Astron. Astrophys. 235, 428–430 (1990)

ASTRONOMY AND ASTROPHYSICS

Observations of Doppler velocity oscillations of mass motion in a quiescent prominence during three consecutive days

G.P. Mashnich and V.S. Bashkirtsev

Siberian Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (SibIZMIR), P.O. Box 4, SU-664033 Irkutsk 33, USSR

Received November 10, 1989; accepted January 13, 1990

Abstract. Using a spatially-differential method Doppler velocity oscillations of mass motion in the Hβ-line were measured in a quiescent prominence during three days in July 1986. The length of time sequences ranged from 2 to 5 h.

Our previous result has been confirmed, namely that long-period oscillations are a typical property of quiescent prominences. Oscillation spectra of the prominence have a complicated structure in the region below 1.0 mHz; short-period variations of Doppler velocity are absent. During all the observing days the quasi-hourly period was dominant.

Key words: the Sun: prominences – oscillations

1. Introduction

During the past several years there have emerged intensive investigations of oscillatory processes in prominences. The observed oscillations may be categorized into two classes: short-period oscillations with periods from 3 to 10 min and long-period oscillations having a period from 40 to 80 min. Oscillatory phenomena in prominences were reviewed by Tsubaki (1987). The prominences studied to date have usually been quiescent ones and were unassociated with flare activity. Balthasar et al. (1988) reported the detection of complicated oscillation spectra of the Doppler velocity in prominences where both types of oscillations are present. The fundamental frequency of eigen-oscillations of prominences is close to 1.0 mHz. These authors made a detailed analysis of periodic variations of the Doppler velocity on the basis of long continuous sequences (of 5 and 7 h) of observations in five prominences. Nevertheless, the question as to how long these periodic variations and their spectra persist in prominences still remains unclear.

In this paper we shall present observations of velocity oscillations in one quiescent prominence made during three days. The duration of a continuous sequence of observations on different days varied from 2 to 5 h.

Send offprint requests to: G.P. Mashnich

2. Observations and results

The observations have been made at the horizontal solar telescope of the Sayan observatory during 28–31 July 1986. The prominence appeared on 28 July at the west limb at latitude $\varphi = -35°$. The image on the spectrograph slit (the spectrograph dispersion in the 5th order is $3.12\,\mathrm{mm\,A^{-1}}$) was maintained with the aid of a photoelectric guider. Doppler velocity variations were recorded in the Hβ-line using the spatially-differential method (Kobanov, 1983). In this method a differential Doppler velocity signal from two prominence areas is recorded. The setting of the prominence on the spectrograph slit was carried out with the help of an Hα-filter. At the beginning and at the end of the recording filtergrams were taken for checking the prominence position on the slit and possible changes in the overall appearance of the target during the time of observation. In Hα-filtergrams on previous days the prominence looked like a very large filament consisting of separate connected fragments and extending by more than 50° along the latitude. Prominence areas of the size $8'' \times 8''$, from which the differential Doppler velocity signal was formed, were separated parallel to the solar limb by 12″. Registrograms were processed by the method of correloperiodogram analysis (Kopecky and Kuklin, 1971).

A general form of the prominence and the records of time variations of the Doppler velocity in it on different days are shown in Figs. 1 and 2. Long-period velocity variations are well traceable in non-processed registrograms on all observing days. The amplitude of quasi-hourly variations changed from $200\,\mathrm{m\,s^{-1}}$ to $260\,\mathrm{m\,s^{-1}}$. The accuracy of determining the amplitude is not worse than $20\,\mathrm{m\,s^{-1}}$. Figure 3 gives power spectra of the oscillations. A solid line denotes the 99% significance level. Peaks in the power spectrum lie mainly in the region smaller than 1.0 mHz. The dominant peak lies at about 0.3 mHz. Such a general behaviour of the spectra remains the same on all days of observations.

In addition to a maximum peak of about 53 min, the spectrum of the prominence on 28 July 1986 (Fig. 3a) shows several peaks above the significance level in the range of 23, 27, 38, and 85 min. The spectrum taken on the subsequent day, 30 July 1986, is presented in Fig. 3b. The longest record of 5 h was obtained on 31 July 1986 (Fig. 3c). On that day, two powerful peaks were manifest in the oscillation spectrum of the prominence: the main

Fig. 1a–c. Examples of Hα slit jaw pictures of the prominence ($\varphi = -35°$ W). **a** 28 July 1986, UT = 00:25; **b** 30 July 1986, UT = 01:25; **c** 31 July 1986, UT = 05:59

