MAGNETIC FIELDS IN SOLAR PROMINENCES

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Abstract: The state of knowledge on magnetic fields in the solar corona and prominences is discussed. The most objective information on the middle corona is shown to be obtained nowadays from the direct measurements in prominences. The results of magnetographic and spectrographic measurements of the field in these solar formations are considered in detail. The essential differences between the field intensity and some other of its features, found from observations at various observatories, resulted in the authors' conclusion on the necessity of further investigations of magnetic fields in prominences.

1. Magnetic Fields in the Solar Corona

Investigations of magnetic fields in the upper solar atmosphere are necessary to understand the processes taking place on the Sun [1—14] and determing the state of the interplanetary medium [1—3, 15—28], magnetosphere [29—32] and atmosphere [33—40] of the Earth. Therefore, they are not only of scientific, but also of a definite practical importance in connection with space pioneering, the study of the electromagnetic field and terrestrial-ionospheric disturbances, as well as the determination of extreme features of plasma processes, which cannot be studied in ground-based laboratories. The structure, orientation and dynamics of the coronal and interplanetary fields, as well as the ejection of high-energy particles define, to a great extent, the troposphere-effective solar activity displays [35], being taken into consideration lately by the weather service [39, 40], helio-biology and medicine [40].

The importance of the solar corona is in the fact that it is the origin of the solar wind [15—28, 41—46], it includes in itself or is gradually transformed into interplanetary space in which some geophysical processes take place and propagate trough it [1—3, 10—12, 19, 33, 41—46].

Magnetic fields play an important role in defining the coronal structure [1—3, 8—13, 19, 18, 42, 45—61] and solar wind [2, 13, 16, 19, 27, 28, 42, 48, 51—53]. Large-scale magnetic fields, taking part in internal processes [58], determine the coronal rotation [1—3, 54] and the angular momentum transfer to the interplanetary medium [1—3, 19, 28, 62—65]. Changes in the low corona define the state of the interplanetary plasma and the field as a whole [2, 18, 19, 21, 26, 28, 31, 44]. Conditions in the interplanetary field reflect both the large-scale [2, 51] and a small-scale [2, 19, 57] coronal structure.

The evolution of coronal fields may at present only be traced by indirect data [2, 3]. The active region fields enter the low corona [66] during less than a day [60, 67—69] and, evidently, reach the height of the order (1.6—2.0) of $R_{\odot}$ [51] within a month, then connecting up with the interplanetary medium [2, 13, 28, 31]. Loops of the coronal fields near the active regions may reclose under the action of proton flares [71]. Large-scale sector fields cause the modulation of interplanetary fields [27]. The evolution of fields during a sunspot cycle determines the general coronal form, including the formation of two zones of its activity [1, 9, 10, 72]. A cyclic change of the field direction was found in the data of solar wind geo-effectivity [73, 74].

The coronal fields play a significant role in different phenomena, rapidly propagating in the upper solar atmosphere [1—12, 75, 76]. Depending on energy relations, the field may remain stable and control disturbances (surges, loop prominences, type III radio bursts, stationary type IV bursts, high-energy particles), become disturbed (activation and sudden disappearance of filaments, Moreton waves and type II bursts, spray ejections) and, finally, colapse with plasma ejection (moving type IV bursts, ejection) [2, 3, 8, 77]. According to some theories of flares the field is considered as the energy source for these intense processes (see, e.g. [4, 5, 78, 79]).

The field effect mechanisms acting on the physical conditions in the solar atmosphere and interplanetary medium are not clear due to a lack of data on the properties of the field itself.

Direct measurements of magnetic fields in the solar corona are a very difficult problem from the physical and technical points of view [2, 14, 80—82, 118]. The only attempt made to measure them above two active prominences (at the height 30,000 km) so far was undertaken by Harvey [81, 82]. Numerous estimates of field intensities in the corona do not always agree, in some respects, with each other [2, 3, 14]. They enable us mostly to define the order of magnitude of its value. Therefore, the fields in the upper solar atmosphere are computed mostly by means of the observed photospheric fields. The latter is possible due to a negligibly small effect of the coronal field on the photospheric level and to the strongest action of the large-scale weak field on the corona at the solar surface [2]. Besides, photospheric fields play the role of boundary conditions.

The coronal fields were computed by integrating the magnetohydrostatic equations [42, 49, 82—88]. In points located at a height small compared with the dimensions of the photospheric region considered and distant from its boundaries, the solution has the form of a potential field. This configuration is in satisfactory agreement with the geometry of a zero-longitudinal field in the region of a filament [84, 89, 90], arch systems in the corona [49], loop prominences and coronal condensations [87, 88]. Subsequently, one may assume that loops, arches and other coronal phenomena are formed by magnetic lines of force in which the matter is condensed to a greater extent [2, 49]. In particular, such tubes may be associated with the active prominences [49]. The prominence fields, thus computed, appear to be an order of magnitude smaller than the measured ones [82, 84, 86, 89].

This discrepancy should, evidently, be attributed to the innaccuracy in measuring the photospheric fields (see below and in [87, 173, 174]). The comparison of the computed fields with those, measured in prominences [82, 84, 89] showed an agreement between the form of the field and the data on the occurrence of prominences inside the fields [2].

The mathematical simplicity of these computations enable us to analyse in detail a great number of points within the limited region. In this connection, photospheric fields should be observed near the centre of the solar disk.

Computation of the coronal field distribution around the whole Sun [2, 13, 50, 51, 91, 92] is analogous to that of a geomagnetic field (see, e.g. [93]). In this case a potential field is described with the help of harmonic coefficients by fitting a spherical harmonic series, derived from the Laplace equation. Being applied up to great distances in the corona, the harmonic expansion is limited by the number of coefficients with which the data are fitted. The comparison of computed coronal fields with photographic plates of eclipses [2, 13], interplanetary field and with observations of the Faraday discrete source emission rotation [94, 96], as well as radioheliograms [2], allow for a computed pattern to be considered as a first approximation for a stationary corona.

The computation of corona fields enables us to establish their detailed relation with photospheric and interplanetary fields [2].

Regular changes of the photospheric fields, as well as some difficulties, due to the projection effect, occurring during the recording of these fields, distant from the disk centre, call for the use of an approximate mean distribution of the field across the solar surface. The limited possibilities of present computers only allow one to exploit a rough pattern of the photospheric fields. Determined on this basis, the potential fields are compared with the corona, observed at the limb. Therefore, this method is not suitable for determining the fine structure of the field above the active regions and for reflecting the rapid changes of the fields in the corona and the interplanetary space.

None of these methods takes into consideration the effect of electric currents which may be generated in the active regions and in the corona as a result of solar wind formation. Since the currents could prove to be rather considerable, one should consider them in treating the problem exactly.

For this purpose one should know how to determine the magnetic field, temperature, density and velocity at any level.

Only two particular solutions have so far been derived from the distributions of these conditions in the upper chromosphere. A magnetohydrodynamic approach [97, 98] enabled us to obtain the profiles of the coronal streams, their temperature and velocity distribution. In the second model the interaction of the solar wind with the field is taken into account by considering a system of surface currents, substituted for volume currents, or zero-potential surfaces of radius $R_w = (1.6—2.5)$ $R_\odot$ [13, 51, 2, 50]. Both models, within the scope of validity of a zero-potential solution, agree as to the form of the field lines. A flux, carried away by the solar wind, is equal in these two models. The second model yields a rather good approximation of the large-scale structure of the coronal an interplanetary fields [2, 50, 51].

