OBSERVATIONS OF LONGPERIOD MASS VELOCITY OSCILLATIONS IN THE SUN'S CHROMOSPHERE

V.S. BASHKIRTSEV, N.I. KOBANOV, and G.P. MASHNICH
Siberian Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (SibIZMIR) of the USSR, Academy of Sciences, Irkutsk 33, 664033, U.S.S.R.

(Received 19 January, 1987; in revised form 7 April, 1987)

ABSTRACT. Observations made by the differential method in the Hβ line have revealed longperiod (on a timescale of 40 to 80 min) line-of-sight velocity oscillations which increase in amplitude with distance from the centre to the solar limb and, as we believe, give rise to prominence oscillations. As a test, we present some results of simultaneous observations at the photospheric level where such periods are absent.

Oscillatory processes in the solar chromosphere have been studied by many authors. Previous efforts in this vein led to the detection of shortperiod oscillations in both the mass velocities and radiation intensity (Deubner, 1981). The oscillation periods obtained do not, normally, exceed 10-20 min (Dubov, 1978). More recently, Merkulenko and Mishina (1985), using filter observations in the Hβ line, found intensity fluctuations with periods not exceeding 78 min. However, the observing technique they used does not exclude the possibility that those fluctuations were due to the influence of the Earth's atmosphere. It is also interesting to note that in spectra obtained by Merkulenko and Mishina (1985), the amplitude of the 3 min oscillations is anomalously small and the 5 min period is altogether absent, while the majority of other papers treating the brightness oscillations in the chromosphere, do not report such periods in the first place. So far, we are not aware of any other evidence concerning the longperiod velocity oscillations in the chromosphere on a timescale of 40-80 min.

Longperiod oscillations in prominences (filaments) in the range from 40 to 80 min, as found by Bashkirtsev et al. (1983) and Bashkirtsev and Mashnich (1984, 1985), indicate that such oscillations can exist in both the chromosphere and the corona (Hollweg et al., 1982).

In this note we report on experimental evidence for the existence of longperiod oscillations of mass velocity in the solar chromosphere.

1. OBSERVATIONAL DATA AND RESULTS

The observations were made at the Sayan Observatory with an automated horizontal solar telescope (the solar image of the spectrograph slit is 185 mm in diameter and the spectrograph dispersion is 3.12 mm $Å^{-1}$) with the aid of a magnetograph with a single photomultiplier. For the study of line-of-sight velocity oscillations in the solar atmopshere, we have applied Kobanov's (1983) differential method. The principle of this method which measures the difference of the line-of-sight velocities for two areas on the solar surface, has also been described by Bashkirtsev and Mashnich (1984). For recording the mass velocity oscillations, we

Solar Physics **109** (1987) 399–402.

used the Hβ line for the chromosphere and, for the underlying layers of the atmosphere, the 4554 Å line of Ba II and the 4875 Å of Ni I.

When observations were taken, the solar image was maintained by a photoguide. A tracking system was also in operation; it took account of the solar rotation and maintained selected areas of the solar surface on the spectrograph slit when photoelectric records of long duration were taken.

The line-of-sight velocity records thus obtained at the solar disk centre and away from it were subjected to the method of correlation periodogram analysis (Kopecky and Kuklin, 1971). Correloperiodograms are presented in Figures 1 to 4.

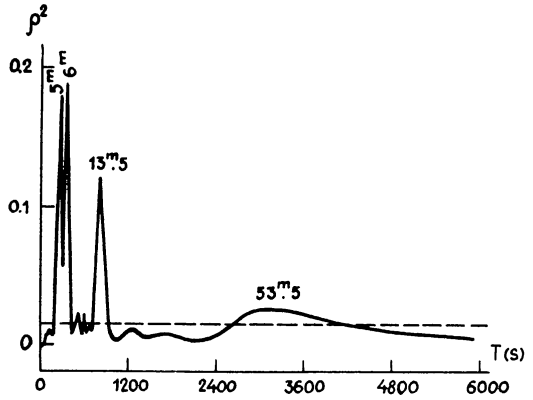

Fig. 1. 04:02 ⩽ UT ⩽ 11:22, 16 July, 1986. The chromosphere (Sun's centre), H line, 4" × 5" spectrograph aperture (from here on, the first number indicates the spectrograph slit width, and the second one indicates height), and the distance between the centres of the observed solar areas L = 12".

