LINE-OF-SIGHT VELOCITIES IN A FLARING ACTIVE REGION

N. Kondrashova

Main Astronomical Observatory, NAS of Ukraine
27 Akademika Zabolotnoho Str., 03680 Kyiv, Ukraine
e-mail: kondr@mao.kiev.ua

Some spectra of a flaring active region were derived with the solar horizontal telescope ATsU-26 at the Terskol Observatory. Some properties of the photospheric velocity field of a bright plage are studied. The measurements of the line-of-sight velocity are made in the Fraunhofer lines Fe I $\lambda\lambda$ 630.25 nm, 630.35 nm and Ti I λ 630.38 nm. Temporal variations of the line-of-sight velocities at photospheric levels of 203, 240, and 515 km of the plage were obtained. Motions directed to an observer dominate on a considerable part of the plage. At the edge of the plage there is a flow from the observer at a photospheric level of 203 km.

INTRODUCTION

During the last years, much work has been carried out on physical properties and dynamics of solar plages. The bright grains (plages, faculae) coincide with magnetic flux concentrations. Steiner *et al.* [4] performed a numerical simulation of dynamical interaction of solar magnetic elements and the surrounding granular convection. They predicted the existence of strong downflows around the magnetic elements. Bellot Rubio *et al.* [1] found the downflows in the deep layers of a plage flux tube and in the external medium from the inversion of Stokes spectra, which could be produced by a strong shear or convective collapse of a magnetic flux. Recently, Rimmele [3] observed strong and narrow downflows at the edge of bright points. It is necessary to have a detailed knowledge of the dynamical characteristics of different solar active regions. The aim of this work was to investigate the behaviour of the line-of-sight (LOS) velocity field of a bright active plage near the solar limb.

OBSERVATIONAL MATERIAL

The observations of the flaring active region on August 21, 2002 were done with the ATsU-26 horizontal solar telescope at Terskol Peak (3100 m above sea level), a spur of Elbrus Mountain (observers O. V. Andriyenko, V. M. Efimenko, and the author). The telescope has the spherical main mirror with 65 cm diameter and 17.7 m focal distance. Diameters of collimator and camera mirrors of the spectrograph are 30 cm, their focal distances are 8 m, the grating is 20×25 cm with 600 grooves/mm. The sunspot group No. 69 had delta-configuration. It was placed near the solar limb ($\cos\theta = 0.3$). In this active region, 18 flares occurred in the day of observations. The spectrograph slit crossed a big spot and a bright plage near it. A time series of spectrograms were recorded with ST-7 CCD camera (765×510 pixels) from 07:25:40 to 07:29:10 UT. An exposure time was 2 s, a time interval between exposures was 30 s. The plage studied was observed after the X1/1B flare occurred at 05:28 UT, the SF flares at 05:54 and 06:18 UT and before the SF flare at 09:30 UT. The Fraunhofer lines Fe I $\lambda\lambda$ 630.25 nm, 630.35 nm and Ti I λ 630.38 nm are used for study. The line cores are formed at photospheric levels of 515, 203, and 240 km, respectively. These heights are calculated by the SPANSAT program [2].

RESULTS OF LINE-OF-SIGHT VELOCITY MEASUREMENTS

The line-of-sight velocities were measured from the Doppler shifts of the Fraunhofer lines for various moments and for various cross-sections of the plage spectra. The distance between the sections corresponds to about 363 km on the solar surface. The instrumental wavelength scale was reduced to air wavelength scale with the help of two telluric O_2 lines recorded in the same spectral region. Then the air wavelength scale was corrected for the gravitational redshift, solar rotation, and Earth–Sun motion. An observational error of the velocity did not exceed 100 m s^{-1}. Figures 1 and 2 show the variations of LOS velocities at three photospheric levels on the plage surface for all the moments of the observation. It can be seen that negative values of LOS velocities (motions directed to an observer) dominate on a considerable part of the plage. The velocity values in

