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VELOCITY FIELD STRUCTURE NEAR QUIESCENT FILIAMENTS

G.P.Mashnich, V.S.Bashkirtsev, H.M.Golubeva, and A.I.Khlystova

Institute of Solar-Terrestrial Physics SB RAS, Irkutsk,
664033, p/b 4026, Russia
e-mail: mashnich@iszf.irk.ru, vsb@iszf.irk.ru, golubeva@iszf.irk.ru

ABSTRACT

The motion of material in the filament region of active complexes has long been the subject of investigation. In this paper we present the results derived from studying the Doppler velocity field in the region of filaments which are not associated with active complexes.

OBSERVATIONS

The observations were made at the SSO with the horizontal solar telescope featuring the automatic guiding system. The photoelectric guider attached to the telescope makes it possible to accurately maintain the solar image on the spectrograph slit, compensate the Sun's rotation, and to scan at given steps the areas selected on the Sun. An additional device with the Hα–filter and the spectrograph mirror slit were used to point to regions of interest and to monitor the position of the object on the spectral slit at the time of observation. The cassette side of the ASP-20 spectrograph includes the Princeton Instruments 1024x256 pixel matrix. The matrix size make sit possible to cover about 8 A of the spectrum (the resolution is 0.0078 A/pixel). The height of the spectrum - 256 pixels along the spectrograph slit - corresponds to 65" on the solar surface. The width of the spectrograph entrance slit is 0.1 mm, which corresponds to 1" on the solar surface. Spectrograms in the region under investigation were taken by a step-by-step scanning at steps of 5". A single scanning takes 30 s. To eliminate quasi-periodic oscillations and minimize the influence of seeing, the scanning of the region under investigation was repeated for 10 min.

Doppler shifts were calculated by a classical method from reference lines. In order to calculate the dispersion and the reference line position, the desired parameters are specified: the values of the wavelengths of the working and reference lines, the positions of their centers, and the number of pixels in the blue and red wings of the lines, which is necessary for an accurate determination of the line centers (Fig.1). The Doppler shift of the working line in all spectrograms is determined with respect to the reference lines of the first spectrogram. This method provides values of the relative line-of-sight velocity in a given object simultaneously in the Sun's photosphere and chromosphere, as well as makes it possible to construct intensitograms from intensity data for the center of the Hβ line. The intensity maps were constructed in arbitrary units in the form of contours. Full-disk Hα images from BBSO taken at the time coincident with the time of our observations were used to determine the angle between the line-of-sight projection and the filament long axis. Based on the intensitograms obtained, we attempted to join together the line-of-sight velocity maps of separate fragments of the filament in which the observations were made. The line-of-sight velocities in the dopplerograms are represented as dark gray – negative velocity, white – positive ones, and gray - zero. Contours of the filament fragments are plotted on the respective chromospheric and photospheric dopplerograms as a black line. The arrow indicates the direction from solar disk center.

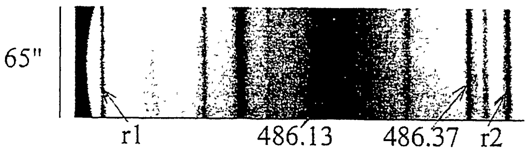

Fig.1 Working region of the spectrum is shown. The first reference line r1 is λ 485.739 nm, the second one r2 is λ 486.432 nm. For the chromosphere the working line is Hβ (λ 486.134 nm), and for the photosphere the working line is Fe I 486.365 nm.

DATA ANALYSIS

We analyzed the observations in three quiescent filaments which were to the east and west of the central meridian and had a different orientation of the filament axis with respect to the line-of-sight projection. The structure of the line-of-sight velocities in filament I was followed for four days, from 25 to 28 August 2001, the period taken by the filament to pass the distance from 59E to 06E of longitude. At the same period filament II in the southern hemisphere crossed the central meridian, so that at the first and fourth days of observation one of its fragments was nearly at the same distance from the central meridian. The position of filament III near the solar limb created favorable conditions for observing horizontal flows along the filament.

