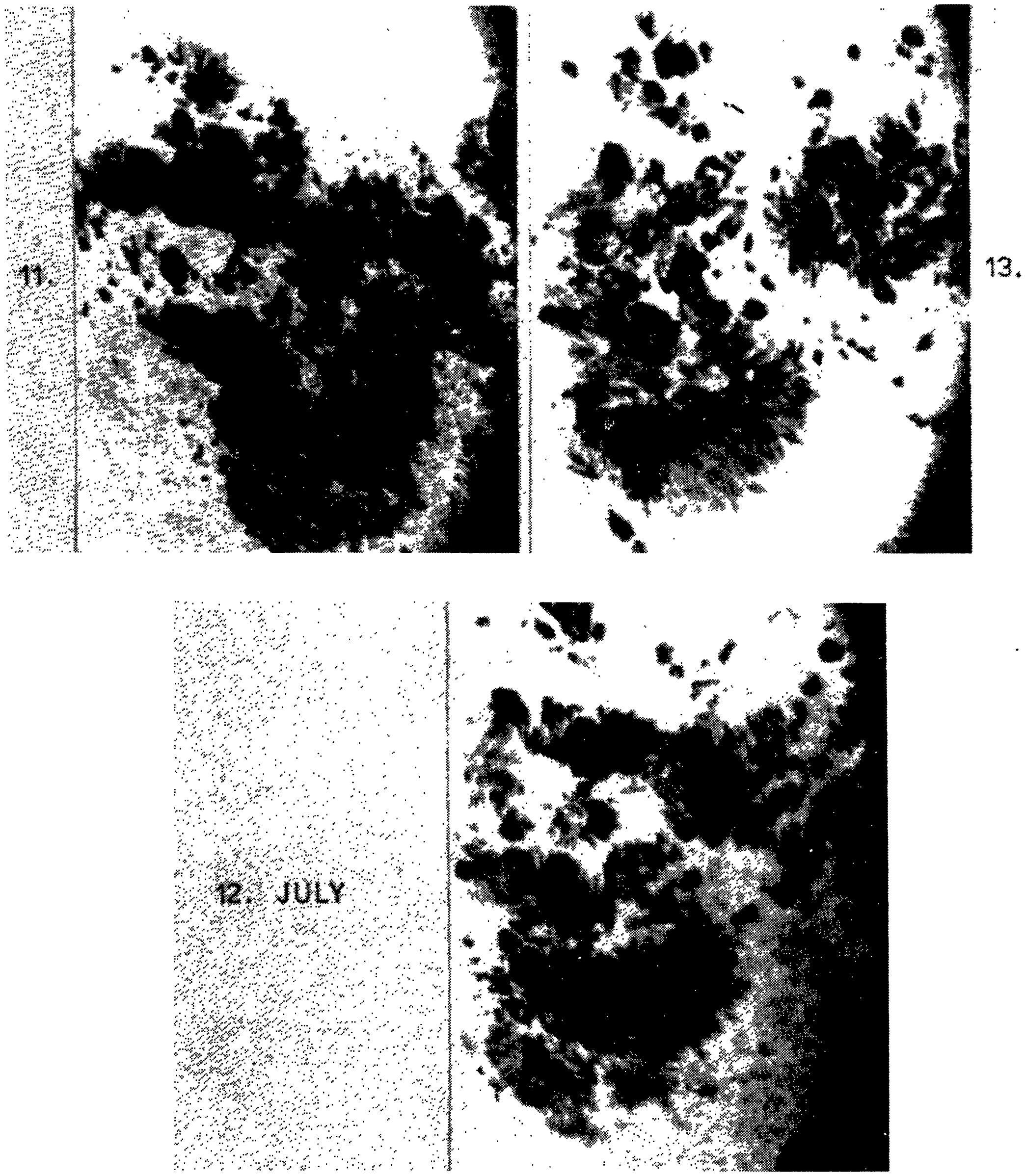

Fig. 7b: Fragments of high-resolution photoheliograms. July 11, 1982, 03:45 UT; July 12, 1982, 04:40 UT; July 13, 1982, 04:05 UT.

July 11-13, that could be outlined using high-quality photoheliograms obtained at the Pamir station of the Main Astronomic Observatory. The Figure 7b represents also some fragments of the photographs. The analysis of these materials shows that: a/ the umbrae in the AR centre are situated along a non-stationary double-thread spiral. Light bridges and photospheric fibrils of the penumbra, as well as elongate elements in the umbrae, that show up on the photographs

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

taken at different exposure times, confirm a non-casual character of such a S-shaped double-thread spiral structure; b/ at the very centre (denoted with letter "C") the size and location of the umbrae change quasi-periodically. It is readily seen, for example, when comparing photos for July 11 and 12. The photo of 12 July was taken after one of the largest flares in the AR under discussion. After the umbrae at the centre had changed sharply on July 12, new large umbrae appeared there by July 13 and 14.

Analogous changes ("sinking" and "emerging") of the umbrae at the centre ("C") are represented in Fig. 8 based on the same high-quality photos of July 14, 16 and 17. Along the main polarity division line (the photo of July 14) one can see a "shearing" penumbra with photospheric fibrils aligned with $(NL)_{B_{\parallel}=0}$ and forming an interwound structure. By July 16 this structure disappeared replaced by a bipolar pair of sunspots.

