SPATIAL DISTRIBUTION OF LINE-OF-SIGHT VELOCITIES IN A QUIESCENT PROMINENCE

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ABSTRACT

In 26- 29 June 1990 Doppler velocity observations in a quiescent prominence were carried out. Using a device based on a image dissector (TV -tube), the Doppler velocity profile in prominence height were measured quasi-simultaneously at two intensity levels in the line H_β 486.1 nm. It was found that through the entire height of the prominence, there are 3-4 elements with quasi-hourly oscillations. Relative to each other, the oscillations in these elements show a random phase. The distance between such elements is about 20". Quasi-five-minute oscillations have a train-like character and a random phase at neighbouring points of the prominence (separation ≈ 4").

Keywords: Prominence oscillations.

1.INTRODUCTION

Numerous investigations of line-of-sight (Doppler) velocities in prominences show oscillations with different periods to be present in them (Refs. 5, 6). In this case observations with low (8"×8") spatial resolution (Ref. 1) reveal periods from 40 to 80 min while short periods are usually absent. Observations with high (2"×2") spatial resolution (Ref. 6) indicate the presence of the quasi-five- minute oscillations in separate places of the prominence. Spectral observations (e.g. Refs. 3, 4) give evidence that quiescent prominences consist of small-scale isolated loops.

One of the likely reasons for the presence of the oscillations in prominences is thought to be the propagation of Alfven waves along a magnetic rope that forms the prominence body. In this case the presence of magnetic flux tubes of different lengths must give rise to oscillations with different periods. So far, however, the presence of well-pronounced structures in the picture of prominence oscillations has not been observed. Some observers (e.g., Ref. 6) observed that the character of the oscillations was different in different parts of the prominence.

Our intention here is to study the spatial picture of the oscillations in a quiescent prominence.

2. OBSERVATIONS

The observations were made at the horizontal solar telescope of the Astronomical Institute of the Uzbek Academy of Sciences (Tashkent) during 26 to 29 June, 1990. The telescope's primary mirror is 440 mm in diameter, and the focal length is 17 m. Image scale is 1.2"/mm. To hold the solar image on the spectrograph slit, a photoelectric guider was applied (the accuracy of holding was about 1-2"). Doppler velocities were measured by means of special device based on a TV dissector-tube. According to the principle of measurement, this instrument is an electronic analog of the magnetograph Doppler compensator. The procedure of measuring the spectral line shift is as follows. By scanning along the dispersion, intensity measurements are made at two points of the spectral line profile (in the red and blue wings, respectively). As the spectral line shifts, the scanning interval is displaced so that signals measured in the opposite wings should be equal. A detailed description of the device is given by Druzhinin and Pevtsov (Ref. 2). The measurements were made in the line H_β 486.1 nm, with 0.32 Å/mm dispersion. The size of the dissector tube aperture was 0.3×0.3 mm^2, and the width of the spectrograph entrance slit was 2". The accuracy of Doppler velocity measurement was 20 m/s, and the r.m.s. spectrograph noise was 60 m/s. The image motion (seeing) was 2-4".

In the observations, the Dove prism was used to orientation the solar image in such a manner that the spectrograph entrance slit was perpendicular to the limb. Spectral line shifts were measured at two levels of its intensity (near the core and at the half-intensity level), with a simultaneous scanning in spectrum height. Thus, we recorded the Doppler velocity profile in prominence height at two intensity levels in the spectral line. The duration of each scan in spectrum height was 152 s. An area 80" in extent was

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scanned, and a scan covered virtually the entire height of the prominence from its top to the solar limb. The duration of a daily observing run was 2-4 hours.

The filament forming the prominence was parallel to the solar equator at +32° W latitude and was 120° in length. Such an orientation of the filament and its length permitted us to follow changes in the character of the oscillations in the prominence during 4 days.

3. HEIGHT DISTRIBUTION OF OSCILLATIONS

We have investigated the time behaviour of the velocity profile in prominence height. For each point of the velocity profile (in prominence height), we constructed a time series, characterizing the Doppler velocity variation at that point with respect to the initial moment. Fig. 1 shows an example of the time variations in Doppler velocity at different points of the prominence on one of the observing days. The distance between the individual points is about 1.7". The axis of ordinates (left) indicates the location of the point in the prominence with respect to the beginning of the scan (the position of the point in the prominence, for which the respective registrogram is given). The beginning of the scan corresponds to the top of the prominence. At right, the axis of ordinates indicates the scale for Doppler velocities (in km/s). The abscissa axis indicates time in minutes. This figure clearly shows the oscillations with a period of about 1 hour. In some places one can discern variations with periods of 20 min or shorter. Long-period (quasi-hourly) oscillations are more well defined in the upper part of the prominence. (Top of Fig. 1). Short-period oscillations (shorter than 20 min) are more characteristic for the lower part of the prominence. The amplitude of such short-period variations (100-300 m/s) is considerably smaller than that of the quasi-hourly oscillations (as high as 2 km/s). Such a picture of the oscillations was typical of all observing days. In the figure one can note some features in the picture of the oscillations. Primarily, the presence of areas with a different oscillation regime should be noted. (In Fig. 1 one can identify at least 3 such areas). Inside such a region the oscillations exhibit similar periods and phases, and the variations in the neighbouring area show markedly different periods or phases. (Thus, for example, the oscillations occurring in the middle of the prominence were opposite in phase to those in its upper part). One gets the impression that these areas have rather sharp boundaries.