However, a generally correct topology of the majority of open and closed field structures, obtained from these models, is not always consistent with the direction of the observed coronal condensations (obliquity of polar plumes and streams towards the equator, the effect of flares on a large-scale structure. These deviations [13] were eliminated when the transverse magnetic pressure and current sheets, separating the regions of the field with opposite signs and "opening" the field in sectorial structures, were introduced. This approach showed better agreement of [13, 51] and [2, 50], as well as the identity of the solution of the new model with the MHD-model. This proved that the assumption of the similarity of multipe currents, flowing in the isothermal corona, and current sheets was correct. At the same time the consistency with the axially symmetric MHD-solution enables one to be more confident in using the current sheet model for computing fields under three-dimensional asymmetric conditions. The computations of the field for the elipses of May 30, 1965 and February 12, 1966 proved that the latter model with asymmetric magnetic conditions yields a field structure, closely coincident with the coronal condensations [13].

In comparing the shapes of the computed field lines with large coronal structures only their general morphology was checked. The computations for November 1966, H_α-spectroheliograms and eclipse photographs of the corona showed a most striking feature of the field: the existence of magnetic arches connecting distant active regions [2]. The presence of such arches may account for the occurrence of correlated radio bursts [8, 77, 99] and sympathetic flares [5, 100].

In computing the coronal fields one may use qualitative comparison with the form [2, 50] and dimension [13, 51] of coronal condensations as the main criterion of accuracy. However, the coronal magnetic fields vary considerably with height and time. These variations, evidently, have a wide range — from extensive weak fields of a sectorial structure (which cannot be measured directly) to relatively strong ones above the active regions, sunspots and intense, but small, magnetic pores [2].

It has so far been impossible to check these computations by comparing the computed and measured coronal fields. Attempts to do this with the help of statistical information on the estimates of the field values in the corona, direct measurements of the field in prominences and in interplanetary space have shown that the coronal fields above the active regions is not potential [2, 3].

At the same time it was found that radio bursts, observed ut to heights of 5—6 $R_\odot$ [101, 102] and even at distances of the order of 1 a.u. [103], represent phenomena, with which strong temporal disturbances of the field are introduced into the corona [8, 99, 101, 102, 104] and the interplanetary space (18, 26], which finally disrupt it. Therefore, estimates of the field from radio bursts need not always be suitable for measuring the surronding magnetic field [2].

Radioastronomical measurements only allow one obtain an average height pattern of the field above the active regions changed so far. We have used the results of the estimates in [105—144] for compiling Table 1. They are also shown in Figure 1. If the heights were not indicated in the original papers, they were estimated with the help of Figure 2 from the wavelengths, used for observations. In Table 1 these cases are marked with the wavelength values. Figure 2 was compiled from limb, eclipse and radioheliographic observations [145—168], which enable one to define the radio emission source height more precisely. It shows that the distribution of the physical conditions above the active regions is such that bremsstrahlung only becomes effective at height of the order of 10^3 km. At lesser heights the radio emission is caused by another mechanism, probably, a thermal one.

The analysis of the given data yields the following empirical relations of the mean field intensity $\bar{H}$ and its gradient $d\bar{H}/dh$ on the height h above the active region:

$$\lg(H_{\max}/\bar{H}) = 10^{-3}(\lg h)^{4.54}, \qquad (1)$$

$$d\bar{H}/dh = -4.54 \times 10^{-3}\,(\bar{H}/h)\,(\lg h)^{3.54}, \qquad (2)$$

where $H_{\max} = 3000$ Gauss is the maximum intensity in the active region at the photospheric level. Equation (1), found with the help of the least-squares method, is a rather good approximation of the observed data up to heights of 10^6 km, i.e. up to heights where coronal structure are mostly closed. Higher up the opened field lines transit into interplanetary space [2, 13]. In this region the

Table 1

λ [cm]	H [gs]	h [ths km]	lg H	lg h	lg $\bar{H}$	lg $\bar{h}$	Reference
0.37	>150	2.18	>2.18	3.46			105
0.42	>7200	3.86	>3.86	3.54			106
0.90—0.35	25—500	6.9—2.7	1.40—2.70	3.84—3.43	2.42	3.68	107
	1250	5	3.10	3.70	3.10	3.70	108
≦1	≧340	≦7	≧2.53	≦3.84			109
	>1000	10—20	>3.00	4.00—4.30		4.18	110
≦3	300—500	≦18	2.48—2.70	≦4.25	2.60		111
3	<1000	18	3.00	4.25	3.00	4.25	112
3.05	1000	18	<3.00	4.25		4.25	113
3.15	500	18	2.70	4.25	2.70	4.25	114
3.57	1000	20	3.00	4.30	3.00	4.30	115
	600	20	2.78	4.30	2.78	4.30	116
7.2	2000	31	3.30	4.49	3.30	4.49	117
	360—700	35	2.56—2.85	4.54	2.72	4.72	118
	360	35	2.56	4.54	2.56	4.54	119,120
10	50	39	1.70	4.59	1.70	4.59	111
	250	40	2.40	4.60	2.40	4.60	116
	<700—800	30—50	<2.85—2.90	4.48—4.70		4.60	121
10—50	1000—2000	39—115	3.00—3.30	4.59—5.06	3.18	4.89	122
	60—100	70—90	1.78—2.00	4.85—4.95	1.90	4.90	123
	1—2.5	100	0.00—0.40	5.00	0.24	5.00	124
	2—6	100	0.30—0.78	5.00	0.60	5.00	125
	5—8	150	0.70—0.90	5.18	0.81	5.18	126—128
73	5	140	0.70	5.15	1.86	5.15	144
150	50	240	1.70	5.38	1.70	5.38	129
150	16—36	240	1.20—1.56	5.38	1.42	5.38	130
	30	210—280	1.48	5.32—5.45	1.48	5.39	131
177	2	260	0.30	5.42	0.30	5.42	132
177	5	280	0.70	5.45	1.29	5.45	144
187.5	3—8	275	0.48—0.90	5.44	0.74	5.44	133
	27	300	1.43	5.48	1.43	5.48	134
	10	300	1.00	5.48	1.00	5.48	135
	5	300	0.70	5.48	0.70	5.48	122
100—500	100—200	180—520	2.00—2.30	5.25—5.72	2.18	5.54	122
	40	350	1.60	5.54	1.60	5.54	108
	1—5	350	0.00—0.70	5.54	0.48	5.54	136
	1—2	400	0.00—0.30	5.60	0.18	5.60	126—128
	14	400	1.15	5.60	1.15	5.60	134
	10	140—700	1.00	5.15—5.85	1.00	5.62	137
	5	420	0.70	5.62	0.70	5.62	138
	4.5	420	0.65	5.62	0.65	5.62	139
375	16	440	1.20	5.64	1.20	5.64	129
375	10	440	1.00	5.64	1.00	5.64	140
	3—8	490	0.48—0.90	5.69	0.74	5.69	141
	7	500	0.85	5.70	0.85	5.70	134
	0.2—1	500	−0.70—0.00	5.70	−022	5.70	124
600	20	590	1.30	5.77	1.30	5.77	142
	2	600	0.30	5.78	0.30	5.78	135
750	200	690	2.30	5.84	2.30	5.84	143
	1.5	1000	0.18	6.00	0.18	6.00	127

distance dependence of the field changes [170, 171].