Fig. 8: A sketch of umbrae and dark filaments of the penumbra in the central part of a sunspot group. a/ July 14/08:10 UT; b/ July 16/05:00 UT; c/ July 17/05:05 UT. A structure formed by penumbral filaments oriented along the polarity division line (dashed line), that was observed on July 14, disappeared almost comple ely by July 16. One can see only its southern edge that forms part of the growing umbra of July 16-17.

Thus, the topologic centre of the active region displayed characteristic quasi-periodic changes that might be a manifestation of some pulses from subphotospheric disturbances. In order to establish the origin of these disturbances, an analysis of photospheric magnetic charts was carried out. Fig. 9a,b (cannot be published in this article for technical reasons) represents the charts of photospheric magnetic field for several days of observation on the Large Solar Telescope in July. They illustrate the evolution of the photospheric magnetic field of the active region. It is worth noting that in spite of considerable changes in the number, size and location of sunspots, the global

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

structure of the field changed very slowly except for a noticeable change on July 16, when the northern "island" of S-polarity merged with the S-field in the southern part of the active region. For the zone of topologic centre, we calculated the magnetic flux within the areas confined by $\geqslant$ 800 G isolines assumed to coincide with sunspot boundaries, and in the surrounding areas confined by 600, 400 and 200 G isolines. A comparison of calculations for two consecutive days showed (see Table 1) that while the magnetic flux in sunspots

Table 1
The magnetic flux for the zone of topologic centre on July 16 and July 17

	F_{16} 800,1000	F_{17} 1500,2000	F'_{16} 200, 400	F'_{17} 600	$F_{16}-F_{17}$	$F'_{16}-F'_{17}$	F_{16}/F_{17}	F'_{16}/F'_{17}
I	2.9 E6	0.8 E6	1.6 E6	1.7 E6	2.0 E6	0.06 E6	3.4	0.96
II	1.5 E6	0.6 E6	1.5 E6	1.0 E6	1.0 E6	0.4 E6	2.6	1.5
III	0.08 E6		0.06 E6	0.09E6		0.03 E6		0.6

changed, the flux in their environment remained practically invariable. It may imply that sunspots sank under the photosphere rather than dissipate splitting into smaller spots with weaker magnetic fields. The chart of proper motions of sunspots (Fig. 10) shows that the centre of AR complex comprised a kinematic element "B" where sunspots broke down and revived making circular, preferably clockwise motions without a noticeable advance like that observed, for example, in kinematic element "A" (KE-"A"). Analogous vortex motions were also revealed in the same central region in August. In September, there remained a cluster of pores arranged in the form of a spiral. The present chart (Fig. 10) of the sunspot trajectories in AR-82-July is based on sunspot coordinates that were obtained using a measuring and computation facility "Askoremat" of the Astronomic Institute of the Uzbek Academy of Sciences. It lacks the systematic errors of the analogous chart in [1].

Therefore, the topologic centre of the active region (especially in July when it attained its maximum evolution) acted as a kind of non-stationary "disturbance plunger". Kinematic elements "A" and "C" in Fig. 10 reflect the passage of disturbance that propagated from the topologic centre (KE-"B"). The direction of propagation was determined by the magnetic field, as seen from Fig. 11, that represents potential magnetic charts at two indicated levels, calculated from magnetographic data by the Nakagawa-Raadu method. Attention should be also paid to the study of radio emission of the AR-82 complex. This study was carried out on RATAN-600 by a group of scientists of the Main Astronomic Observatory and the Special Astrophysical Observatory and on VLA by Drs. K.R. Lang and R.F. Williams [10]. One of the important results of this study is that the characteristic large maximum of radio emission ("extra-spot component") revealed with RATAN-600 is localized above the AR topologic centre considered. It suggests that a disturbance (in particular, magnetic field) above

