THE CHAIN OF THE SOLAR MAGNETOGRAPHS AND ITS RESULTS

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ABSTRACT. The chain of solar magnetographs is one of the main observational programmes in solar physics within the multilateral KAPG-cooperation. We describe the main progresses of this programme especially during the last 5 years. Magnetographic results gave contributions to several periods of analysis of cooperative periods. This concerns longitudinal field magnetograms of active regions as well as vector magnetic fields and large-scale magnetograms of background fields. Some methods of interpretation are summarized and examples of results are given.

ЦЕПЬ СОЛНЕЧНЫХ МАГНИТОГРАФОВ И ЕЕ РЕЗУЛЬТАТЫ: Цепь магнитографов является одной из главных наблюдательных программ по солнечной физике в рамках многостороннего сотрудничества КАПГ. Описываются основные достижения этой программы особенно в течение последних 5 лет. Магнитографические результаты внесли важный вклад в некоторые периоды кооперативного анализа. Это относится как к магнитограммам продольного компонента магнитного поля в активных областях так и к векторным магнитным полям и к крупномасштабным магнитограммам фоновых полей. Представлены некоторые методы интерпретации и примеры результатов.

SIEŤ SLNEČNÝCH MAGNETOGRAFOV A JEJ VÝSLEDKY: Jedným z hlavných pozorovacích programov výskumu Slnka, v rámci mnohostrannej spolupráce KAPG AV SK, je koordinované meranie magnetických polí na Slnku, pomocou vybudovanej siete magnetografov. V práci sú uvedené základné výsledky tohto programu, ktoré boli dosiahnuté za posledných päť rokov. Magnetografické merania podstatne prispeli k úplnosti koordinovanej analýzy určitých období. Boli získané detailné mapy pozdĺžnej zložky magnetickej indukcie pre vybrané aktívne oblasti, ďalej záznamy o priebehu vektora magnetickej indukcie a rozdelenie veľkorozmerných

magnetických polí na Slnku. V práci sú zhrnuté niektoré metódy interpretácie meraní a výsledky sú ilustrované na príkladoch.

1. INTRODUCTION

The chain of solar magnetographs started its work in 1974 as one programme of the multilateral cooperation in solar physics between observatories of socialist countriec. The first goals of this programme were a first calibrational comparison between available magnetographs and an exchange of technical experiences. These results were summarized at the seminar of the chain of magnetographs which was held in 1975 at the Crimean Observatory as a common seminar of the soviet working group about "Magnetic Fields and the Chemical Composition of the Sun and the Stars" and of the participants of the chain of solar magnetographs (results see A.B. Severny, K. Pflug at al., 1977).

In the following period the main goals were:

- The completion of the calibrational comparison between magnetogrammes of different observatories.
- A brief discussion of all disturbing effects.
- Cooperative investigation of selected active regions and quasiperiodic oscillations of magnetic and velocity fields.
- The technical development of magnetographs concerning the observation of full vector magnetograms as well as the observation of large-scale magnetic fields.

These results were briefly discussed during the 2nd seminar of the chain of magnetographs held in 1980 at Irkutsk and published by K. Pflug et al. (1980). There is included a special report about the work of the chain of solar magnetographs (K. Pflug, 1980) as well.

In the present invited report we will give an overview about results obtained since 1980. This includes a summary of our main progresses in magnetographic observations, references on cooperative results, especially during coordinated observational periods, an overview concerning the application of theoretical methods for the interpretation, results from full-vector magnetograms, and finally recommendations for future work.

2. MAIN PROGRESSES IN MAGNETOGRAPHIC OBSERVATIONS

10 observatories in Soviet Union, Czechoslovakia and GDR participated in the programme of the chain of solar magnetographs. In this observatories a large number of different instruments is working designed for observations of magnetic and velocity fields in active regions, for measurement of large scale magnetic fields, and for the investigation of parameters of the Sun as a star. In Table 1 the different methods are summarized which are available in the participating observatories for investigations of magnetic fields.

Table 1

Observational methods in participating observatories

Observatory	Methods
Ussuriisk	$H_\parallel$, $v_\parallel$
Irkutsk	$H_\parallel$, $v_\parallel$, $H_\perp$, multich., Pan., STOP, Sun as star
Alma Ata	$H_\parallel$, $v_\parallel$
IZMIRAN/Kislovodsk	$H_\parallel$ in prominences by <u>spectral scanning</u>
IZMIRAN	$H_\parallel$, $v_\parallel$, $H_\perp$, <u>multich</u>.
Pulkovo	<u>videomagnetograph</u> with high resolution in time
Crimean AO	$H_\parallel$, $v_\parallel$, $H_\perp$, <u>multich</u>., <u>Sun as star</u>
Kiev University	$H_\parallel$, $v_\parallel$, <u>spectroscopic methods</u>
Ondřejov	$H_\parallel$, $v_\parallel$, ($H_\perp$)
Potsdam	$H_\parallel$, $v_\parallel$, $H_\perp$, (multich.)

notations:	$H_\parallel$	- longitudinal magnetic field
	$v_\parallel$	- line-of-sight velocities
	$H_\perp$	- transverse magnetic field
	multich.	- observations in 2 or more independent lines
	Pan.	- panoramic magnetograms of large areas with high resolution in time
	STOP	- solar telescope for operative prognosis

remarks: Main tasks of magnetographic observations are underlined future plans for magn. obs. are given in parantheses.