As regards the observations of filament II in the southern hemisphere (those days it was in the longitude range E21 - E18 and W20 - W23 at latitude S12), dopplerograms for 25 and 28 August are presented

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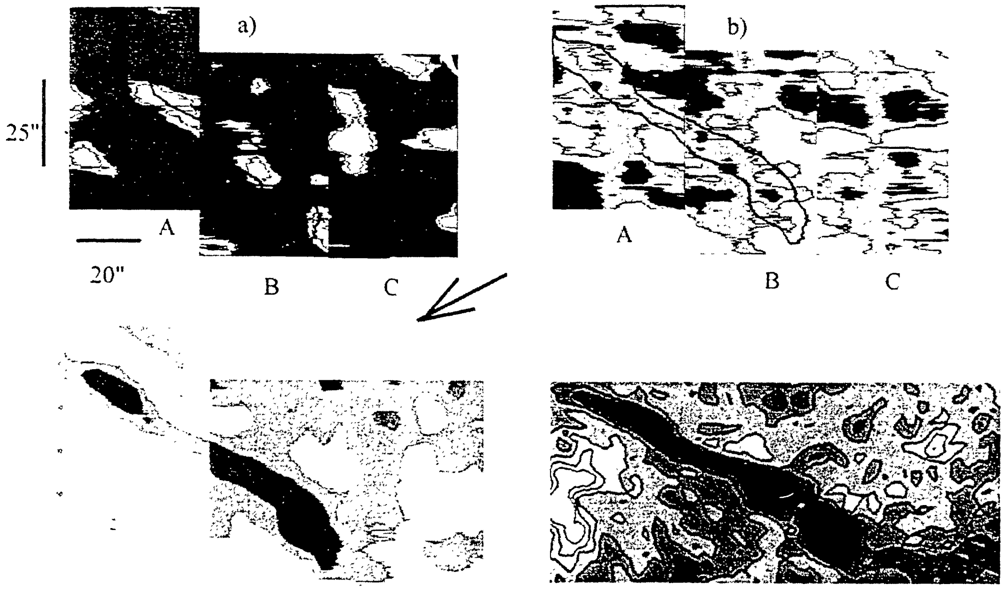

Fig.2. August 25, 2001, Filament II (ES), UT ~ 07h: (a) Chromospheric radial velocity map (λ 486.1 nm), (b) photospheric radial velocity map (λ 486.3 nm) c) Hβ intensitogramm ,d) Hα image from BBSO. Dark gray areas mean the negative line-of-sight velocity (motion to observer), white ones – the positive line-of-sight velocity, and gray –zero. The black line is plotted contour of the filament.

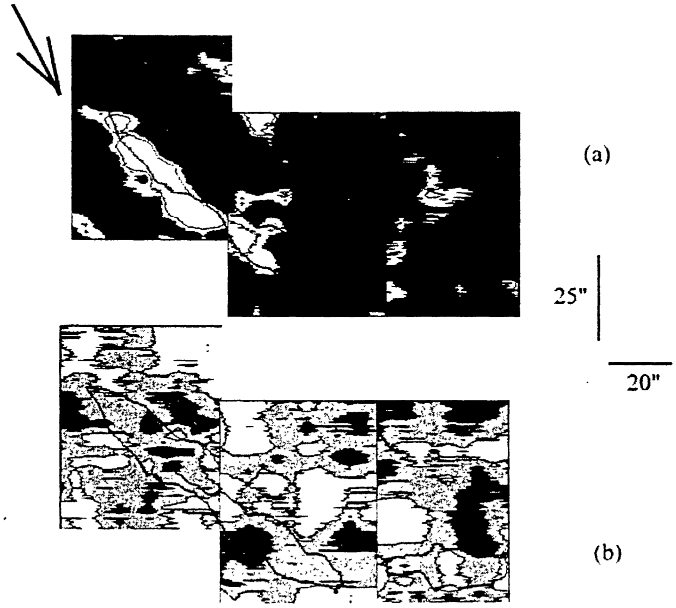

Fig.3. August 28,2001, Filament II (ES), UT ~ 06h30m – 08h: (a) chromospheric radial velocity map (λ 486.1 nm), (b) photospheric radial velocity map (λ 486.3 nm). Dark gray areas mean the negative line-of-sight velocity (motion to observer), and white ones – the positive line-of-sight velocity.

