ON THE MAGNETIC-FIELD STRUCTURE AROUND FILAMENTS

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The results of an investigation of the magnetic-field structure in the chromosphere around filaments are briefly given in this paper. The hypothesis of the existence of a two-field system is suggested: an outer field which has the form of arches and supports the filament against gravity, and an inner one, directed along the filament.

The magnetic-field measurement was carried out with the magnetograph of the IZMIRAN Tower Solar Telescope (Zhulin *et al.*, 1965) in the photospheric line (Fe I λ 5250·2 Å) and the chromospheric line ($H\beta$). The study of the distribution of the longitudinal component in photosphere and chromosphere confirms Babcock's original conclusion that the filaments are preferably located near the boundary of the magnetic-field polarities. One can also see from a study of the magnetic maps that in a number of cases filaments near their ends cross the zero-line of the longitudinal field of the photosphere (it was also stated previously by Stepanov (1959) and by Howard and Harvey (1964)). They also pass through regions of strong chromospheric field of a single polarity (Ioshpa, 1967). Figure 1 shows the chromospheric (a) and the photospheric (b) field near the spot surrounded by the filament in the centre of the disk (August 4, 1963). For the same region all the photospheric field components were measured simultaneously (according to the method described by Ioshpa and Obridko, 1966). The distribution of the magnetic-field azimuths over the solar surface in that region for August 1 and 4 is presented in Figure 2 (a, b). One can see that the middle, the most 'massive' part of the filament, is preferably located across the magnetic field; but in those places, where the filament is pulled into the spot, the position of the filament appears to be along the direction of the lines of force. Comparison of the magnitudes of the longitudinal $H_{\parallel}$ and transversal $H_{\perp}$ components shows that in the region of the filament location the photospheric field is close to the horizontal one (the longitudinal field near the filament does not exceed several tens gauss, while the mean value of $H_{\perp}$ is about 200–300 gauss (Ioshpa, 1967). Thus in the region of a strong field the structure of which is mainly determined by the spot, the filament lies perpendicular to the nearly horizontal magnetic-field lines in the photosphere and at its ends – parallel to them.

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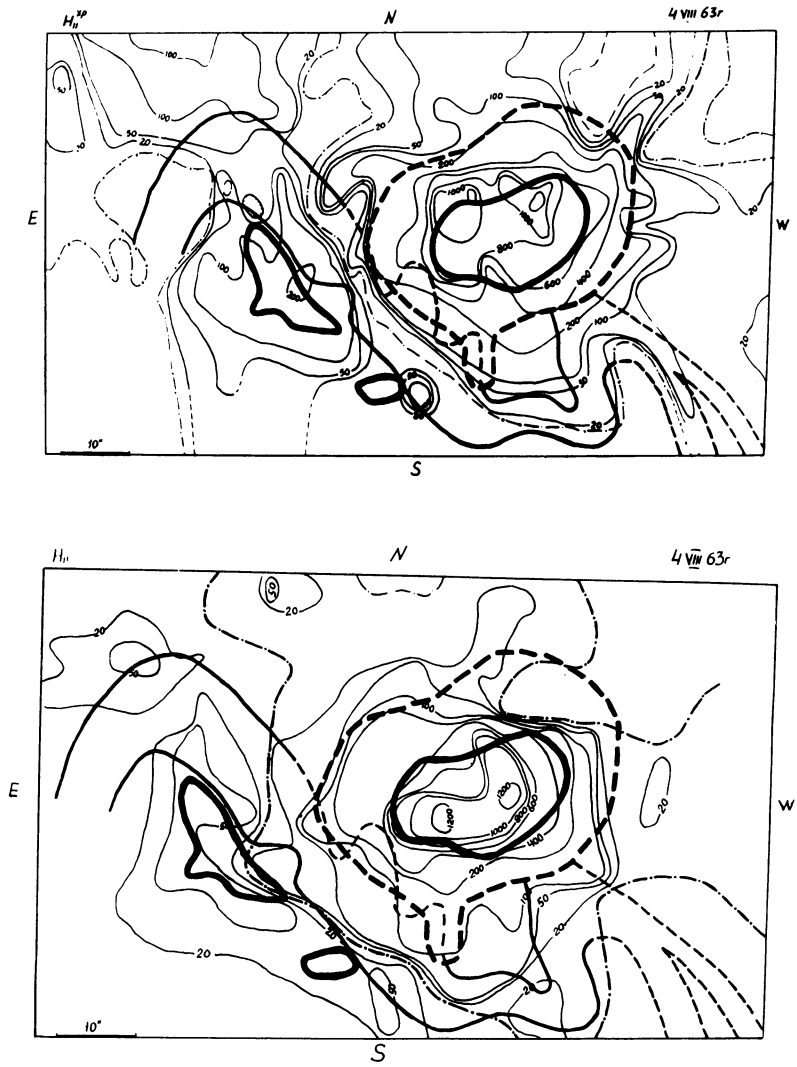