The solid line in Figure 1 is the height variation of the logarithm of the mean field intensity, determined from (1). The dotted lines represent the "σ-corridor", corresponding to the standard deviations from the mean value lg $\bar{H}$. For the data used $\delta = \Delta \lg \bar{H} = 0.66$, i.e.

$$\lg \bar{H} - \sigma \leqq \lg \bar{H} \leqq \lg \bar{H} + \sigma, \tag{3}$$

so that,

$$\frac{\bar{H}}{4.6} \leqq H \leqq 4.6 \bar{H}. \tag{4}$$

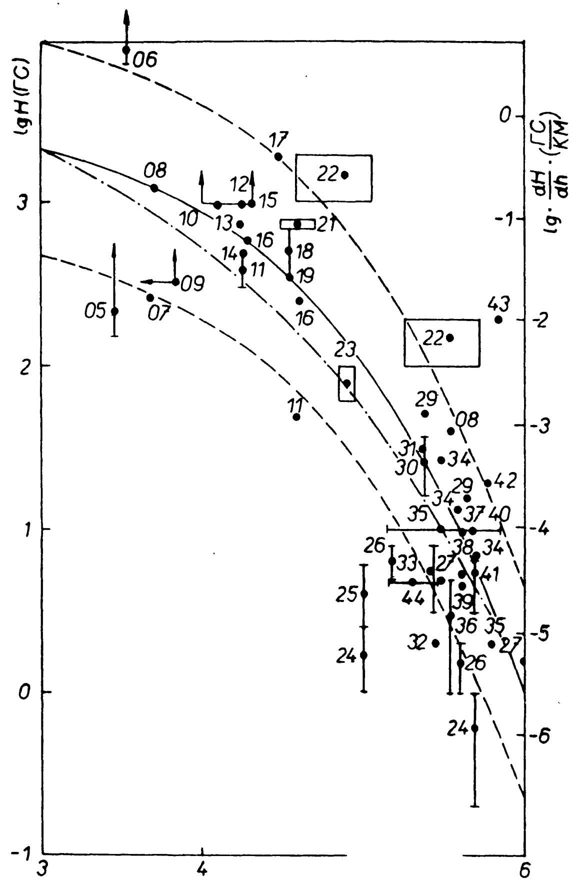

Fig. 1. Change of the intensity and the magnetic field intensity gradient in the solar corona above the active region as a function of height.

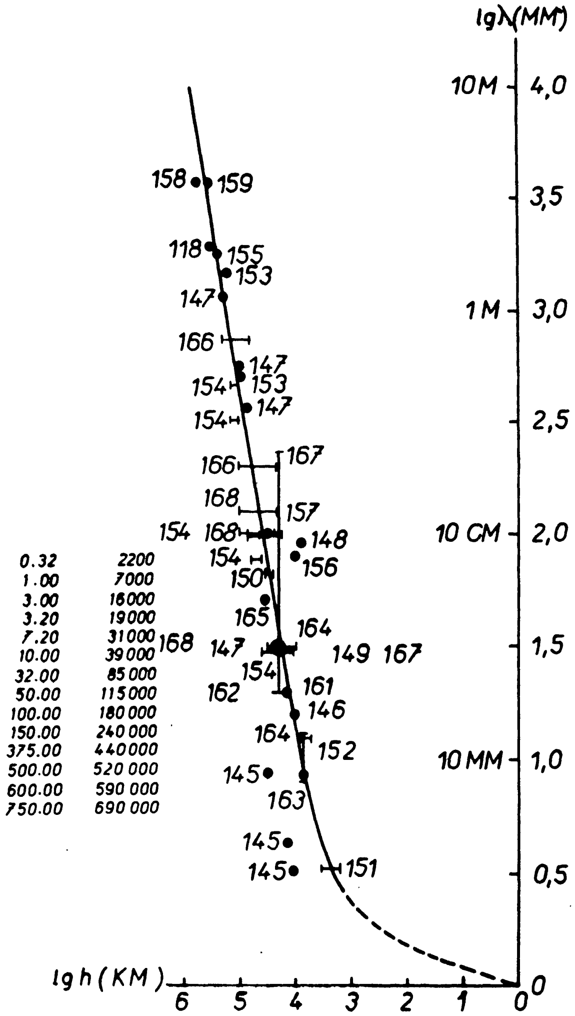

Fig. 2. Radio-emission wavelength above the active region as a function of height.

From (4) it follows that the radioastronomical estimates of the magnetic field intensity *H* at a given height do not differ by more than a factor of 5. This agrees well with similar conclusions of Takakura [169]. One should keep in mind that in our analysis the scatter of the field values is increased by the approximate character of the heights, determined with the help of Figure 2.

From Eq. (4) and Figure 1 it follows that the lower limit of the field intensity at typical heights of prominences (10,000—30,000 km) [211—213] inside the active zone regions, where the radio-emission generation of local sources takes place [167, 168] with a probability of 2 σ (0.95), is some hundreds of Gausses ($\geqq$20—40 Gauss). This result is important when prominence fields are being considered. Table 2 gives the mean intensities for a number of heights, determined from Eq. (1).

In Figure 1 the dash-dotted line represents the height change of the logarithm of the meanfield gradient, computed by means of Eq. (2). Gradients of the mean field for the same heights are given in Table 2. They are in satisfactory agreement with the estimates of the gradients in the chromosphere (see, e.g., [66, 172]) and with our computations for prominences (see below), but exceed, to a considerable extent, the gradients, found in prominences by Rust [89, 90].

The heterogeneous character of the observed data available and their insufficient space resolution do not allow for a more detailed consideration of the question of the field gradient.

In Table 2 one can also see that at heights of the active region prominences fields with intensities upto some hundreds of Gausses should be observed. The most objective way of checking whether the computations and estimates of the fields in the corona are correct, is their comparison with direct measurements of fields in prominences [2, 3, 14].

It follows that a study of the magnetic fields in the upper solar atmosphere depends to a large extent upon the knowledge of the properties of the prominence fields. Such investigations are important in themselves and in connection with some other circumstances:

Table 2

h [km]	$\bar{H}$ [gs]	$\frac{d\bar{H}}{dh}\left[\frac{gs}{km}\right]$	$\lg\left(\frac{d\bar{H}}{dh}\right)$
Photosphere	3000	—	—
1000	2140	$4.75 \,.\, 10^{-1}$	−0.32
5000	1200	$1.12 \,.\, 10^{-1}$	−0.95
10000	850	$5.22 \,.\, 10^{-2}$	−1.28
20000	530	$2.10 \,.\, 10^{-2}$	−1.68
30000	375	$1.14 \,.\, 10^{-2}$	−1.94
50000	225	$4.89 \,.\, 10^{-3}$	−2.31
100000	95	$1.38 \,.\, 10^{-3}$	−2.86
350000	12	$6.69 \,.\, 10^{-5}$	−4.17
500000	6	$2.58 \,.\, 10^{-5}$	−4.59
1000000	1	$2.58 \,.\, 10^{-6}$	−5.59

(a) The filaments are located above the regions of the zero longitudinal photospheric field [84, 175—179]. Consequently, their properties reflect the topology and evolution of photospheric and chromospheric fields [70], as well as the coronal activity [9—12, 19, 180—185] during the sunspot cycle [186—188]. The degree of activity of the prominences is closely associated with the lifetime of the active regions in which they are located and with their stage of development. Prominences are sensitive indicators of the interaction between different regions, sometimes located at large distances from each other. One can say that prominences are associated with most displays of solar activity.