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

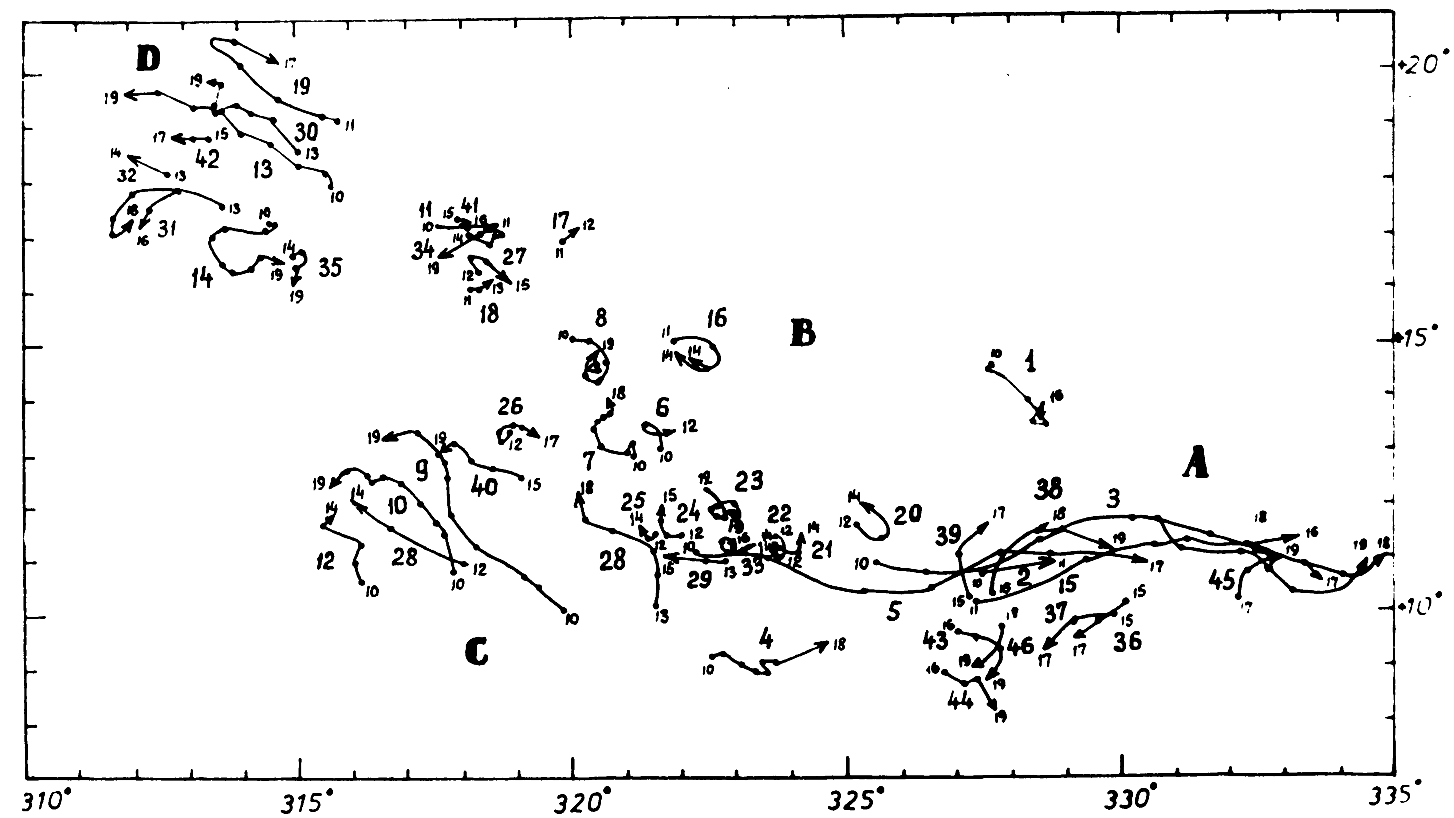

Fig. 10: Measured trajectories of sunspot proper motion in the active region of July 1982. Letters A, B, C, and D denote corresponding kinematic elements (KE). Large figures are the numbers of the umbrae and pores (see Fig. 10a). Small figures are the dates of the first and the last days of observation.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

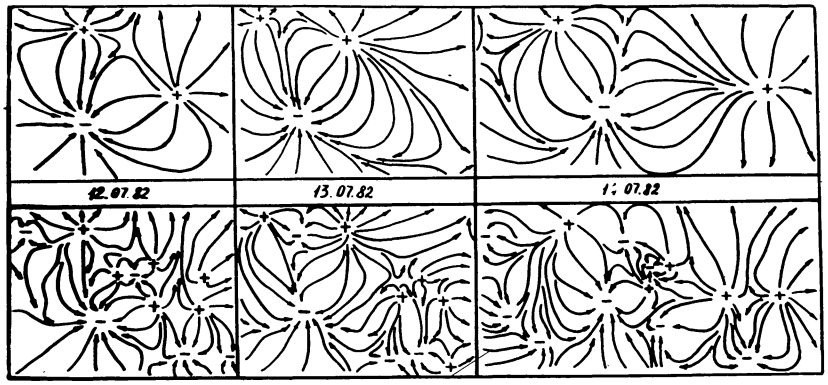

Fig. 11: Structure of the calculated magnetic field lines in a potential approximation (a plane projection corresponding to the heights of 1700 km and 2600 km).

the topologic centre may extend high enough to reach the chromosphere and corona of the active region. Within the frames of a qualitative consideration we may assume that the evolution of the active region in July 1982 was to a large extent determined by the topologic centre.

4. A GLOBAL AND SPORADIC SPIRAL-LIKE STRUCTURE IN THE DISTRIBUTION OF SUNSPOTS AND PORES

As noted above, a spiral-shaped distribution of sunspots (both general and local) was observed in the complex under consideration at different stages of evolution (in different rotations of the Sun). It is readily seen in the magnetic chart of this region (Fig. 12) obtained with the help of an automatic panoramic magnetograph on June 17. The central part (dark-N-polarity) - a complex multi-core spot of "δ"-configuration - constitutes the origin of a long chain of sunspots and pores (mainly of S-polarity) arranged in the form of a typical single-thread spiral. The stability of the structure and the "rigid" rotation of the spiral agree with the main properties of a spiral auto-wave of magnetic field concentration [13] in the absence of external disturbances. The evolution of the general and local spiral-like structures is especially well pronounced in July when the information available was sufficiently complete and detailed. As shown in [1], the AR-82 in the July rotation took the form of a double-thread spiral. One of its branches was directed parallel to the equator (kinematic elements "A" and "C"), while another formed an angle of $\sim 40^{\circ}$ with the meridian and its continuation in the form of a large filament stretched far northwards. The maximum extension of the equatorial branch was about 21° and of the meridional one (KE-"D") - about 11°. At the