A urgently needed progress was attained in several observatories by the installation of technical equipments for digital recording and by the disposal of a large number of computer programmes for the reduction and interpretation of magnetographic data. As an example we show in Figures 1 to 5 magnetograms and results of possible data analysis from the Solar Observatory "Einsteinturm" at Potsdam. In our chain of solar magnetographs an automatical system for the recording and reduction of data existed at first in Ondřejov. Presently this work is finished also in Irkutsk and Potsdam. Furtheron a unique system for the exchange of magnetographic data on magnetic tapes has been developed and shortly described by A. Hofmann (1986a).

Large efforts are finished in the SibIZMIR and at Potsdam in the field of the observation of the full vector of the magnetic field distribution. In both observatories magnetographs with 2 DKDP-crystals and rectangular modulation are in operation, and all disturbances especially arising from the instrumental polarisation are taken into account. For coelostat telescopes this is possible by means of a special calibrational procedure using a polarisator and a retardation plate (diameter 30 cm) in front of the coelostat (Grigorev et al., 1985). An example of available vector-magnetograms is shown in Figure 2. A

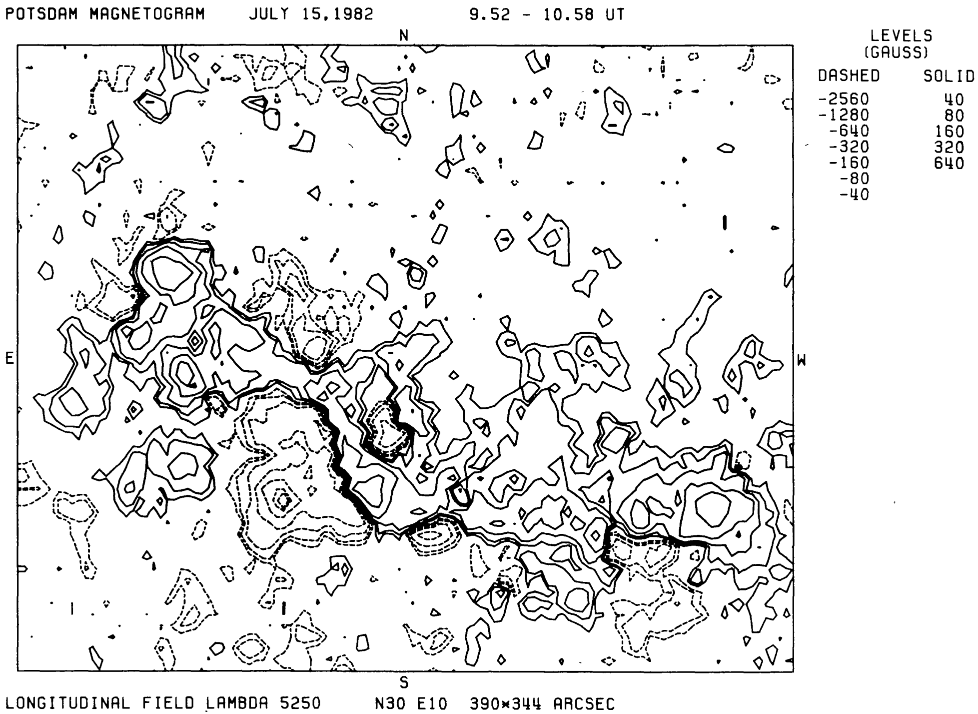

Fig. 1: Potsdam Magnetogram, Longitudinal Field Component, July 15, 1982

first calibrational comparison between the magnetographs at Potsdam and at SibIZMIR has been performed by A. Hofmann (1986a) and shows satisfying agreement. In other participating observatories, for instance Ondřejov and IZMIRAN, similar systems are in preparation.

The investigation of the relations between the birth and development of active regions and the large-scale structure of solar magnetic fields required new types of magnetographic observations which should include measurements of magnetic fields and other parameters inside active regions as well as measurements of background magnetic fields on the whole solar disc. Taking into account these demands, the colleagues from SibIZMIR constructed a new Solar Telescope for Operative Prognosis (STOP) which especially is capable to measure small background magnetic fields. Regular observations were started by use of this telescope in June 1983. The magnetograms of the background field distribution have a spatial resolution of 2', a sensitivity of 0.1 Gauss and the map of the Sun needs 1 hour. A more detailed description of STOP is given by Grigorev et al., 1986. Moreover, measurements of the mean magnetic field of the Sun as a star are performed with a sensitivity of 0.05 Gauss. Besides STOP is also able to measure the mean magnetic field of whole active regions with a selected spatial resolution corresponding to the size of the region.