(b) Data on the presence, length, orientation and type of prominences make it possible to determine coronal structures and corpuscular streams [19, 155, 189—193]. A comparison between three-dimensional coronal structures and a computed configuration of the field proves that the coronal streams are formed above the magnetic arches [2]. This also agrees with the often used theoretical conception [97, 194], according to which the streams are developed above the regions of a neutral (longitudinal or radial) field [2, 13]. Besides, one may consider the streams as flat fine formations — current sheets [13], emerging from the filaments. The coronal structures have the same longitudinal extension as the low-lying filaments and the same stability [189]. Thus, the prominences and filaments are associated with large regular structures and streams in the corona. Taking into account point(a), one can understand the high correlation between the interplanetary and photospheric large-scale formations [195].

(c) Prominences are in relationship with flares [5, 196, 197], or are stimulated by flares [5, 198, 199]. Besides, the prominences and filaments may be the source of corpuscular [2, 192], X-ray [200] or radio emissions [8, 140, 201—203].

(d) Solar plasma is subject to the most severe dynamics in prominences [205]. This behaviour can be observed to heights of the order of 10 $R_{\odot}$ [206]. When moving through the corona the prominences have an effect on its state [207].

(e) A study of the field properties in prominences is necessary for explaining the prolonged stability of the cold dense plasma in the surrounding rarefied hot corona, i. e. for determining the nature of the prominences themselves [208]. The presence of a magnetic arch with the depression above [209, 210] is the necessary and sufficient condition for the prolonged existence of prominences. *In this connection the main problem of prominence physics is, at present, the determination of the structure and configuration of the field* [210].

The state of knowledge of the properties of magnetic fields in prominences requires their detailed consideration.

2. Magnetic Fields in Prominences

2.1. The low limit of the field intensity in prominences is computed in terms of the equality of the kinetic energy density and the magnetic fields, based on the fact that knots of these formations move along trajectories, resembling field lines [10, 100, 205, 214, 227]. The computed field values vary from some fractions or units of Gauss [10, 221, 228—231] up to tens [229—232] or hundreds of Gauss [233] (on the reliability of [233] see below).

The same estimates are obtained from the analysis of radioemission data when the filaments and prominences change [140, 201—203]. Ioshpa has computed the minimum internal field needed for compensating the gravitational instability and for long-term conservation of the filament by means of the equality betwen the attracting force of the magnetic field, occurring at the point where the filament bends and the gravity force, causing it to bend. A field of about 10 Gauss is enough to ensure filament stability [84]. Within the accuracy of the estimates, the value of the field in the filaments, found in a similar way by Stefanov[175] and Harvey [82], agrees with Ioshpa's results.

But the prolonged existence of prominences [199], the constancy of their shape [223] and the trajectories of knot motions, taking place sometimes over several days, are evidence for the predominance of the magnetic field energy [231] and, consequently, the field intensity should be computed more precisely. Under these conditions the changes of the structure or magnetic field configuration should cause rearrangement or oscillations of the prominences and filaments. Hyder [234] has computed a radial magnetic field component in winking filaments and in the adjacent corona in terms of the observed frequency and damping constants of vertical harmonic filament motions. The prominence fields appeared to be within 2—30 Gauss and 0.09—0.18 Gauss range in the surrounding corona. Kleczek and Kuperus [235] have examined the same phenomena in the form of harmonic prominence oscillations in the plane parallel to the solar surface being damped by the action of a magnetic field, localized in the direction of the prominence, and the energy losses due to the excitation of acoustic waves in the surrounding corona. The observed periods and time of the quiescent prominence oscillations are satisfactorily accounted for by this model, if the field intensity in it is equal to 9 Gauss.

The uncertainty of such quantitative estimates is associated with the variety of types of prominences and filaments, with incomplete knowledge of the motion mechanism and parameters of these formations, as well as errors, incurred in the computations (e. g., in [233] field intensities in flare sprays are more than an order higher).

2.2. The intensity of the prominence fields can be determined more directly by using the measurements of polarization lines in their spectrum, accounted for by the resonance fluorescence in the magnetic field [236]. The polarization of lines H_α and D_3 is very low. A polarization vector mostly has a poleward orientation [236—238]. In lines D_3 [239], H_α,H and K [240—242] the polarization is expressed more expressively in active prominences than in quiescent ones.

Hyder [243, 244] found a longitudinal field of about 60—80 Gauss by linear polarization of H_α in loop prominences after a small flare. The field in young equatorial prominences is mainly perpendicular to the line of sight, provided the directions of the polarization line D_3 and the magnetic field coincide. It has either a normal or tangential orientation with respect to the solar limb. The intensity of the longitudinal field in such prominences is between 0 and 30 Gauss. In old and high-latitude prominences the field component is 60—150 Gauss. The difference in values and orientation is associated with the effect of differential solar rotation [244, 245].

Hyder [244] discovered the agreement between the polarization of lines of quiescent prominences [240, 246] and the magnetograms of the photospheric field [176]. In 30 out of 60 prominences the polarization appeared to be the same as one would anticipate if the photospheric fields were distorted by differential rotation over a corresponding period of time. In 6 cases the absence of the coincidence is due to local peculiarities in the distribution of photospheric fields. In so far as the quiescent prominences are organically associated with bipolar magnetic fields (BM) [84, 175—179], Hyder assumes the possible existence of synchronization in the polarization sign change when the sunspot cycle is changed [246]. However, it was found that definite conclusions on the magnetic field behaviour could not be obtained due to the lack of observational data [246] and the incomplete treatment of the model [244].

The main difficulty in determining the field from polarization measurements is that it is impossible to separate exactly the field effect from the effects, associated with the radiation scattering process. Therefore, in interpreting the observed data some assumptions are needed which reduce the reliability of the estimates of the magnitude and orientation of the field. In [236, 239—242], e. g., self-absorption in prominences is considered to be absent, the magnetic field vector is oriented perpendicularly to the solar surface in the meridional plane, and the direction of polarization coincides with that of the magnetic field. Unlike the unambiguous identification of directions of polarization and the field, assumed by Brückner [240—242], Hyder [244] introduced a magnetic vector, not coincident with the direction of maximum polarization and dependent on the intensity and inclination of the magnetic field with respect to the solar limb normal. The definition of the field magnitude by line polarization becomes more complicated due to the effect of depolarization and instrumental polarization. For instance, the observed polarization in line Ca I λ 4227 ($\approx 4\%$) is less than that expected from pure photoexcitation ($\approx 20\%$). The difference may either be due to the action of another excitation mechanism, producing no polarization (e. g., excitation by electron shock) or with the depolarization by a magnetic field (a change in orientation of the atoms during their lifetime in the excitation state). The latter mechanism is more effective, if $H > 25$ Gauss [247]. The instrumental linear polarization is not constant in the course of the day and may reach 18% [248]. To determine it is a difficult problem [248—251]. An even greater linear polarization is introduced by spectrographs [252]. For this reason one should know the polarization properties of the instrument being used and take special measures to reduce their effect on the results obtained.