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

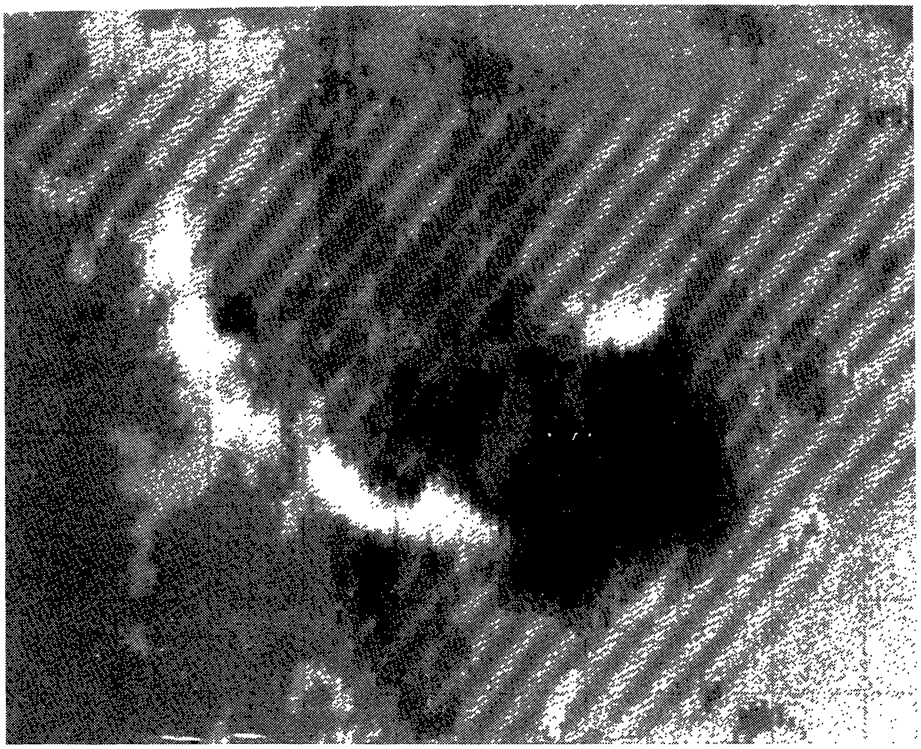

Fig. 12: A magnetogram of active region HR 18422 in the FeI 5253 Å line obtained on June 17, 1982 at 01:59 UT with an automatic panoramic magnetograph of SibIZMIR. The boundaries between the regions of different darkening density correspond to ±200, ±600, ±1000, ±1400, and ±1800 isogausses of the longitudinal magnetic field. One can see the prevalence of a magnetic flux of northern (dark) polarity, as well as a spiral-like distribution of the field hills and polarity division lines.

intersection of both branches there was the above-considered topologic centre of the active region (KE-"B"). The meridional branch divided the equatorial one into the eastern (KE-"C") and the western (KE-"A") parts. The disturbance that propagated both westwards (KE-"A") and eastwards (KE-"C") from the topologic centre affected the two parts in a somewhat different way, since the eastern part of the branch contained only sunspots of S-polarity, whereas in the western part (KE-"A") there were sunspots of both N- (the majority) and S-polarities. In the western part of the branch, the velocity of the westward drift of sunspots was rather high: the average velocity being about 100 m/s, the main spots in the region (NN 3, 5, 15) on July 11-13 moved at an anomalous high velocity of $\gtrsim$ 300 m/s which by a factor of 1.5 exceeded the statistic mean velocity of new sunspots [11]. It should be noted that this "induced" high velocity is likely to be due to disturbances at the topologic centre,