The presence in the prominence of areas with a different regime of the oscillations is confirmed by a spectral treatment. Fig. 2 shows a spatial power spectrum for the same sequence of observations as in Fig. 1. The abscissa axis indicates the oscillation periods in minutes, and the axis of ordinates indicates the location of points in prominence height in arc seconds (as in Fig. 1). Contours show the spectral power (the square of the correlation coefficient) of the oscillations with corresponding periods. The contours are run out every 0.1 from level 0.1. The figure reveals four regions in the prominence body with

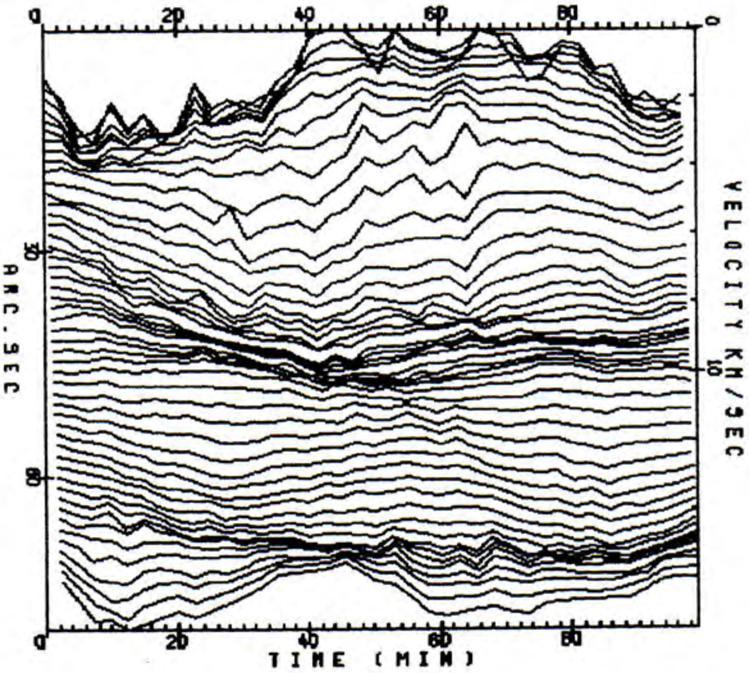

Fig. 1: Oscillations of Doppler velocity for the positions along the spectral slit (the axis of ordinates) crossing a quiescent prominence. The distance between the scan points is 1.7". Solar limb - at bottom.

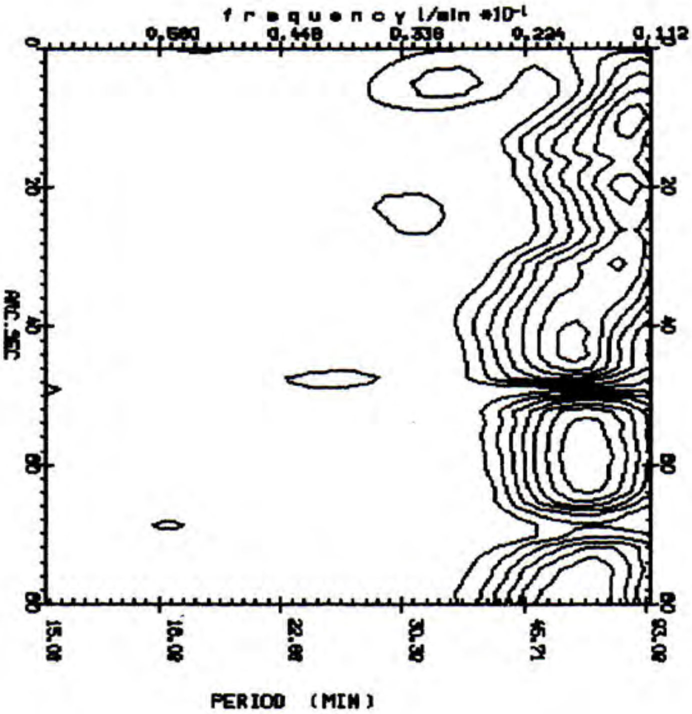

Fig. 2: Spatial power spectrum for the registrograms shown in Fig. 1. Contours (every 0.1 from level 0.1) show the spectral power (the square of the correlation coefficient) of the oscillations with corresponding periods indicated on the abscissa axis.