The considered attempts to determine the magnetic field in prominences are in the nature of order-of-magnitude estimates.

2.3. The direct and, therefore, most reliable measurements of the field in prominences are carried out by means of the Zeeman effect with the help of mahnetographic and photographic methods. The basic principles of these methods and the description of magnetographs are given in [253—269]. So far only the longitudinal component of the magnetic field intensity has been measured. The discrepancy in the results, obtained at different observatories, requires more detailed consideration.

2.3.1. The first magnetographic measurements of the prominence field, carried out in 1960 by Zirin and Severny (270—272] in line H_β, showed the presence of large fields in these formations. In quiescent prominences the fields were recorded from the sensitivity treshold of 25 Gauss to 100 Gauss. In active prominences the fields appeared to be even more intense, from 100 to 200 Gauss (270). In the very bright mount, evidently consisting of complex loops, Zirin found a field of 740 Gauss above the active region, 5000—10,000 km from the limb. After two hours, when this prominence became a bright point like a limb flare, the field was only equal to 150 Gauss. In other active prominences, also transformed into small flares, Zirin has observed a change of sign of a longitudinal field of about 100—200 Gauss. In small limb surges the field was, apparently, not more than 100 Gauss [271].

Zirin has emphasized that the quantitative definition of the field intensity is a difficult problem [272]. The difficulties are mostly associated with the variability of the line brightness and the form of its profile in the prominence. Besides, one should take into account the difference between the line profiles in the solar spectrum and in that of the prominences. The error in the definition under the assumption of constancy of the Doppler-line profile width in one and the same prominence, or at the transition from one prominence to another, was found by Zirin to be not less than 30%. The other characteristics of the line profile — self-absorption, assymetry, Doppler shift — were not taken into consideration, because the main problem in the measurements was to define, at least the order of the field value [271].

In 1966 the prominence field was measured by Krotov [273] with the help of the magnetograph, mounted at the Crimean Astrophysical Observatory. The field was measured for two days in two or three quiescent filaments, located between two BM and observed at the limb under different angles in the form of a complex prominence [274]. At various points of the prominence the field was found to be from 10 to 130 Gauss. The measurement technique was adopted from [270—272]. The noise level of the magnetograph was 30 Gauss.

Iospha's measurements [84, 275, 276] at the limb showed evidence of the existence of considerable prominence fields, associated with the active regions. These fields, as a rule, reached some hundreds of Gauss. For instance, in the eruptive surge from the region of a flare, occurring some minutes before, one could observe at different stages of its development fields of 200—300, 600—800 and 500 Gauss with different signs and at different times (visible height above the limb was about 50,000 km!). The prominence was stretched out, and the appearing individual bright points ascended with velocities of 350—400 km/sec. Some time dater a recurrent surge was observed. On the next day a group of sunspots appeared on the disk where flares had been observed for several days.

Evidently, Ioshpa, like Zirin [271], has in this way observed the effect of changes of the intensity and field structure above the active regions, caused by a flare. Most eruptive prominences are known to have the same character of motion. Those preceding the eruption, are reduced to a simplified configuration of the magnetic lines of force and formation of loop-type streamers and extended arches [225], associated with the attracting regions [100, 225, 227, 277]. At the moment of the eruption the magnetic shell of the prominence is usually lifted. This means that the disturbance across the whole prominence is simultaneous [225]. In the active region the flares are followed by an extension of the field structure at the chromospheric level [278]. Simplification of structure, decrease of gradients and sometimes of active region fields themselves after flares [260, 279], as well as sudden changes of the field direction in the flare were observed earlier by Severny [280] and others [260]. The decrease of the active region field during the flare was observed later by Rust [281] and its increase after the flare by Chistyakov [283]. The change in the structure of the above-mentioned field during the flare was also observed by Malville and Tandberg-Hanssen [282]. Simultaneous changes of photospheric and chromospheric fields with the appearance of surges were recorded later by Harvey (82), but to draw a definite conclusion on the causative relation between these phenomena was impossible.

In prominences observed on the disk as quiescent filaments, enveloping active regions, Ioshpa has recorded fields of 50 to 200 Gauss. But usually the field in these prominences is below the sensitivity treshols (40—60 Gauss). In the prominences, not associated with active regions, the field was 60—150 Gauss. In all these cases the prominences have the form of bright caps and, on the disk, of filaments, oriented almost parallel to the equator. Ioshpa assumed that the measured field component in this case was directed along the filament and corresponded, possibly, to the inner prominence field. In quiescent prominences not associated with the active region and located along the meridian, the field is not revealed (84).

The relative error in Ioshpa's measurements was 40—50% because the approximation of the H_β-line profile was rougher that in Zirin's [271] and because the variability of the line profile shape was neglected in the prominence and in the undisturbed chromosphere when calibrating the magnetograph. However, the field intensity, determined by Ioshpa, can be considered reliable enough.The evidence in favour of it is the coincidence within the accuracy of the measurements, obtained either by calibration on the solar disk in the absorption line, or in the emission line, first introduced by Ioshpa [84].

The results of the intensity measurements, carried out at the Crimean Astrophysical Observatory and in IZMIRAN, are practically the same. They are in satisfactory agreement with the estimates of the field magnitudes made by means of indirect effects and from radioastronomical data (Fig. 1 and Table 2), but considerable deviations exist in most magnetographic measurements at station Climax [81, 82, 89, 90, 259, 269, 282, 284—288] and in the photographic observations by Shpitalnaya and Vyalshin [289] and by Wiehr [290].

The magnetograph at Climax was developed under Dr. Zirin's guidance after his return from the Crimean Observatory [259, 272, 291] specially for measurements of fields in prominences [259, 269]. Its calibration is made in the emission line simultaneously with the measurement of the prominence field. This essentially simplifies the definition of the field magnitude in the case of symmetric profiles, the self-absorption of the line not being considered and the widths and positions of magnetograph slits with respect to the line being optimum. Besides, the dependence of the recorded signals on the characteristics of the line profile is eliminated. However, if one of the indicated conditions is not satisfied, the measurements subject to an error, omitted in the estimate, and the field magnitude will be underestimated.

The relatively high sensitivity of the magnetograph (0.5—2.0 Gauss for H_α; 0.1—1.0 Gauss for D_3 and 2.0 Gauss or more for metallic lines in quiescent prominences and half in active prominences [259, 269, 82, 89, 287] is attained due to the long time of accumulation of the signal (~10 min) [259, 269]. This considerable inertia of the instrument only enables one to measure the field *in some of the brightest parts of the quiescent* and gradually varying active prominences. Rust's measurements [89, 90, 259, 285, 291] showed that the range of field magnitudes inside the most quiescent polar and old (high-latitude) prominences is such that the mean and maximum fields in them are about 6 and 20 Gauss, respectively. In young quiescent prominences of the active region zones the field is 60 Gauss, but the mean only 8 Gauss.

Other measurements of the field in quiescent prominences at Climax support the field intensity values obtained by Rust [86]: 2.5—12.5 Gauss [269]; 10—13 Gauss [286]; 3—8 Gauss and the mean 7.3 Gauss [287], 4—13 Gauss [293]. In some prominences, not associated with active regions, the fields are in a range of 3—18 Gauss. The mean value of the field is 6.6 Gauss [82]. At Climax a great number of measurements was carried out, but since they only concerned some bright knots in various prominences, we cannot get a realistic picture of the field configuration in the individual objects. Investigations of field properties have a statistical character.