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

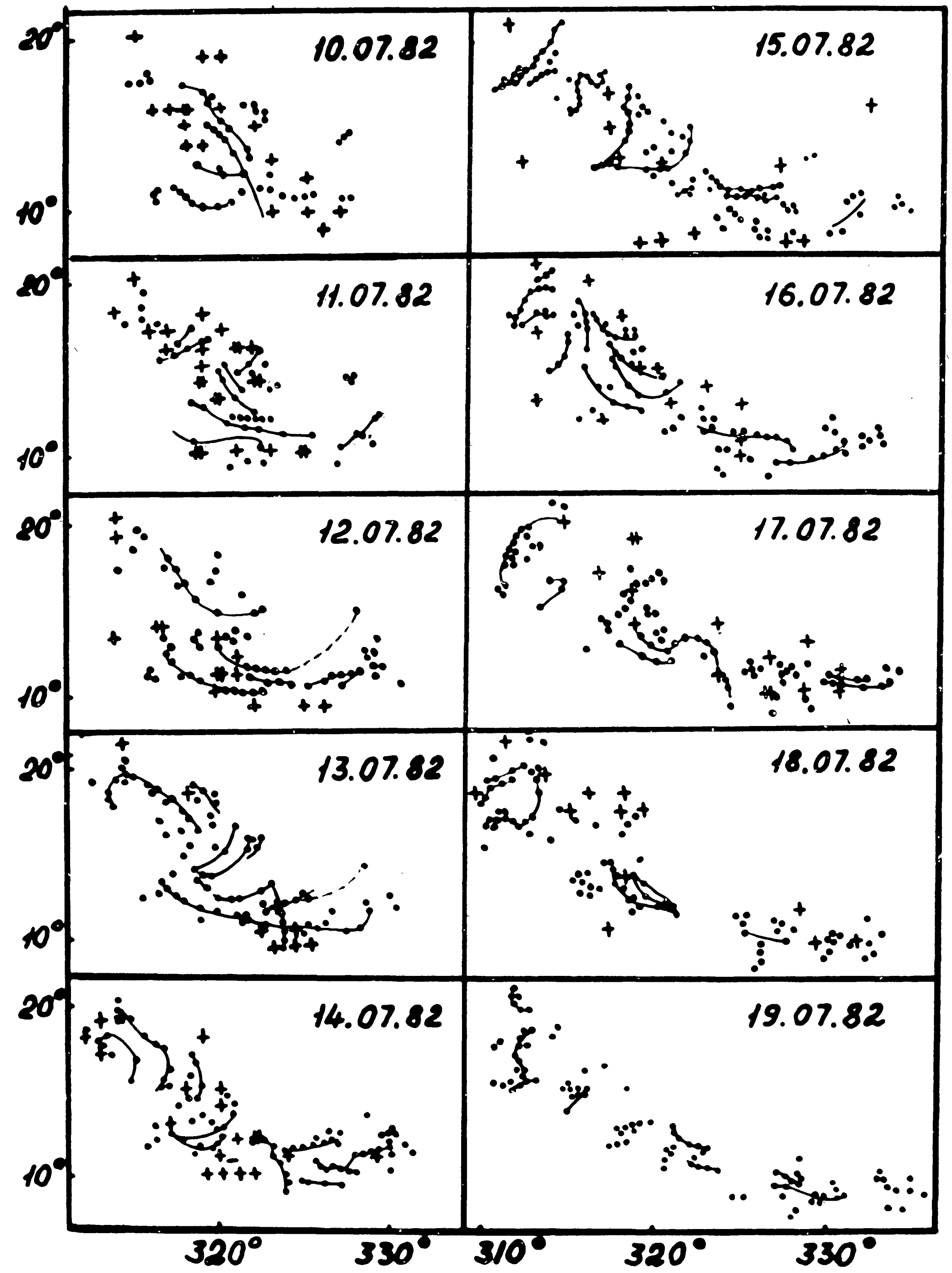

Fig. 13: The location of sunspots (dots), spiral-like chains (solid lines) and flare centres (crosses) in the sunspot group of July 1982.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

where the largest flares of the month occurred on July 9 and 12. It is important to note that while the rapidly moving sunspots of N-polarity advanced west-wards, the spots of S-polarity revealed preferably rotational and eastward motions. Such a shearing motion resulted in the formation of two local single-thread spirals. If we assume that the spiral-shaped distribution of sunspots is a manifestation of auto-wave motions of sunspot concentration in the convection zone, then the formation of these local spirals may be explained as an effect of different propagation velocities of disturbances in N- and S--fields where the magnetic field (sunspot) concentrations differed essentially. In the eastern part of the branch (KE-"C"), where all sunspots were of one and the same polarity (S), the effect of local spirals arisen as a result of a disturbance propagating from the topologic centre, was not observable.

The meridional branch may be divided into two parts: KE-"D" and a compact cluster of not mobil unstable spots (NN 11, 17, 18, 27, 34, and 41; see Figs. 10 and 10a). The latter constituted a magnetically isolated part of the old active region [2]. As a result of isolation of the magnetic field, the H-alpha plage surrounding the group did not brighten during a large flare of July 12, though a bright flare filament was situated nearby in the magnetic field of the same polarity as the group. In KE-"D" on July 10-13 the umbrae in complicated spot N 13 were arranged in the form of a spiral. Dark paths in the penumbra stretched out of the umbra of the slowly rotating leading spot as a continuation of the spiral. A new spiral structure formed on July 14 as a result of counter-clockwise rotation of sunspot N 14. On the following days, spiral chains were observed to appear sporadically in the KE-"D".

In Fig. 13 the locations of the main umbrae on all days of observation from July 10 through 19 are indicated with dots. The umbrae and pores may be combined in chains on the following basis: a/ if the umbrae are arranged (oriented) in a chain; b/ if individual spots are connected by penumbral filaments that form a chain; c/ if the umbrae in the central part of an active region inside a large penumbra are connected by dark paths of the penumbra. These chains and unstable spirals made it possible to trace the direction of the main branches of the principal double-thread spiral, the decay and interaction of sporadic structures in the course of AR evolution. In the same figure, the crosses mark the centres of H-alpha flares that on different days concentrated at the topologic centre, at the sites of reconstruction of spiral--like structures or in the region of shear motions in the western equatorial chain. The sites of flare concentration at different times in June and July were indicated in [1].

Thus, spiral-like structures of sunspot concentration may form in an active region in three cases: a/ at characteristic non-stationary disturbances near the topologic centre; b/ at shear motions of the system of sunspots and pores (the western equatorial branch); and c/ at the rotation of the main spot (e.g., in KE-"D"). These forming conditions alongside with the observed instability of spirals at their interaction with the neighbouring parts of the active region and the rigidity of the structure may indicate that spiral auto--wave structures in sunspot (magnetic field) concentration considered in the