increased spectral power. In this case the oscillation period typical of each of the elements, increases with the height. Thus, the oscillation period in the upper and lower parts of the prominence is, respectively, 85 and 60 min. For the other days, the spatial power spectra also exhibit 2 to 4 elements in prominence height with their own oscillation regime. Analysis shows that the oscillations in each such element occur with similar phases. Oscillations in neighbouring elements with respect to each other have a random phase (that is, they occur independently of each other). Sometimes, oscillations in neighbouring elements proceed strictly opposite in phase (as in Fig. 1). A spectral analysis made by using the time sequence of 3-4 hour duration does not reveal any significant peaks in the power spectrum in the region of short periods (shorter than 20 min); however, the analysis of individual areas of a duration of up to 1 hour (from the same sequence of observations) reveals elements with oscillation periods 8- 20 min in prominence height. Fig. 3 shows the spatial power spectrum for a sequence of about 1 hour duration. One can see that the short-period oscillations have a smaller scale as compared with the long-period oscillations. Elements with short-period oscillations are located randomly in prominence height. The size of the elements with long-period oscillations is about 20", and the elements with short-period oscillations are 3-4" in size. The absence of short-period (8 -20 min) oscillations in the analysis of long time sequences seems to indicate their inconstancy (possibly, a train character). The spatial distribution of the prominence oscillations described here can be interpreted in terms of the presence of different-scale structures there. In our opinion, elements with oscillation periods from 40 to 100 min are associated with separate ropes of magnetic flux tubes that form the prominence. The shorter-period oscillations (shorter than 20 min) refer to individual flux tubes involved in these ropes. Taller ropes are also greater in length, which, possibly, explains the increase in the period of the quasi-hourly oscillations with height in the prominence. As has been pointed out above, we measured the velocity profile in the prominence at two intensity levels in a spectral line. The velocity profile measured near the line core, slightly differs from that measured at the half-intensity level. Slight differences are also observed in the spatial picture of the oscillations. We have not carried out a detailed investigation of the differences of these two velocity profiles, however.

4. CONCLUSIONS

The observations described here can be interpreted as a possible manifestation of the Alfven waves propagating in magnetic flux ropes forming the prominence. Our conclusions, however, are based upon the observations made with low spatial resolution. In order to understand the nature of the prominence oscillations, we believe, it is very important to reconcile the structures we observed in the

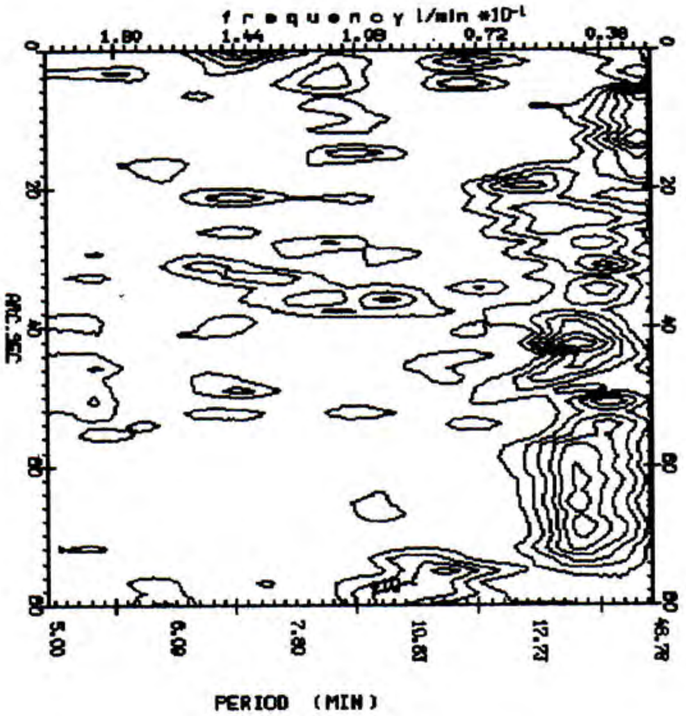

Fig. 3: Spatial power spectrum for a sequence of a duration of about 1 hour.

oscillation picture with the structures in the brightness. In our view, observations with high spatial resolution must show the presence of short-period (8-20 min) Doppler velocity oscillations in separate fibrilles involved in the prominence. Such an observational task could be formulated within the SIMURIS Mission. In turn, we are ready to participate in ground-based observations to support this program.

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