The different classifications of prominences and different resolutions in measurements, as well as high selectivity of the published data do not permit one to consider the system of measurements at this station to be stable. Thus, e. g., Rust [89, 90] has published only some of the most significant data from measurements in almost 100 prominences, Harvey [82] — 333 of 2×10^6 measurements (the number of prominences is not indicated); Tandberg-Hanssen [287] — 1000 measurements in 400 prominences. The resolution varied from 20" [89, 90] to 10"–5" [82]. Rust [89, 90] outlined the specific features of each type of prominence, Harvey [82] divided all prominences into 2 groups, associated (coronal cloud, streamer, loop prominences, surges, sunspot prominences, etc.) and not associated (quiescent, active, eruptive, tornado) with active regions. Tandberg-Hanssen [287] divided prominences into active and quiescent ones. For this reason it is difficult to compare the results obtained by the individual authors.

Therefore, the attempts to attribute the increase of the mean intensities of the prominence fields between 1964—1965 and 1968—1969 to their dependence on the sunspot cycle development [82, 287] are not reasonable enough, though such a dependence is obvious from other properties of the solar magnetic fields.

Results of measurements of the field in active prominences at Climax are also contradictory. Tandberg-Hanssen considers that the mean field in the active prominences is almost the same as in quiescent ones, but the scatter of the values is greater; only sometimes their field is not more than 100 Gauss [287]. Meanwhile, Lee, Harvey and Tandberh-Hanssen [269] have found that the fields in the active prominences are usually greater than in quiescent ones and that those, exceeding 100 Gauss, are rather typical. The most frequently observed fields in such prominences are about 20 and 80 Gauss, on the average they are equal to 26 Gauss [82], which is 3—4 times more than in quiescent prominences [284].

A maximum field intensity of 200 Gauss was observed in a "knot" prominence (the height above the limb was about 13,000 km) with a large error (±100 Gauss), because the observation were interrupted by cloudiness. For this reason the value (200±100 Gauss) may not be representative [82]. In Rust's review [291] values of 200—300 Gauss are given with no references to the authors.

Distributions of the prominence field intensities were obtained by Harvey [82] from observational histograms under two formal assumptions: (a) the value and direction of the field are independent and (b) all directions of the field are equally probable.

In surges the field is equal, on the average, to about 35 Gauss but in some cases it is 130 Gauss [81, 287]. In the surge ejections the field does not exceed 30 Gauss [81]. In loop prominences it is between 10 and 60 Gauss [81] and may be equal to 80 Gauss [284]. In a prominence, slightly varying in shape due to activation by a flare, the field was found to be 25 Gauss [284]. In a tornado prominence, not associated with the active region, the field appeared to be between 80 and 90 Gauss [82].

In analysing the prominence field measurements, made at Climax, a certain tendency was found for the field intensity to increase both in quiescent and, even more, in active prominences as the resolution and accumulation of data increased.

However, the persisting discrepancy between the field values, observed in prominences at the Crimean Observatory and at Climax, was not explained although they have a common participant (Dr. Zirin) [259, 270]. Rust has checked the accuracy of his measurements by comparing photospheric field records, taken simultaneously at Climax and Mount Wilson [89, 90]. Later, the inaccuracy of the measurements at the Mount Wilson Observatory was found and as a result they should be increased 2.5 times [87, 173, 174]. Besides, since the fields at the former station were measured, as a rule, in large bright prominences [82, 89, 287] and there was an inverse relation between the field value and the brightness [82, 89, 90, 273], the measured fields may have been regularly underestimated. But this is, evidently, not always the case because the intensity also depends on the orientation, structure and prominence development stage. Therefore, the fields in active region zones are found to be 60 [89, 90] and even 100 Gauss [82, 269, 287]. Apart from the difficulties mentioned above, one may add the height selection, associated with the uncertainty in measuring the field near the limb [82]. Probably, such peculiarities of field measurements are the reason for the different intensities in prominences, recorded at Climax.

To verify and explain this difference further measurements are necessary [291].

Photographic observations of the field in prominences, which sould support the correctness of magnetograph measurements, yielded contradictory results. Shpitalnaya and Vyalshin [289] have found field intensities of the order of $10^3 - 10^4$ Gauss in "dashes" surges from ascending loop prominences during or after a flare [294, 296]. It may be considered the lower limit of the field in dashes, generated by the so-called "eruptive" instability of the pinch-column, compressed by electrodynamic forces in the course of the flare process [297]. Meanwhile, Wiehr [290] has not discovered any field in prominences at all. His negative result may possibly be accounted for by an imperfect measurement technique [317].

2.3.2. There is no general opinion as to the structure and orientation of the prominence field either. Zirin and Severny [270], Ioshpa [84], Rust [89, 90] and Kotov [273] have observed changes of the sign and value in the prominences. Tandberg-Hanssen [287] has only noted the variability of the field value in quiescent ones. Zirin [271, 272], Ioshpa [84] and Rust [89, 90] have indicated that the field varies unmonotonically with height. Besides, the height gradient of the longitudinal field is 10^{-4} Gauss/km [90], which is in satisfactory agreement with the filament stability criterion [209, 291, 292]. However, Harvey has observed in some quiescent prominences that the field is increased with height, but also the opposite. In the active region zones strong fields are associated, as a rule, with small heights and vice versa [82]. Tandberg-Hanssen has proved the above stated increase [287] but, like Harvey [82], could not define in many cases the character of the field behaviour. Rust [89] is of the opinion that the prominence field has no fine structure. Harvey's measurements with a better resolution showed that some prominences have a fine field structure of the order of some seconds [82]. This type of structure possibly changes during the lifetime of a filament.

The high value of the field was responsible for Zirin's conclusion[297] on its force-free character in active prominences. His opinion is that the field ascends together with the prominence. Rust [89, 90], hafing discovered fields of both signs in one and the same prominence, came to the conclusion of the confused character of the field in quiescent prominences. He and Tandberg-Hanssen assumed the possible display of individual features of each sampled prominence [89], or of each of their types [12]. Drawing on Rust's conclusions [89] in investigating the effect of the field on plasma motion in quiescent prominences, Malville [298] has proposed that the field is ordered in a random way.

Nevertheless, having considered all the data combined, Rust [89, 90] found that the field has a tendency to increase with the angle between the filament axis and the observation direction. But he does not admit the existence of fields only parallel or only perpendicular, relative to the filament. Lately, Rust considered, without any substantiation, the field to be directed along the filament axis

No distinct relation was found by Harvey between the measured field value and the orientation of the prominences though he suggested that the active region prominences are located along their axes.

He discovered a regular change in the value and sign of the field from their bottom to the top only in loops [82]. Malville [284] assumes the field direction in loop prominences to be along their arch.

Based on measurements of the longitudinal prominence field and of the field strength vector on the disk in the region of filaments, two systems of the fields were proposed by Ioshpa to be present in these formations: the external, supporting the filaments according to Kippenhahn-Schlüter's hypothesis [209] and oriented across the filament axis, and the internal, directed along the filaments and preventing it from becoming gravitationally instable [84]. Of the same opinion is Pikelner [208], although in his last model, concerned with the formation and prolonged existence of prominences, only the outer arch field is examined [210].