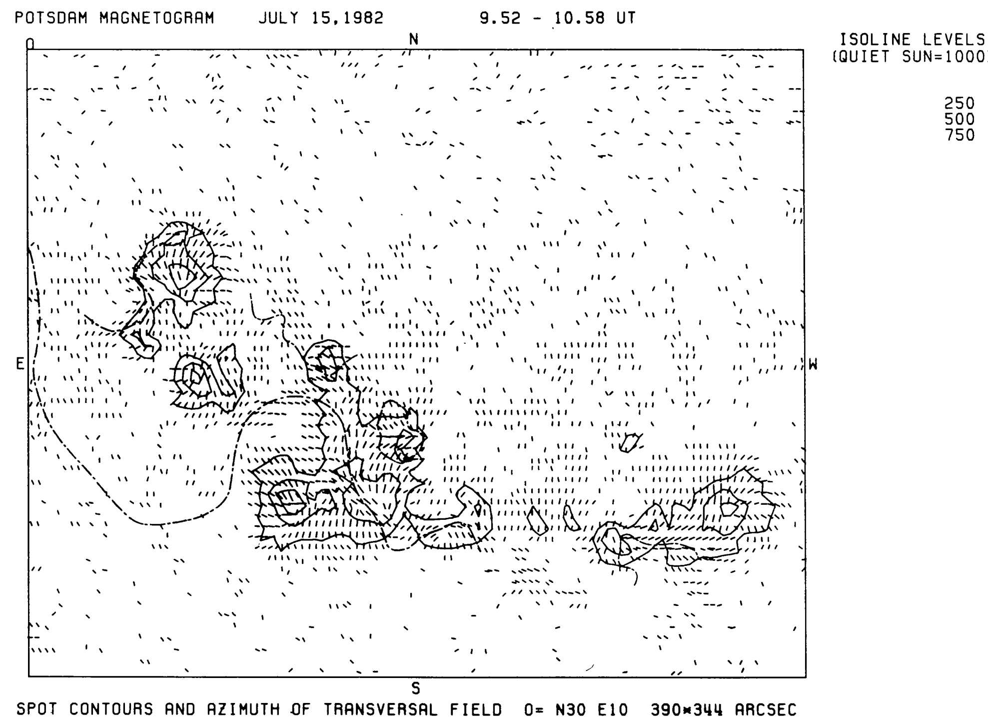

Fig. 2: Potsdam Magnetogram, Spot Contours and Azimuth of Transverse Field, July 15, 1982

Long time sequences of such mean magnetic field parameters may be useful in combination with detailed magnetograms for the analysis and interpretation of radioastronomical observations. First results of complex observations in combination with STOP were obtained during the period of the cooperative programme "June 1984" (see also N.N. Stepanyan et al., 1986).

3. RESULTS ABOUT PHENOMENOLOGY OF SOLAR ACTIVE REGIONS

Results about the morphology and phenomenology of magnetic fields are obtained during a number of cooperative observational programs, which are listed in Table 2.

This table contains: (i) the period of observation, (ii) the Carrington longitude and solar latitude of the target, (iii) the numbers of the sunspot group according to Solnechnye Dannye, and (iv) references to the results. The analysis of these periods of cooperative work was performed on the basis of different kinds of observations including optical as well as radioastronomical methods, and a lot of detailed results could be obtained. From magnetographic measurements informations are included concerning (a) the distribution of mag-

Table 2

Cooperative observational programmes

Period	Coordinates	SD	Results
May 1980	160 - 180 S 8 - 20	268 - 270	Mogilevsky et al., 1981: Publ. Debrecen Obs. Vol. 5, 93-126.
May 1981	147 - 167 N 12- 15	221 / 226	Publ. Debrecen Obs. Vol. 5, 167-222
June 1982	312 N 12	203	Publ. Debrecen Obs. Vol. 5, 341-386.
July 1982	315 - 330 N 12- 15	228 / 229	Mogilevsky 1986
May 1983	157 N 17	134	
June 1983	85 - 125 N 13- 18	163 - 165	A. Hofmann 1986b
July-August 1983	280 - 300 S 11	204 / 205	cooperative analysis coordinated by A. Hofmann
June 1984	315 S 15	135	Stepanyan et al., 1986
July 1985	0 , S 14 315, N 5 255, N 0-20	84 / 49 52 -	cooperative analysis coordinated by V.A. Burov and G.B. Gelfreikh

netic and velocity fields with different resolution in time and space, (b) the behaviour of the zero-line and the gradients of the longitudinal component of the magnetic field, especially, in connection with the discussion of the flare processes, and (c) informations about the development of magnetic structures concerning the emergence, development and dissipation of magnetic fields or flux values as well as the relations to the large scale magnetic field and relations between different centres of activity. It appears necessary that further observations will be denoted to the small-scale structure of the magnetic field as well as to magnetographic measurements in different height-levels of the solar atmosphere which are very rare until now.