The abscissa axis indicates the time, T, in seconds, and the axis of ordinates indicates the square of the correlation coefficient ρ obtained by comparison of our records with the harmonic oscillations. Dashes indicate the 99% significance level.

By analyzing the observations handled in this way we arrived at the following results.

(1) Longperiod oscillations (40-80 min) are distinctly seen in the Hβ line; no such oscillations however, were found to be present in underlying layers of the Sun's atmosphere (the 4857 Å line of Ni I (Figure 2(b) and the 4554 Å line of Ba II (Figure 3)), whereas shortperiod oscillations (of about 5 min) are quite prominent in all correloperiodograms. The presence of longperiod oscillations in the Hβ line and their absence in the abovementioned spectral lines in the case where photoelectric records were made of the same area on the solar surface simultaneously, both exclude any Earth-atmospheric or instrumental origin of the oscillations detected. We suppose that longperiod oscillations are also present in the photosphere but their amplitude is too small to be

detected. According to data reported by Grec et al. (1976), their amplitude cannot exceed 0.7 m s^{-1}.

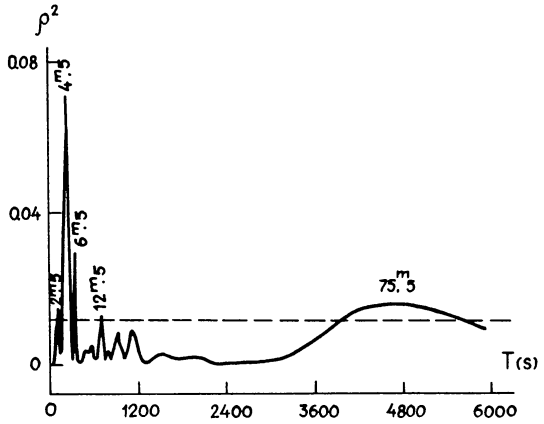

Fig. 2a. 09:18 ⩽ UT ⩽ 11:22, 16 July, 1986. The chromosphere (Sun's centre), Hβ , 2" × 50", L = 12" (areas spacing across the slit).

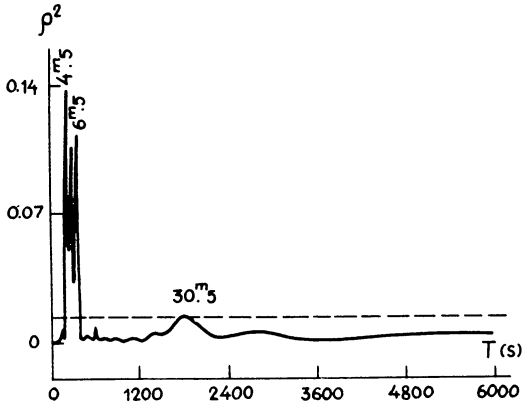

Fig. 2b. 09:18 ⩽ UT ⩽ 11:22, 16 July, 1986. The photosphere (simultaneous record of the same area on the solar surface as in the case of Figure 2 (a) but in the 4857 Å line of Ni I), 2" × 50", L = 12".