Nakagawa and Malville [293], having considered the field structure in typical quiescent prominences to be chaotic in explaining their periodic structure, draw the conclusion that a division of the field into two components is possible in some of them. The inner prominence field is observed when studying the fine structure and motions in the filaments [282, 284] and when measurements in the prominences are taken with the help of a magnetograph. This field is associated with the photospheric sources of the opposite polarity [282] and its direction suffers a large shift at the filament ends, being oriented along their axes. It is necessary for prominence plasma isolation. A supporting field, indicated by the structure of the lower lying photospheric field, is oriented at angles from 60° to 90° relative to the filament axis [293].

The statistical analysis, performed by Tandberg-Hanssen and Anzer [300], showed that the field in quiescent prominences is on the average, at an angle of 15° relative to their axes. Besides, it was assumed (as in [82]) that the correlation between the intensity and direction of the field was absent. It is also assumed that the field enters the prominence at one side and exits at the other one, changing its direction inside the prominence.

The assumptions on the field direction inside the prominence being along its axis, are in agreement with those on the orientation of a transverse photospheric field component along the filament [301]. But later Ioshpa [204] showed that the field azimuths above the filament are, on the average, equal to 37° and 45° at emission levels of Fe I λ 5250 and Ba I λ 4554, respectively (the azimuthal difference possibly reflects the incidence of the filament plane at the photosphere [302]). In a number of cases, especially for filaments associated with large sunspots, the direction of the field is perpendicular to the middle part of the filament and only at its edges is parallel to it [84, 175]. The latter agrees with Prata's opinion [303] on the existence of two types of neutral lines: parallel and perpendicular to the filaments. If the fine structure of the chromosphere reflects the distribution of the field [304—306], the orientation of fibriles along the filament near it and chaotic orientation remote from it [306] shows that the filaments are located in regions of the ordered chromospheric field.

The question of the orientation of the prominence field is of great significance, because it will help to define the nature of the fields in these formations and their relation with the underlying ones. The results obtained are somewhat contradictory for a number of reasons:

(a) low space resolution in terms of image quality enables us to sample, at best, the parts of prominences with dimensions of the order of 7000—15,000 km. Besides, not the field intensity, but the total magnetic flux, integrated along the line of sight, is recorded. With such rough measurements it is impossible to select a fine structure of the prominences, observed on the disk with high resolution [299, 303, 304] with sufficient reliability. The total magnetic flux is recorded under these conditions even if two systems of the fields exist;

(b) only a longitudinal field intensity component is measured in the prominences.

One can obtain the observational material needed for determinating the field orientation only when field vector recordings or a two-dimensional distribution of the longitudinal high resolution field are available;

(c) a formal approach in the statistical study of the problem (82, 89, 287), or the simplification of the realistic picture of the field may yield unambiguous results which can hardly be consistent with specific observational data.

2.3.3. But little is know of the relation of the field with other physical conditions in prominences. In a number of cases an inverse relation between the field and the brightness is noted [89, 90, 273]. The field appears to be the same when measurements are taken in hydrogen, helium, natrium and magnesium lines [82, 269, 287]. This may indicate plasma and field homogeneity in quiescent line-of-sight prominences. Nevertheless, one cannot neglect the differences between the lines of various elements as the resolution increases [287]. According to a recent representation of the mechanism of prominence formations [210] one could expect the physical conditions across the arch field, supporting the prominence, to be anisotropic.

Zirin and Severny [270] assume that the field governs the plasma motion in the prominences. Malville [298], draving on the random orientation of the field [89, 90], has found that the latter suppresses both macroscopic and turbulent motions, perpendicular to the lines of force, but that the increase of the field and plasma density in the prominences may be due either to its activation by the flare, or to the ordering of the earlier chaotic field, or to the orientation with respect to the observer [284]. Turbulent velocities were defined by Malville from Doppler K-line widths (the field was measured by Rust [89, 90] in H_α-line) without taking into account the possible changes of the kinetic temperature and the differences in the behaviour of the line profiles of various prominence elements [308, 309].

2.3.4. Harvey has determined that approximately in 40% of the quiescent and in 33% of the active prominences there are regular oscillations of the plasma motion velocity. Their average period is 5.5 min and range from 2 to 16 min [82]. Deubner [307] has explained these oscillations by the combined effects of the horizontal velocity gradient and image motion across the magnetograph aperture. However, the frequency of the solar image oscillation is much higher. Velocity oscillations in prominences may be due to oscillations of photospheric origin, transmitted by the magnetic field [82]. The typical time of most rapid changes in the active