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

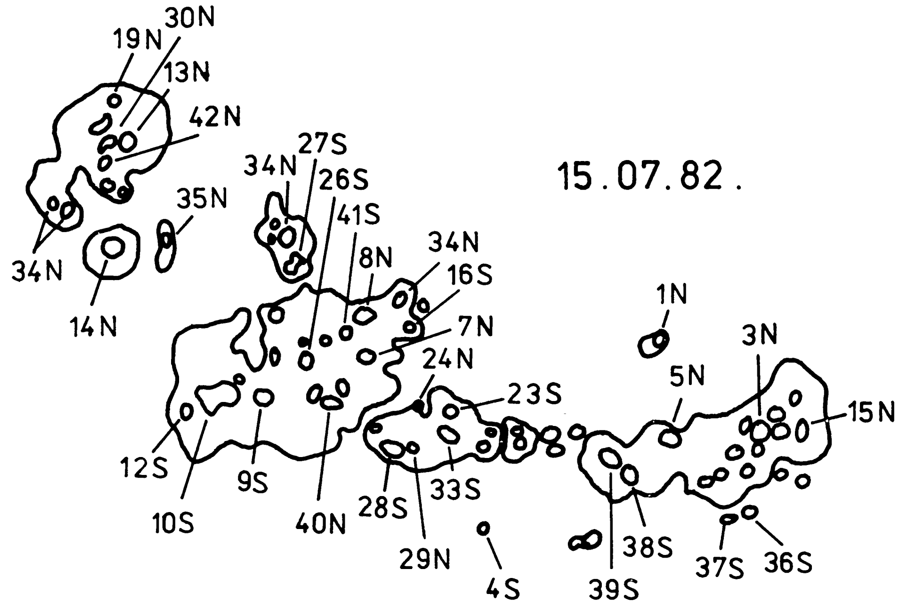

Fig. 10a: The numbers and magnetic polarities of sunspots.

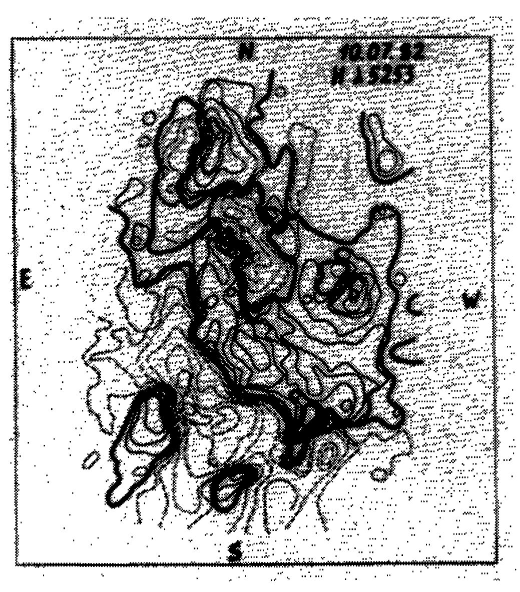

Fig. 9: The photospheric magnetic field. Thick solid line represents the zero line of the longitudinal field.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

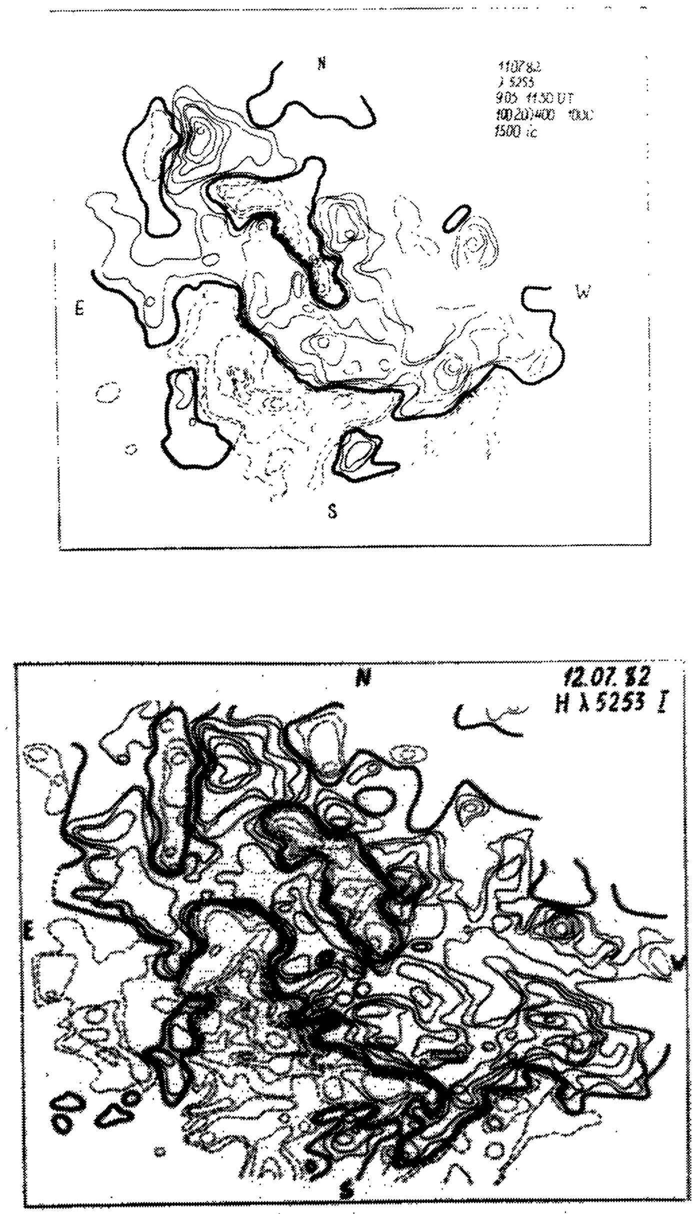

Fig. 9: The photospheric magnetic field. Thick solid line represents the zero line of the longitudinal field.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