We gratefully acknowledge that the cooperative analysis mentioned above was guided, especially, by N.N. Stepanyan, E.I. Mogilevsky, G.B. Gelfreikh, V.A. Burov and V.N. Ishkov. The analysis is finished for the periods up to 1982 and June 1984. The cooperative analysis of the periods from July-August 1983 and July 1985 is running.

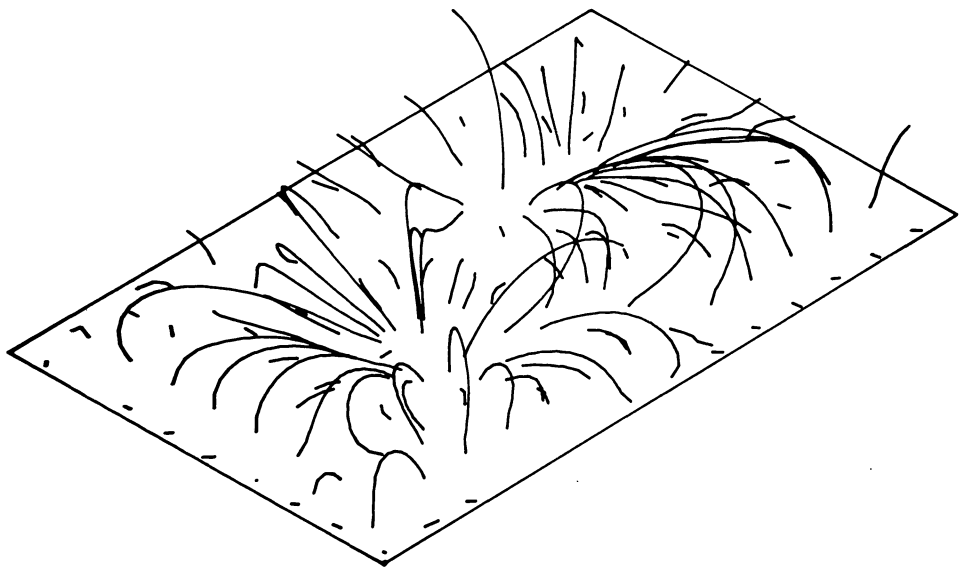

Fig. 3: Analysis of Potsdam Magnetogram, Example for force-free extrapolation of photospheric magnetic fields, perspective view of magnetic field lines, July 31, 1983

4. SIMULTANEOUS OBSERVATIONS AT DIFFERENT HEIGHTS OF THE SOLAR ATMOSPHERE

Investigations of the dependence of the magnetic field structure on the height in the solar atmosphere plays an important role for the study of physical processes at chromospheric and coronal levels. This concerns especially the flare process, models of the solar atmosphere and correlations with processes in the radio-and UV-spectral ranges. Simultaneous observations in different spectral lines, which originate at different heights in the solar atmosphere, are the best method. In Table 1 it is noticed, that the magnetographs by the Crimean Observatory, IZMIRAN and SibIZMIR are able to perform such observations. Results were obtained by IZMIRAN in the lines FeI 5250 and BaII 4554. But the calibration of the magnetographic measurements is difficult for chromospheric lines because the influence of NLTE must be taken into account.

Until now the most successful way is the use of photographic Zeeman spectra, but this method demands much work. Results were presented, for instance, from the Crimean Observatory (A.N. Koval and N.N. Stepanyan, 1983) and from the Kiew Univ. Astron. Observatory (V.G. Lositzky et al., 1986). Koval and

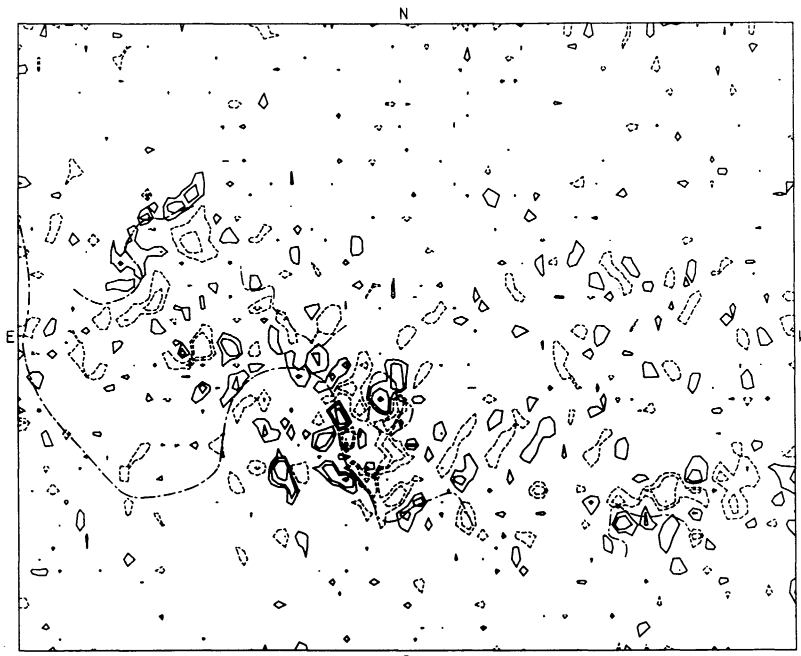

Fig. 4: Analysis of Potsdam Magnetogram, Verical Current Density J_z, July 15, 1982

Stepanyan found, that the field strength is maximal in a height of about 400--600 km and increased during the flare. Lositzky et al. found using a echelle spectrograph a very heterogeneous field during a flare. The use of CCD-arrays will lead for this kind of observations to remarkable improvements.