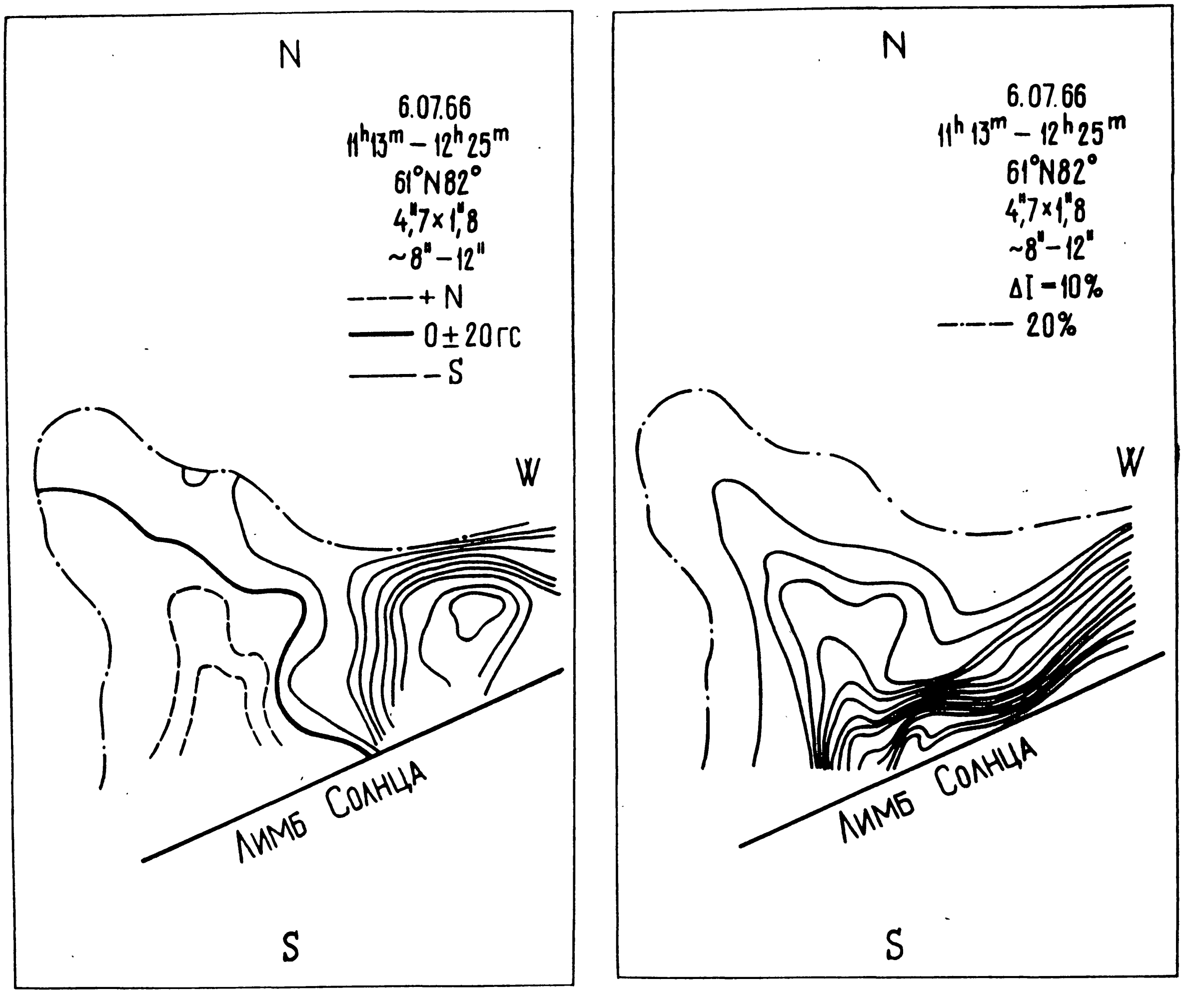

Fig. 3. Distribution of field (a) and brightness (b) in the quiescent prominence.

prominence field is 10^3 sec [82], which agrees in order of magnitude with the period of the prominence oscillations or their activation [234, 235].

2.3.5. In all the papers, mentioned above, the field was measured in individual parts of the prominences. Only Zirin [272] and Harvey [82] each succeeded in drawing maps of the field which showed its variability in the quiescent prominences. As already noted, the main difficulty in measuring the prominence field is associated with the change of the line profile shape within these formations.

A detailed study of the character of the change of some line profile shapes in the quiescent prominence spectra [308, 309] showed that not only Doppler widths [84, 271] affect the magnetograph signals, but other parameters too [310]. On this basis, a magnetographic method was developed [311, 312], which enabled us to start recording the two-dimensional distribution of the longitudinal field in quiescent prominences [309, 313—316] in 1966. One of the maps is given in Fig.3.

The maps of the field, obtained at the Sayan High-Altitude Observatory, provide new information on magnetic field properties in the quiescent prominences. A preliminary study of the field, combined with other physical conditions in these prominences, did not yield definite results on the relation of the field with the hydrogen distribution, and macroscopic and turbulent motions [309, 316]. It was only found that neutral hydrogen, neutral helium and ionized calcium move in the prominences with different radial velocities [308, 309]. Two types of the two-dimensional distribution of motions in the quiescent prominences have been established — motions in two opposite directions, divided quasi-normally and quasi-horizontally relative to the limb. In the former case, the plasma rotated as if clockwise, in the latter, near the limb, it moved toward the observer. In arch prominences it streamed down along both branches. The field intensity is sufficient to contribute to macroscopic plasma motions [270, 316]. The directions of the radial velocities do not depend on the field sign [316]. These results do not support Malville's conclusions [298]. First of all, considerable peculiarities of the field properties were observed, associated with the orientation of prominences, the variability of their shape, the specific features of the underlying photospheric field sources. The magnitudes of the field, obtained by measurements at the Crimean Observatory [270—273] and in IZMIRAN [84, 275, 276], are confirmed. Fields of the order of 100 Gauss were first shown to be present in quiescent prominences by means of an independent photographic method [317], described with regard to these studied in [317—320]. The field value is changed unmonotonically with height and latitude. The height gradient may be 0.1 Gauss/km but more frequently is equal to $10^{-2}-10^{-3}$ Gauss/km.

The field configuration is often of an arch character. Its sign in the arch branches is unambiguously defined by the photoshperic fields [313–315]. In prominences, not associated closely with active regions, the field is oriented mostly normally with respect to the filament axis [314].

Polar prominences reflect the behaviour of the magnetic field separation line of the current and preceding sunspot cycles. The field sign in them strictly obeys a definite pattern [304]. This tendency was discovered by Rust [89, 90]. These circumstances show evidence for the unambiguous relation of the fields in quiescent prominences with underlying photospheric fields [313, 314].

Drawing on the present knowledge of the fine chromospheric and prominence field structure one may assume that the orientation of the field in filaments depends on the value of the underlying fields, or upon the extent of their relation with the active regions. In stable quasi-stationary filaments, or in some parts of them, the predominant field is directed across their axes. Besides, the prominence material can move along the fine fibriles (~ 1") representing the materialized lines of force and oriented normally to the filament axis, or along the arched magnetic field lines. The axes of unstable dynamic prominences or unstable parts of quasi-stationary prominences, as well as fine structural features coincide with the direction of a strong field in the active regions.

In this case the object, consisting of a system of fibriles, can move along the field as a whole, e. g., to the "centre of attraction".

Therefore, only the fine-fibered filament structure coincides with the direction of the fields which may form, together with the filament axes, different angles, depending upon the prominence type: the field is mostly perpendicular to the axes of the quiescent filaments, located far from active regions where there are no strong photospheric fields, i. e. the disturbances are small, and, on the contrary, the field should be directed, as a rule, along the axes of unstable active prominences. Considering these representations, two field systems, introduced by Ioshpa [84], may be explained by the external field of the photosphere. This also makes it possible to understand the results of the American researchers better [81, 82, 89, 90, 291, 293, 300].

The following facts are evidence in favour of the field orientation across the filament:

(a) The discontinuity of filaments in places where the fields are of equal sign [86];

(b) the fine structure of filaments, consisting in some cases of fine fibriles, oriented across the filament axis and terminated above the fields of opposite polarity [299, 303]. When the resolution is not high enough, this fine structure merges, forming an amorphous filament image of the usual type;

(c) the reversal of the field sign when observing the prominence from different sides relative to its axis [89, 90, 314];

(d) the coincidence of field signs on the disk and in the prominence over its whole extent [84, 89, 90, 271, 311, 314].

In the active prominences, surges, fields of the order of 600–800 Gauss were recorded by us with the help of a photographic method [319, 320] well consistent with the magnetograph measurement results obtained by Zirin [271] and Ioshpa [275, 276]. But in one surge uncomprehensibly large fields were found at simultaneous measurements in the H_ε-line — about 3000 Gauss, in H and K over 1000 Gauss. The difference in field values, determined in various lines, can hardly be explained. It is quite possible that the difference of the measurements in lines H and K is within measurement errors (in [320] they are not completely taken into account) and in H_ε the field was underestimated due to line weakening. The discrepancy in the data, obtained in different lines, having various forms of magnetic splitting, may be caused by the interaction of the emission of σ-components [257] in strong fields, or by excitation of hydrogen and ionized calcium lines in different parts of the surge [320].

Thus, one may at present consider that the existence of relatively strong fields in prominences is a well established fact: upto 300–400 Gauss in quiescent prominences and of the order of 1000 Gauss in active ones. The field energy is considerably higher than that of plasma motions. In prominences it has an arch configuration. The sign of the field in the arch branches depends unambiguously upon that of the photospheric field. All this explains the significant role of the magnetic field in the formation and prolonged existence of prominences.

The main goal of subsequent investigations of magnetic prominence fields is to determine the relation of their properties with the other physical conditions in these formations and in the surrounding corona. Of a great practical interest is the study of these properties in prominences and filaments during the pre-flare period.

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