FIG. 1. *The longitudinal magnetic-field maps near the centre of the disk in the region of the sunspot, surrounded by the filament; a – in the chromosphere (Hβ). b – in the photosphere (λ 5250·2 Å). Thick solid lines represent the sunspot umbrae, the hatched thick line – penumbra; the solid line of medium thickness – the filament – the thin solid lines, the lines of an equal field intensity; the thin hatched-dotted line represents the zero line of the longitudinal field ($H_{\parallel} = 0$). In the places where the measurements were not very certain, the isolines are hatched. In the S–W corner of the maps the chromospheric fibrils are shown by the hatched lines.*

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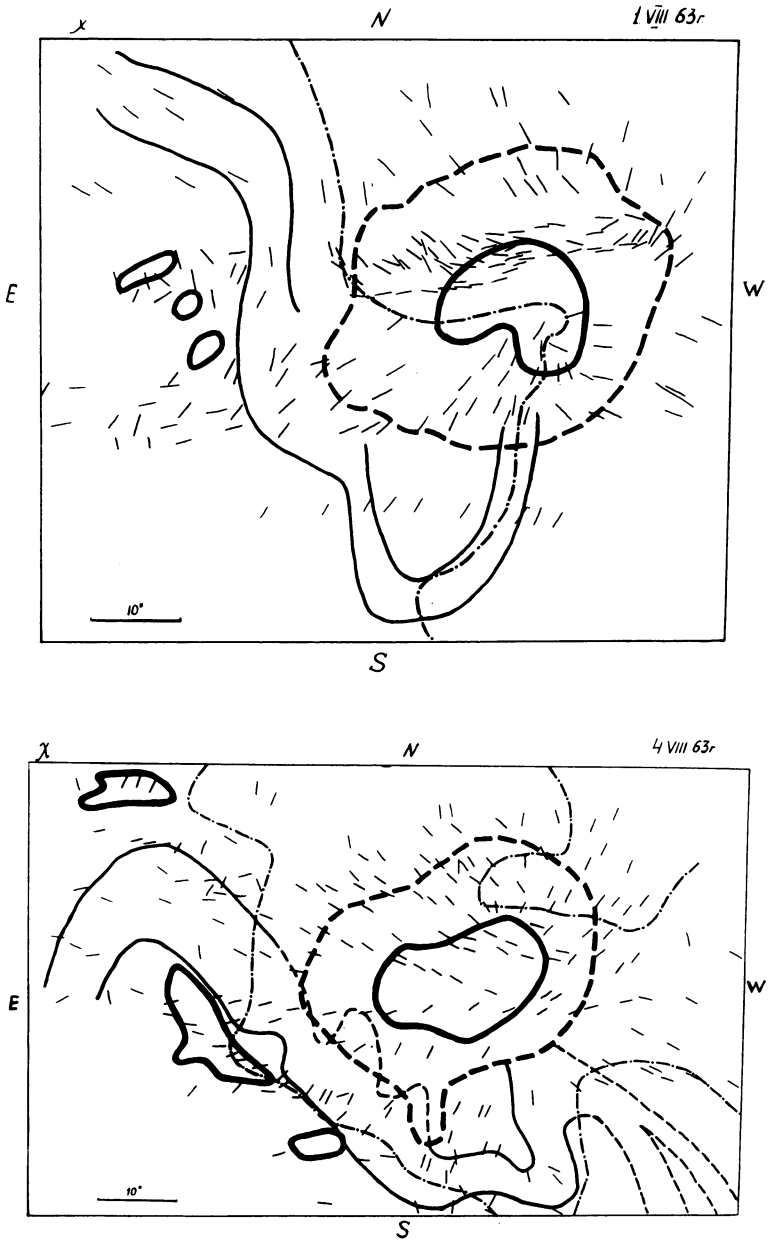