Besides these synchroneous observations, a number of other methods were used for the determination of magnetic field parameters at higher levels of the solar atmosphere. In SibIZMIR Merkulenko et al. (1983) used filtergrams in the wings of the H $\pm$ 0.2 Å line to construct maps of the line-of-sight velocity and brightness. They estimated also magnetic fields. Observations of magnetic fields in prominences were performed by the group of G.M. Nikolsky at IZMIRAN and V.S. Bashkirtsev et al. in SibIZMIR. The colleagues from IZMIRAN used the spectral scanning magnetograph installed in the focus of the 53 cm coronograph at the Kislovodsk station (Kim et al., 1982) and Bashkirtsev and Mashnich (1980) used a special magnetographic equipment in the Sayan Observatory. The observations were performed in the lines H_α and He D3. Finally we should notice, that magnetic fields at coronal levels may be estimated by measurements of the polarization of the radio emission of the Sun, which was proposed and performed. e.g., by G.B. Gelfreikh.

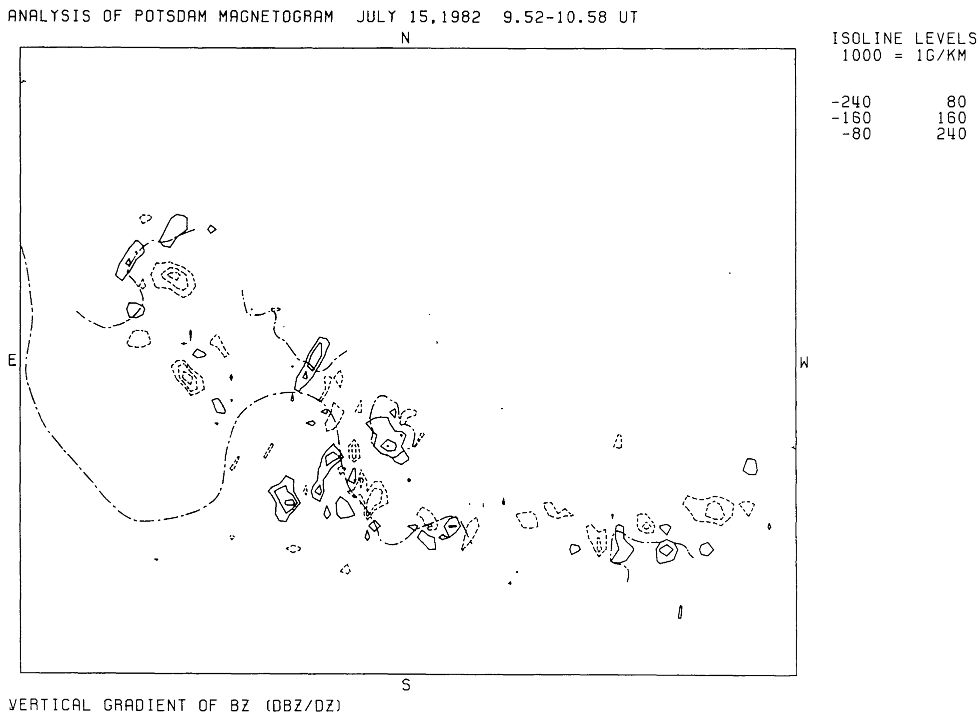

Fig. 5: Analysis of Potsdam Magnetogram, Vertical Gradient of B_z, July 15, 1982

5. RESULTS CONCERNING THE LARGE-SCALE MAGNETIC FIELD

The birth and evolution of active regions is strongly correlated with the large-scale structure of solar magnetic fields. The appearance of large complexes of activity as well as the rate of the flare activity depends, in a considerable degree, on the location of the active region within the pattern of large-scale magnetic fields. Even the birth of an active region is not only a local process but depends also on evolutionary changes on a large area of the solar surface.

In our participating observatories especially the colleagues from the Ondřejov observatory and the Crimean astrophysical observatory investigated the large-scale pattern of solar magnetic fields. The observational base of these investigations were the daily magnetograms of the whole solar disc from the Mount Wilson Observatory, the H-alpha synoptic charts by McIntosh and additional observations of H-alpha structures or magnetograms from our observatories. In the papers of our consultation results are included concerning solar magnetic fields and their relation to background fields (Bumba, 1986) the relation between the large-scale solar magnetic field distribution, and the global horizontal circulation in the photosphere (Ambrož, 1986). These are