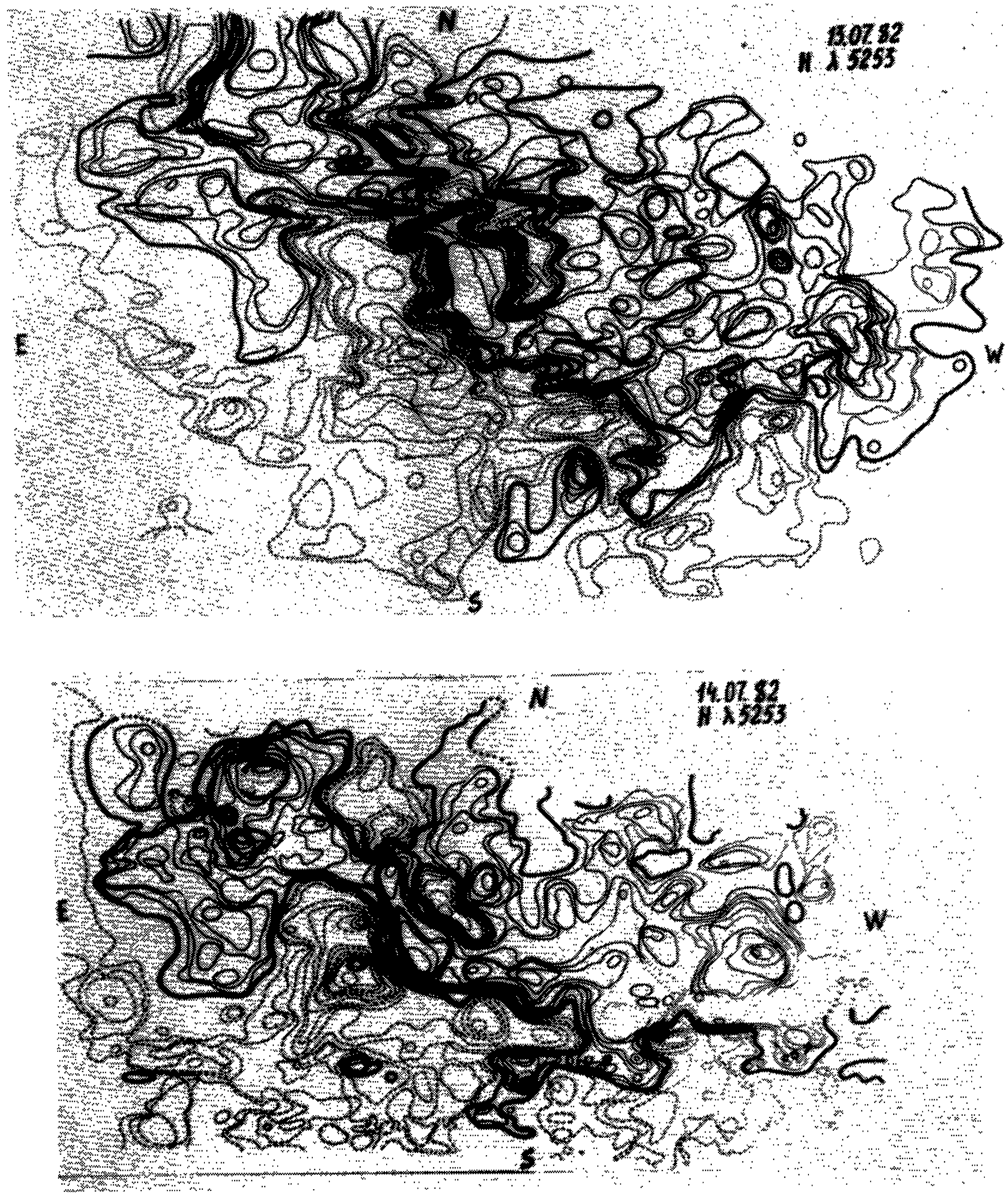

Fig. 9: The photospheric magnetic field. Thick solid line represents the zero line of the longitudinal field.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