FIG. 2. *The distribution of the magnetic-field azimuths in the same group as on the Figure 1. (a) for August 1; (b) for August 4, 1963. See caption to Figure 1.*

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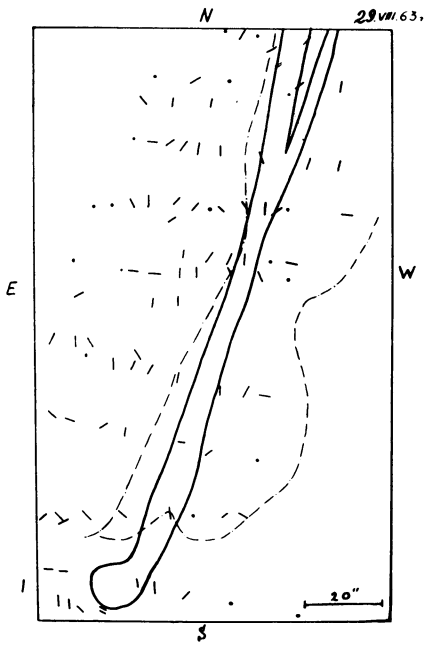

FIG. 3. *The distribution of the magnetic-field azimuths in the region of the quiet filament. The zero line of the longitudinal field is represented by hatched-dotted line (–•–•). The places where the transversal magnetic field is less than the sensitivity of measurement (50–60 gauss) are shown by dots.*

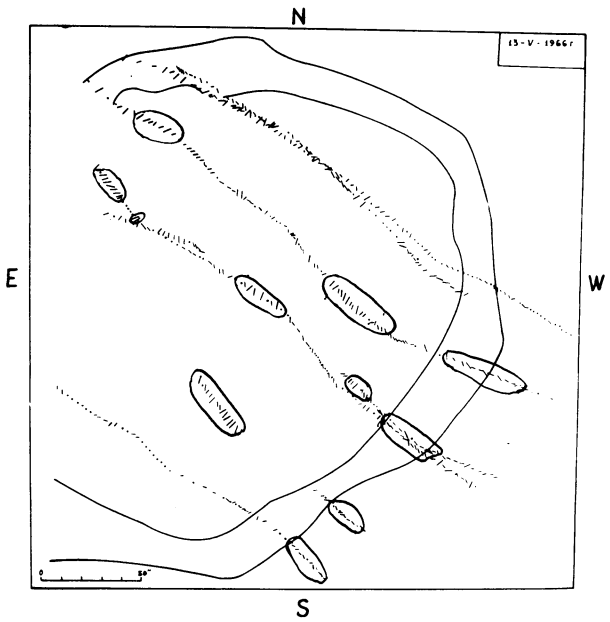

FIG. 4. *The distributions of the magnetic-field azimuths in the region of the quiet filament near the centre of the disk. The most reliable values are encircled.*