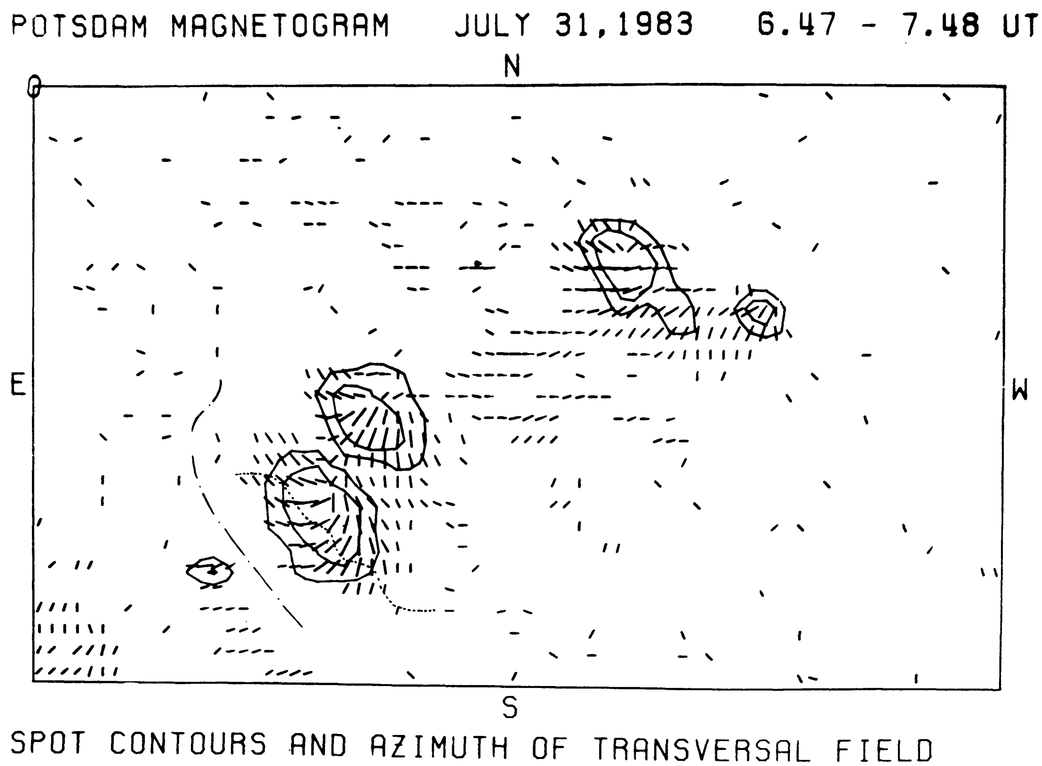

Fig. 6: Potsdam Magnetogram, Spot Contours and Azimuth of Transverse Field, July 31, 1983

valuable results concerning the long-term structure and the development of complexes of activity. In the Crimean observatory N.N. Stepanyan (1983) used also H-alpha data and confirmed the hypothesis that the large-scale background magnetic fields on the Sun are actually the reflection of convection by elements of sizes of about 0.5 solar radii.

The behaviour of the large-scale structure of background magnetic fields during 14 years was investigated by L.A. Plyusnina in SibIZMIR. She developed a method for the reduction of synoptic charts of magnetic fields, which are publicated by the Mount Wilson Observatory. Using this method L.A. Plyusnina compiled 1983 an atlas of synoptic charts of solar background magnetic fields for the period from 1969 - 1982. The comparison of this charts with the synoptic charts of the Stanford Observatory for the last years shows a good agreement between both series.

For the purpose of the investigation of large-scale magnetic fields the new solar telescope for operative prognosis (STOP) was constructed in SibIZMIR which was already mentioned in Chapter 3. With STOP we obtained the first results concerning the evolution of the background magnetic fields during the birth and evolution of a new active region. It was found that a new structure of the background field developed at the same time as the emergence of new magnetic flux. The new structure of the background field occupied a region of 35^{o} - 40^{o} in longitude. This result may confirm the model which was proposed by McIntosh and Wilson (1985).

Finally it should be montioned that, of course, the use of synoptic H-alpha charts is a valuable method for the investigation of the background fields. But it is necessary to take into consideration that they cannot exactly represent the neutral line of the magnetic field. For instance, the observations with STOP did not confirm the assumption, that opposite polarities of an emerging active region are situated on opposite sides of the pre-existing neutral line.

6. OBSERVATIONS OF MAGNETIC FIELDS FOR A REAL-TIME PROGNOSIS OF SOLAR ACTIVE PHENOMENA

It is well known that the structure of the interplanetary magnetic field (IMP) and the solar wind are related to the structure of background magnetic fields on the Sun. The application of this connection to the prognosis of the characteristics of the interplanetary medium and the subsequent estimation of geomagnetic disturbances is one of the main tasks for STOP. Regular observations with STOP lead by use of mathematical methods to an operative prognosis of geomagnetic disturbances.