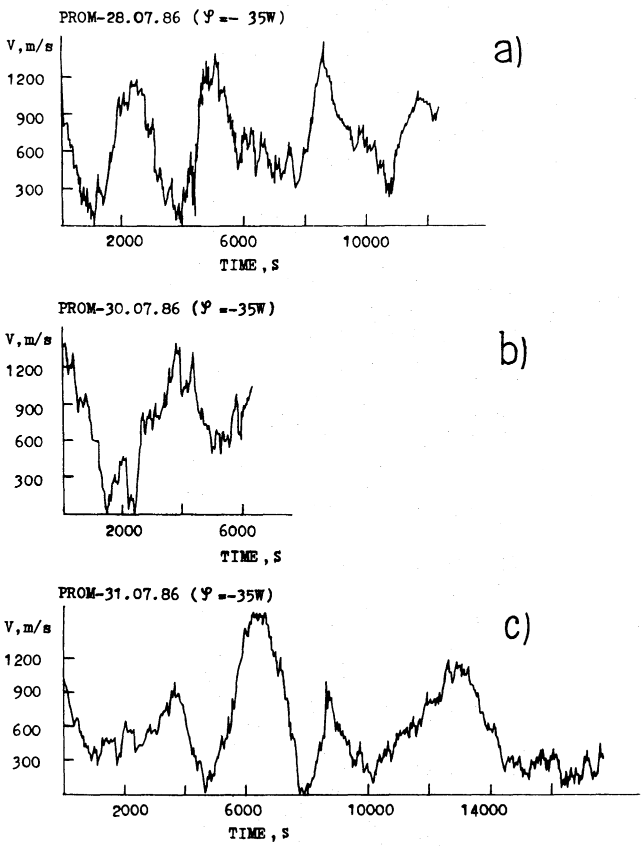

Fig. 2a–c. Copies of the time variations of Doppler velocities as derived from the Hβ-line. **a** 28 July 1986, 00:34 ≦ UT ≦ 04:00; **b** 30 July 1986, 23:22 (29 July 1986) ≦ UT ≦ 01:18 (30 July 1986); **c** 31 July 1986, 00:50 ≦ UT ≦ 05:55

peak of about 54 min and a secondary peak of about 114 min. As in the preceding days, several significant peaks are present in the spectrum; of 28 and 39 min. In this prominence, as before (Bashkirtsev et al., 1983; Bashkirtsev and Mashnich, 1984) on none of the observing days did we identify in the spectra any significant variations of Doppler velocity in the range of short periods.

3. Discussion

The purpose of this study has been to examine how the oscillation spectrum varies during several observing days in the same quiescent prominence. We have shown that these are not mono-harmonic spectra and that they have a complicated structure in the region below 1.0 mHz. Our analysis has lent further support to the earlier conclusion that long-period oscillations are a typical property of prominences. A peak of about 0.3 mHz (a period of about 1 h) was dominant in the oscillation spectra for all observing days.

Is the quasi-hourly period an eigen-mode of prominence oscillations or is this some other dynamic equilibrium in response to a disturbance in the outer environment of the prominence?

The quasi-hourly period of velocity oscillations remained, within the accuracy of measurement, unchanged during all three days. It is most likely that lower-lying layers of the solar atmosphere are sources of the observed long-period oscillations in prominences (Bashkirtsev et al., 1987) which, most probably, are large-scale ones.

That short-period oscillations are absent in our observations, may be attributed to a number of factors:

(1) If it is assumed that the prominence oscillates as a single entity, then the differential method fails to detect such oscillations. However, owing to the inhomogeneous structure of prominences, there always exists a certain non-differential character and, therefore, we could record oscillations of the prominence as a whole. Our observations, which were specially made in the non-differential mode, did not reveal *stable* short-period oscillations. The incidental character of the occurrence of short-period oscillations in some places of a prominence was pointed out by Wiehr et al. (1984) and Balthasar et al. (1988) as well as in a series of publications by Japanese researchers (see, for example, a review by Tsubaki (1987)).

(2) Possibly, our rather large aperture, normally 8″ × 8″, does not permit us to record short-period oscillations if they are small-scale ones.

Attempts to detect short-period Doppler velocity oscillations using a differential method for prominence areas separated by 3″.9, 5″.5 and 12″, gave a negative result (Bashkirtsev and Mashnich, 1984).

We believe that the main reason why short-period oscillations are recorded or are not recorded, is the following:

We conjecture that oscillations of the lower-lying photosphere (chromosphere) excite in the magnetic field of the prominence Alfven waves which, as they propagate along individual flux tubes, penetrate the prominence body. Several oscillating elements of a prominence may be present within the spectrograph aperture and on the line of sight during an observation. Since the oscillations will generally not be coherent, we are unable to record them. Whenever coherency arises on some occasions or a single flux tube