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Another structure of the magnetic field was found in the region of quiet filaments not associated with spots. Figure 3 shows the distribution of the magnetic-field azimuths in the region of the quiet chromospheric filament, obtained on August 29, 1963 (co-ordinates of the filament $\varphi \approx -10°$, $\lambda \approx 290°$). The filament was surrounded by flocculi. The field (from the comparison of $H_{\parallel}$ and $H_{\perp}$) is also nearly horizontal. The preferable direction of magnetic-field lines is along the filament. It should be noted that in this case the filament's position is also near the zero line of the longitudinal field. As some other examples, we present the maps of the magnetic-field azimuths obtained on May 18 and 19, 1966 near c.s.m. in the region of the two quiet filaments, which are arch-shaped (Figures 4 and 5). On Figure 4 the most reliable values are encircled. One can see, that the magnetic-field structure in the region covered by the filament is in a good correspondence with the shape of the filament. But near the filament and directly under it the direction of $H_{\perp}$ in some cases changes sharply and is perpendicular to the filament (it is seen most clearly on Figure 4).

We have already suggested (Ioshpa, 1967) the existence of a two-field system near the filaments; an outer arched one on which the filaments lie, and an inner one directed

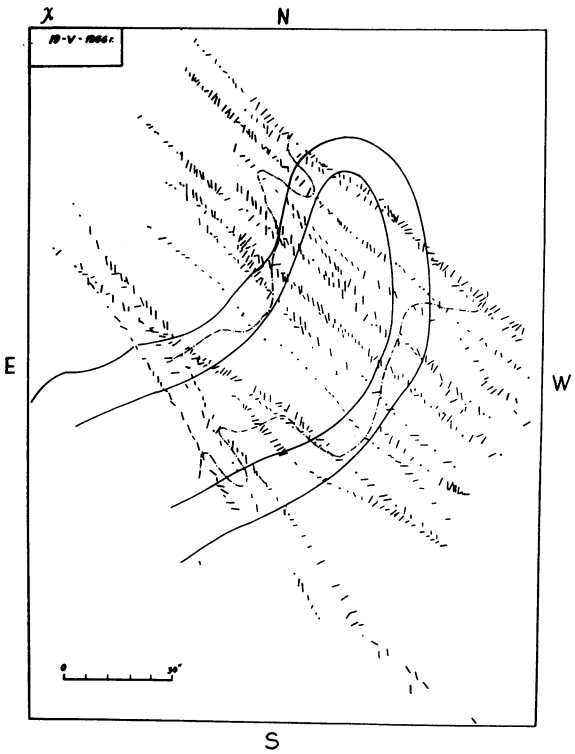

FIG. 5. *The distribution of the magnetic-field azimuths in the region of the quiet filament near the centre of the disk.*

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along the filament. An outer arch field supports the filament against the gravity (Kippenhahn and Schlüter, 1957). The existence of such a field explains the filament's preferable location along the zero line of the longitudinal field. Our results also confirm the existence of such a field. At the same time a number of facts speak in favour of the existence of a field which is directed along the filament: in particular the discovery of a significant field (~ 60 gauss) observed in some prominences not connected with an active group along their great axis; the field structure near quiet filaments; the field structure near the ends of sunspot filaments and some theoretical considerations on the filament stability (Ioshpa, 1967). The orientation of the filament, and consequently of the field in the filament, as it is shown in Figures 4 and 5, are closely associated with the field structure at the photosphere level. It seems that the presence of a two-field system near the filament corresponds to the presence of such systems of the field in the photosphere.

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DISCUSSION

Sturrock: If there is slippage at the neutral line at the photosphere the force-free magnetic field will have component transverse to and parallel to the neutral line. Is this interpretation compatible with the observations?

Ioshpa: The observations suggest that in some cases there are two components of magnetic field: one is parallel to and another is transverse to the filament or the neutral line in the photosphere. But I do not consider yet, how well these results correspond to the force-free model of the magnetic field. It seems that, at least, they do not contradict it.