This work started on the basis of cooperative investigations of colleagues from the Institute for Applied Geophasic in Moscow (IPG), SibIZMIR and the Institute of Physics of the Leningrad University (NIIF LGU). In the Sayan Solar Observatory from SibIZMIR the work was performed concerning (i) the automatization of the observations of background fields with STOP, including their reduction, and (ii) a preliminary interpretation by use of a complex of computer programmes. In the NIIF LGU methods and algorithms were developed for the calculation of parameters of the IMP and the solar wind. Input data for the estimation of these parameters (in the vicinity of) the Earth's are data of background magnetic fields of the Sun as well as current informations about solar flares.

In the end of 1985 a trial period was carried out. During this period the observations from STOP were analyzed in real time by use of a computer SM-2 and the resulting prognoses (concerning, for instance, K_p-indices of geomagnetic disturbances) were transmitted by telex to the IPG. The results of this trial period demonstrated that the whole system telescope /real-time analysis using the computer/ transmission by telex is able to work.

It seems useful and promising for the completion of the methods of prognosis of characteristics of the IMP and geomagnetic disturbances that we in future combine the informations about the background fields with informations from detailed vector-magnetograms of active regions. This seems particularly necessary for the prognosis of geomagnetic disturbances during periods of enhanced solar activity.

7. ANALYSIS OF MAGNETOGRAMS BY MEANS OF THEORETIC METHODS

The estimation of physical parameters plays an important role for a better understanding of physical and plasmaphysical processes in the solar atmosphere. The analysis of magnetograms by means of theoretic methods is a necessary method for a complete utilization of existing observations. But this demands a theoretic foundation as well as adequate computer programs. In the observatories participating in the chain of solar magnetographs we have available three different types of methods for the analysis of longitudinal field magnetograms. These methods concerns (i) the calculation of magnetic fields in higher levels of the solar atmosphere by means of force-free extrapolation, (ii) the estimation of the radio emission above active regions, and (iii) the estimation of velocity fields.

Methods of the theoretic extrapolation of magnetic fields into higher levels of the solar atmosphere were developed in several observatories. In Potsdam Seehafer proposed 1978 a procedure for the force-free extrapolation, in the Crimean observatory Gopasyuk, Kalman and Romanov used 1983 a potential--field extrapolation and also in IZMIRAN and Ussuriisk methods of extrapolation were used. Moreover it should be mentioned, that P. Ambrož in Ondřejov (1983) developed a method for a current-free extrapolation of large scale magnetic fields into the corona for comparison with noise storms. The most adequate method for the analysis of magnetograms seems us to be the force-free extrapolation. The input data are charts of the photospheric magnetic field as well as observations of the chromospheric structures in H-alpha. The fundamental equation is rot $B = \alpha . B$ with the assumption of a constant parameters alpha for the whole active region. This parameter may be determined by comparison of the extrapolated magnetic field structure with the structure in H-alpha. An example of an extrapolated field is given in Figure 3. By means of this method we are able to discuss relations between photospheric fields and chromospheric structures, questions of the flare activity caused by special configurations of magnetic fields and problems of the topology of the field (see for instance Seehafer 1980 and 1985).

The fundamental supposition is the constant value of alpha for the whole area of the magnetogram. In future methods should be developed which may also work with a variable value of alpha. This may become realistic if vector magnetic fields are available and was shortly discussed by Wu et al., 1985.

The estimation of the S-component radio emission by use of observed magnetic field distributions is the second theoretical method, which should be mentioned in this review. This method was described and applicated in several publications (see for instance Hildebrandt et al., 1984 or Seehafer et al., 1983). The input data are (a) models of the S-component radio emission taking into account gyro-magnetic radiation and Coulomb bremsstrahlung, (b) models of the solar atmosphere above sunspots, plage regions and the quiet Sun, and (c) the magnetic field distribution in dependence on the height in the solar atmosphere. The magnetic field values were computed by use of the forcefree extrapolation. In this wax maps of the radio-emission (brightness temperature and degree of circular polarisation) can be computed. The comparison of this results with observed maps from WRST or observations from RATAN 600 shows qualitative agreement. But the comparison gives also indications for future improvements of the input data, that means, aspecially, the model atmospheres and magnetic fields distributions in higher atmospheric layers.

Finally in SibIZMIR a method was developed for the determination of the velocities responsible for time variations of the longitudinal field component (Kuklin et al., 1980). Two or more well calibrated magnetograms are the basic data from which we may determine the derivative

$$\frac{\partial Bz(x, y, z, t)}{\partial t} \approx \frac{\Delta Bz(x, y, z)}{\Delta t}$$

(x, y, z are the coordinates on the Sun, z vertical, t is the time). If the vertical motion w(x, y) is neglected, then it becomes possible to determine the two dimensional horizontal velocity field u(x, y) and v(x, y). From the velocity vector $\vec{v}$ with its components $\{u(x, y), v(x, y), 0\}$ it is possible to estimate

(i) the values of div $\vec{v}$, that means the places of emergence or disappearence of magnetic flux,

(ii) the values of rot $\vec{v}$, that means the vortical velocity field, and

(iii) the value of $\varepsilon = \frac{1}{2}\left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)$ which represents a measure of the increase of the shear tension in the magnetic field.