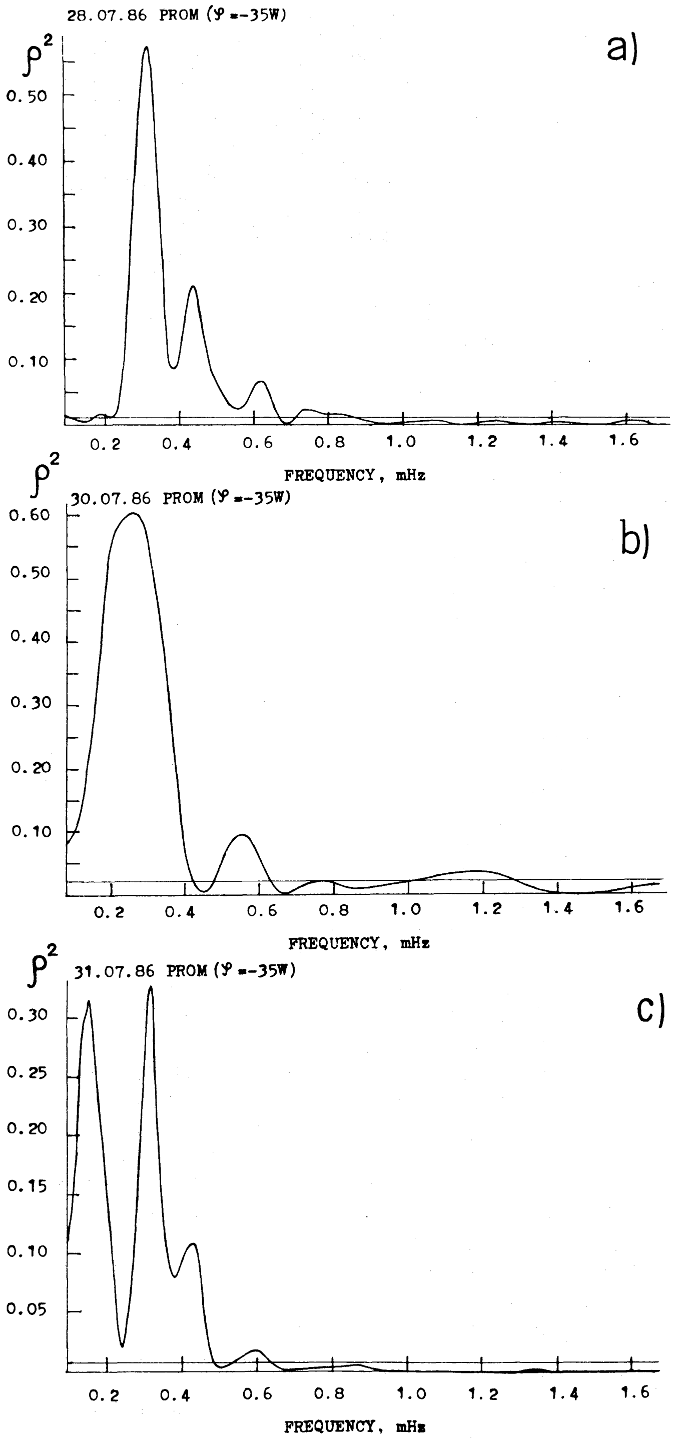

Fig. 3. Power spectra of Doppler velocity oscillations in arbitrary units. A solid line in the figures shows the 99% significance level

lies on the line of sight, short-period oscillations will be recorded. However, even in the case of a single flux tube the situation does not seem to be a simple one. It might be expected that an Alfven wave excited in some part of the flux tube (at the photospheric level, say), will propagate with different velocities along the flux tube: the velocity will be the highest in the skin-layer of the tube where the magnetic field strength is larger and the plasma density is smaller, and the velocity will be the lowest at the center of the tube where the magnetic field strength is smaller and the plasma density is larger. Thus, in the observed part of the flux tube (in the limits of the aperture) Alfven oscillations will be incoherent ones and, therefore, it will be difficult to record them. With a spectrograph aperture smaller than ours (8″ × 8″), short-period oscillations must be recorded with higher probability, although the presence of a number of oscillating elements on the line of sight does not permit the problem to be resolved.

Acknowledgements. We are grateful to the referee, Dr. E. Wiehr, for his comments which helped to improve this paper. Special thanks are due to Mr. V.G. Mikhalkovsky for his assistance in preparing the English version of the manuscript and for typing and retyping the text.

References

Balthasar, H., Stellmacher, G., Wiehr, E.: 1988, *Astron. Astrophys.* **204**, 286
Bashkirtsev, V.S., Kobanov, N.I., Mashnich, G.P.: 1983, *Solar Phys.* **82**, 443
Bashkirtsev, V.S., Mashnich, G.P.: 1984, *Solar Phys.* **91**, 93
Bashkirtsev, V.S., Kobanov, N.I., Mashnich, G.P.: 1987, *Solar Phys.* **109**, 399
Kobanov, N.I.: 1983, *Solar Phys.* **82**, 237
Kopecky, M., Kuklin, G.V.: 1971, *Issledovaniya po geomagnetizmu, aeronomii i fizike Solntsa* **2**, 167
Tsubaki, T.: 1987, Proc. of the Workshop 19–21 Aug. 1987 at the Nat. Solar Obs., Sunspot, NM, USA
Wiehr, E., Stellmacher, G., Balthasar, H.: 1984, *Solar Phys.* **94**, 285