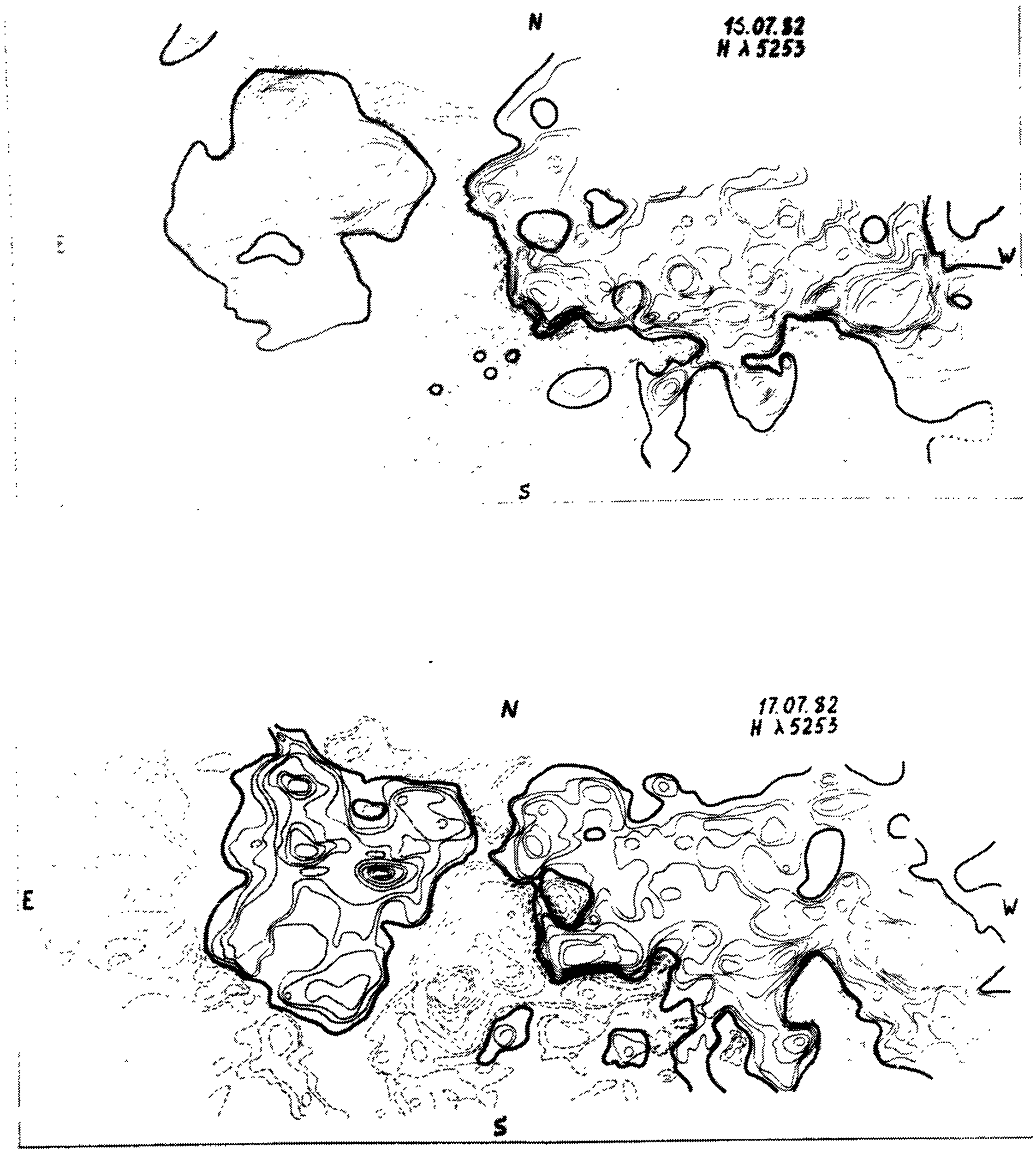

Fig. 9: The photospheric magnetic field. Zhick solid line represents the zero line of the longitudinal field.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

previous works [12, 13] are observed even in a complex as intricates as AR-82.

To conclude with, let us note that limiting ourselves to qualitative evolutional characteristics of the structures in AR-82 we have managed to reveal two important features: a/ characteristic non-stationary properties of the topologic centre in which the disturbances propagating determined to a large extent the evolution of the entire active region; b/ characteristic forming conditions for spiral-like auto-waves of magnetic field concentration in an active region.

Later on, these and other conclusions are supposed to be considered quantitatively using some synergetic concepts of forming and evolution of dissipative structures in an active region [12].

REFERENCES

1. Ishkov V.N., Korobova Z.B., Mogilevsky E.I.: 1983, In: Publ. Debrecen Heliophys. Obs., 5, 355-367 (in Russian).
2. Golovko A.A.: 1985, In: Issled. po Geomagn., Aeronom. i Fiz. Solntsa, vyp. 72, 114-128 (in Russian).
3. Sattarov, I., Korobova Z.B.: 1983, In: Publ. Debrecen Heliophys. Obs., 5, 341-353 (in Russian).
4. Ikhsanov R.N., Shchegoleva G.P.: 1985, Solnechnye Dannye. Bull. No. 7, 65-72 (in Russian).
5. Kryundal A.V., Makulaev V.G., Stoyanova M.N.: 1985, Solnechnye Dannye, Bull. No. 2, 79-84 (in Russian).
6. Solar Geophysical Data: 1985, No. 487, II.
7. Bumba V.: 1983, BAC, 34, No. 1, 219-229.
8. Stepanyan N.N.: 1984, Doctor's Thesis, KrAO (in Russian).
9. Golub P.A.: 1984, Solnechnye Dannye, Bull. No. 5, 88-99 (in Russian).
10. Akhmedov Sh.B., Bogod V.M., Borovik V.N. et al.: 1985, preprint SAO, No. 19L, 58 (in Russian).
11. Korobova Z.B., Tishchenko B.M., Tshai A.A., Baturin V.V.: 1973, In: Solar processes and their observatons (ed. Yu.M. Slonim), FAN, Uzb.SSR, Tashkent, 57-76 (in Russian).
12. Mogilevsky E.I.: 1985, Preprint No. 21c(554), IZMIRAN, Moscow (in English) 1985, Kinematics and Physics of Celestial Bodies, 2, No. 2, 75-82 (in Russian).
13. Korobova Z.B., Mogilevsky E.I.: 1984, Solnechnye Dannye, Bull. No. 10, 71-79 (in Russian).

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System

DISCUSSION

G.B. Gelfreikh
Почему Вы говорите о поршне в центре АО - имелись ли там движения, наблюдаемые в лучевых скоростях ?

M.A. Mogilevsky
Наблюдения лучевых скоростей проводились на магнитографе и приборе Кожеватова. Наблюдались движения с периодом порядка часа.

A. Antalová
Было при анализе рассмотрено диференциальное вращение, так как широтное расстояние границ комплекса около 10 градусов ?

M.A. Mogilevsky
Да.

© Astronomical Institute of the Slovak Academy of Sciences • Provided by the NASA Astrophysics Data System