This method was especially used for the role of shear motions in the production of the preflare situation (Golovko et al., 1986). The most problematic assumption is that the vertical motion is neglected, that means w(x, y) = 0. Furtheron Kuklin et al., especially, emphasizes that the motions are not necessarily mass motions. On the other hand the magnetic field in photospheric layers should be strongly frozen in, and in this case a difference between the motion of the magnetic field and the mass motions should not to exist.

8. RESULTS FROM FULL-VECTOR MAGNETOGRAMS

During the last years the observation of realistic distributioens of the full-vector magnetic fields was performed by an increasing number of participating observatories. This fact was already mentioned in Chapter 2. Vector magnetograms permit to use a number of additional methods fo the analysis of the magnetic field parameters in active regions and some examples will be presented in this section.

At first, it is evident that full-vector magnetograms give valuable additional information concerning the morphology and phenomenology of the investigated active regions. For instance, we mentioned at the end of Chapter 5 that H alpha synoptic charts do not exactly represent the zero line of the longitudinal field. In connection with full-vector magnetograms it must be re,arked that the neutral line of the magnetic field can be estimated only by the use of vector magnetograms. As an example, in Fig. 6 the zero line of the longitudinal field component is marked by a dotted line and the neutral line is marked dashed-dotted. On the basis of such considerations the xestion of delta-configurations in sunspots can be examined in more detail. This feature was also outlined in the Sacramento Peak Observatory Conference on the "Physics of Sunspots" (Patty, 1981).

As an example for the interpretation of vector magnetic fields we like to refer to a cooperative analysis concerning the flare situation on July 31, 1983 (Hofmann et al., 1986). In this analysis chromospheric and photospheric fine structures from the Debrecen Observatory, full-vector magnetograms from Potsdam and radio observations from Tremsdorf were used. In H-alpha a two-ribbon flare with one footpoint in a spot umbra and a surge were found, and radio observations indicated a slowly outward moving disturbance. From vector magnetograms the following information could be obtained:

- The structure in the surroundings of the flare region was very disturbed.
- The inclination of the field lines was nearly parallel to the surface of the sun.
- The azimuth of the transverse field component was nearly parallel to the zero line.
- Inhomogeneities of the transverse field were remarkable.
- The structure of the delta-configuration could be analyzed.
- Differences between the location of the zero line of the longitudinal field component and the neutral line could be analyzed.

These results are illustrated in Fig. 6 and Fig. 3.

Finally, vector magnetograms allow the determination of further physical parameters from the Maxwell equations. If the derivatives of the transverse field components $\frac{\partial B_x}{\partial x}$, $\frac{\partial B_x}{\partial y}$, $\frac{\partial B_y}{\partial x}$ and $\frac{\partial B_y}{\partial y}$ are available then we may calculate the vertical current density J_z from the equation $\mathrm{rot}\,\vec{B} = \frac{4\pi}{c}\vec{J}$ and the vertical gradient of B_z from the equation $\mathrm{div}\,\vec{B} = 0$. Examples of the results are given in Figures 4 and 5. Such investigations were also proposed by Hagyard et al. (1981) in the framework of the programme of the Marshall Space Flight Center, and should be included also into future analyses of our vector magnetograms.

9. FUTURE PLANS FOR THE PROGRAMME "CHAIN OF MAGNETOGRAPHS"

In our review we have tried to give information about the obtained results, actual possibilities concerning the measurements, and the interpretation of magnetic fields as well as special available methods. In the concluding remarks we would like to compile some recommendations for the future work in our participating observatories:

1. Observational results about magnetic fields are not yet available in a sufficient number. This was the case in several cooperative investigations of active regions. It is very desirable that we will enlarge the number of observations of magnetic, as well as of velocity fields, especially during the cooperative observational periods.
2. We recommend that our complex observational periods should be concentrated on the questions of the birth, development, and dissipation of active regions, and especially should take into consideration the problem of the decay of large magnetic fields in sunspots.
3. The methods of the prognosis of the evolution of the magnetic field structure at higher levels of the solar atmosphere should be further developed. This especially concerns the use of the new telescope STOP and the consideration of the action of proper motions of sunspots and pores.
4. We recommend to use more widely our possibilities of simultaneous observations at different heights of the solar atmosphere also with the aid of more-channel magnetographs.
5. The methods of the observation of the full vector should be further developed. This concerns especially
   - the calibrational comparison between different magnetographs (above all, comparison of the azimuth) and
   - the development of methods for the solution of the problem of the ambiguity of the determination of the azimuth.
6. There is needed a further development of our methods for the extrapolation of magnetic fields, especially in the approximation of force.free fields with variable . There should be included results of measurements of the magnetic vector at two different heights of the solar atmosphere.

The authors like to express their gratitude to all participants of the cooperative programme "Chain of magnetographs" and hope that we will continue our successful work also in Future.

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SUGGESTION

V. Bumba

Разрешите мне добавить к задачам, которые Вы представили в конце своего доклада еще один пункт: измерять с помощью цепи магнитографов скоростные поля активных областей и регулярно обрабатывать эти измерения и подготовлять карты распределения скоростей.