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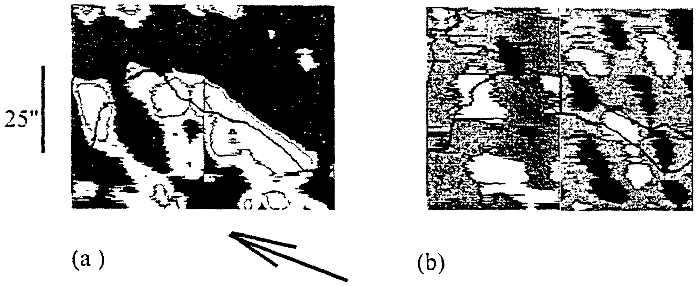

(a) (b)

Fig.4. August 25, 2001, Filament III, UT ~ 00h20m – 01h: (a) Chromospheric radial velocity map (λ 486.1 nm), (b) photospheric radial velocity map (Fe I λ 486.3 nm). Dark gray areas mean the negative line-of-sight velocity (motion to observer), white ones – the positive line-of-sight velocity, and gray - zero .

in the Fig. 2 and Fig. 3. On 25 August the filament showed an alternation of oppositely directed motions. The filament position with respect to the line of sight and the simplicity of the neutral line suggest that the observed motions reflect a spiral structure of the filaments with oppositely directed motions in neighboring spirals. The distance between different-sign velocity elements is about 15 000 km. Counterstreaming mass within filaments in fine structures were detected by Zirker at al., (1998). The fragment C in Fig.2 refers to the region where the fibril structure in the Hα image corresponds to the structure of the filament channel, as described in the literature (see, for example Gaizauskas et al., 1997); in this case, however, there are no dark filaments either in Hα image or in Hβ intensities. The velocity field structure differs from neighboring fragments by the larger scale of cells with a different velocity and by their relative position. Marked changes in the filament were observed on 28 August. Extensive areas of oppositely directed motions with high velocity gradient along the filament axis were in fragment A (Fig. 3 (a)) and partially in B. The long axis of the filament was oriented at a small angle to the line of sight and on different sides of the filament the line-of-sight velocities of a different sign are observed, which implies the presence of shear motions in these parts. It should be noted that around the filament in the chromosphere there occurred an enhancement of the negative velocity in the three fragments by as much as (-3 km/s), which must signify an increase of the vertical component, i.e. the rise of material around the filament. Simultaneously with all these changes, a small dark element of the filament developed in fragment C.

Finally, filament III was observed on 28 August at latitude N12 in the longitude range E67-E60. The axis of most of the filament coincided with the line of sight, so that there was an ideal possibility of investigating the motions along the filament axis, if any. As can be seen from Fig.4 (a), in the chromosphere the filament lay at the interface of two regions with counterflows and a high line-of-sight velocity gradient along the filament axis. The structure of the velocities in this filament, as well as in filament II of the southern hemisphere in the fragment A (Fig. 3b) reflect the presence of shear motions.

Some regularities in the structure of photospheric velocities under the filament are derived from analyzing the dopplerograms taken in the line of Fe I λ 486.3 nm. In many fragments there exist regularly alternating regions of a different sign. This is particularly evident in photospheric dopplerograms in Fig. 4 (b) for filament III. In the part of the filament where shear motions are observed in the chromosphere, in the photosphere under and outside of the filament chains of elements of positive and negative line-of-sight velocity are arranged at a large angle to the filament axis. In some of the fragments of the filaments in the chromosphere the motions are oppositely directed (see the fragments A in Fig. 2 (a) and (b); fragments A and B in Fig. 3 (a) and (b), and others). The value of the velocity of the motions in the photosphere is typically about 0.5 km/s. Values of photospheric velocities under the filaments are decreasing as the features come nearer to the central meridian.

CONCLUSION

Results of our investigation are of interest primarily because of the line-of-sight velocity measurements that were made in the region of quiescent filaments simultaneously at two levels in the solar atmosphere. It has been shown that not only the well-known helical motions but also flows implying the presence of shear motions are observed in the filaments at the chromospheric level. Until the present time shear motions have been discussed in connection with photospheric motions under the filament (Magara & Kitai, 1999) or as one of the conditions of filament eruption. We believe that the horizontal component makes a large contribution to photospheric motions

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under the filament. The combination of many kinds of motions in a single filament brings up many questions. It only remains for us to agree with other authors on the fact, in order to solve the many problems in the physics of prominences we should investigate the filament over the course of its lifetime, especially in the initial phase of its formation.

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