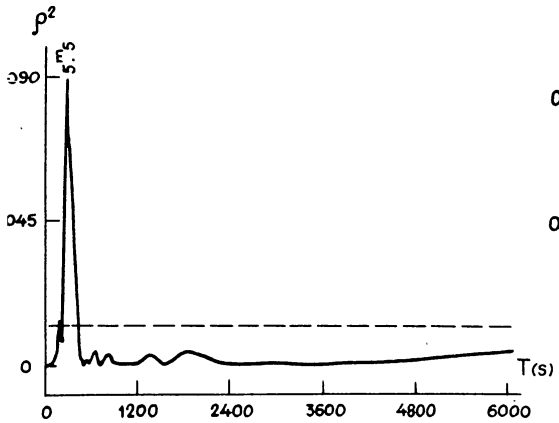

Fig. 3. 23:31 ⩽ UT ⩽ 02:00, 9 July, 1986. The chromosphere (Sun's centre), Ba II 4554 Å, 2" x 50", L = 12" (areas spacing across the slit).

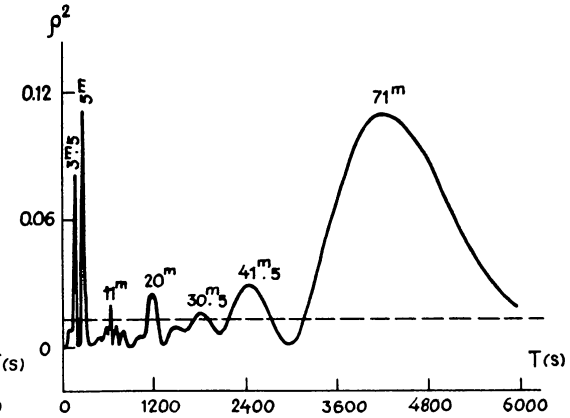

Fig. 4. 02:00 ⩽ UT ⩽ 03:59, 23 July, 1986. The chromosphere (ϕ = -40°, λ = +50°), Hβ, 2" x 9", L = 12" (areas spacing across the slit)

(2) The observable longperiod oscillations are probably the result of horizontal oscillations because the oscillation amplitude at the disk centre - according to our data - did not exceed 40 m s^{-1}, while nearer the solar limb (λ = 50°), the amplitude was as high as 220 m s^{-1}.

(3) Longperiod oscillations in prominences (filaments), which we have detected earlier, are most probably due to the abovementioned longperiod chromospheric oscillations.

ACKNOWLEDGEMENTS

The authors are grateful to L.G. Bashkirtseva for preparing the figures. Thanks are also due to Mr. V.G. Mikhalkovsky for his assistance in preparing the English version of the manuscript and for typing the text.

REFERENCES

Bashkirtsev, V.S., and Mashnich, G.P.: 1984, Solar Phys. 91, 93.
Bashkirtsev, V.S. and Mashnich, G.P.: 1985, in 'Kolebaniya i volny na Solntse' (Oscillations and Waves on the Sun), First Scientific Seminar of the Working Group on 'Waves in the Solar Atmosphere' (Riga, March 1985), Book of Abstracts, Riga, Zinatne, p.6
Bashkirtsev, V.S., Kobanov, N.I., and Mashnich, G.P.: 1983, Solar Phys. 82, 443.
Deubner, F.-L.: 1981, in S. Jordan, (ed.), The Sun as a Star, NASA Scientific and Technical Information Branch, Washington, D.C., pp. 65-84.
Dubov, E.E.: 1978, in Itogi nauki i tekhniki, Ser. 'Astronomiya', Vol. 14, Moscow, Nauka, p. 148.
Grec, G., Fossat, E., and Vernin, J.: 1976, Astron. Astrophys. 50, 221.
Hollweg, J.V., Bird, M.K., Volland, H., Edenhofer, P., Stelzried, C.T., and Seidel, B.L.: 1982, J. Geophys. Res. 87, 1.
Kobanov, N.I.: 1983, Solar Phys. 82, 237.
Kopecky, M. and Kuklin, G.V.: 1971, Issledovaniya po geomagnetizmu, aeronomii i fizike Solntsa 2, 167.
Merkulenko, V.E. and Mishina, M.N.: 1985, Astron. Astrophys. 146, L9.