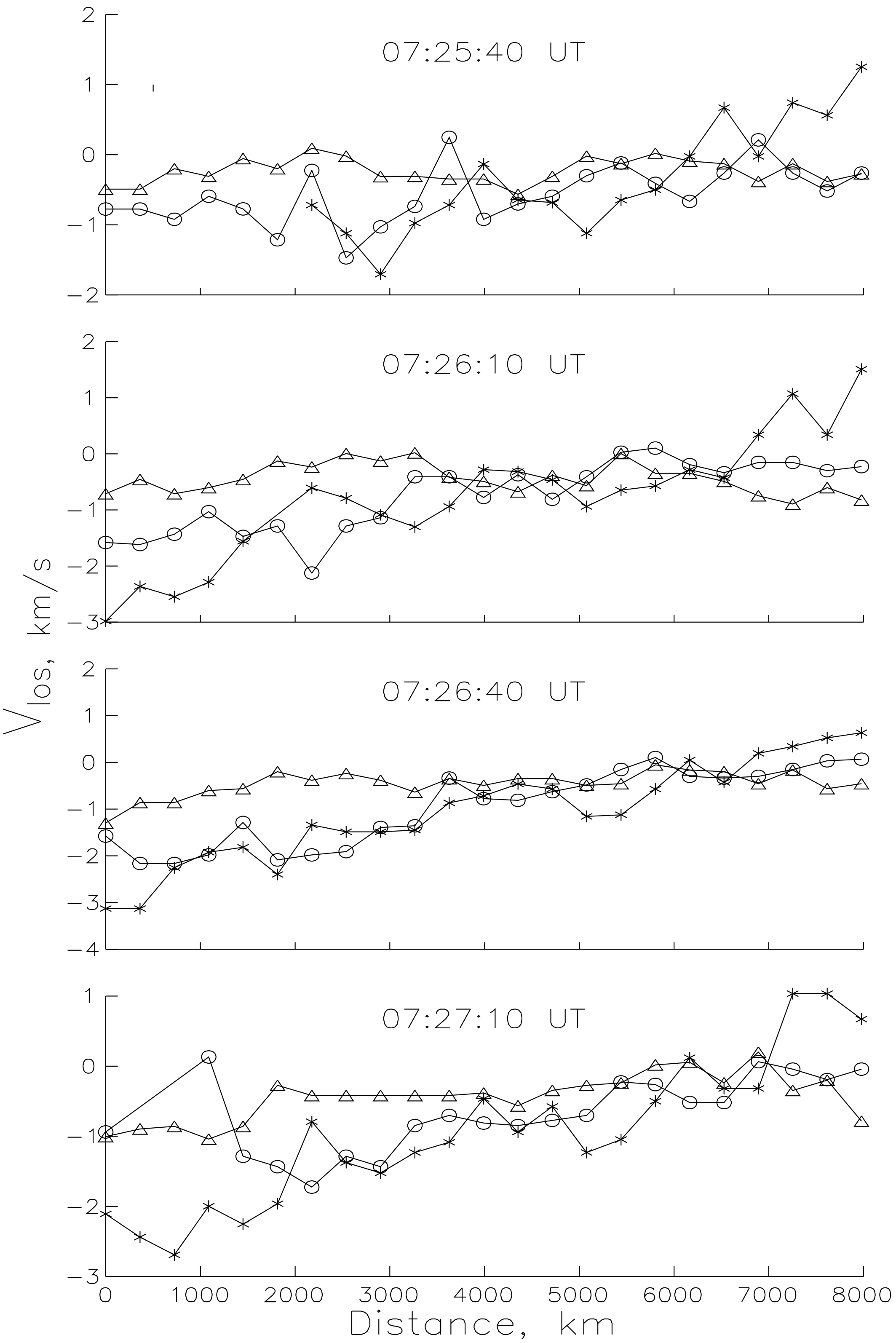

Figure 1. Variations of photospheric line-of-sight velocities derived from the Fe I λ 630.25 nm line (triangles), the Fe I λ 630.35 nm line (asterisks), and the Ti I λ 630.38 nm line (circles) on the plage surface at 07:25:40–07:27:10 UT. Positive values represent the motion from an observer. Vertical bar is the observational error of the velocity

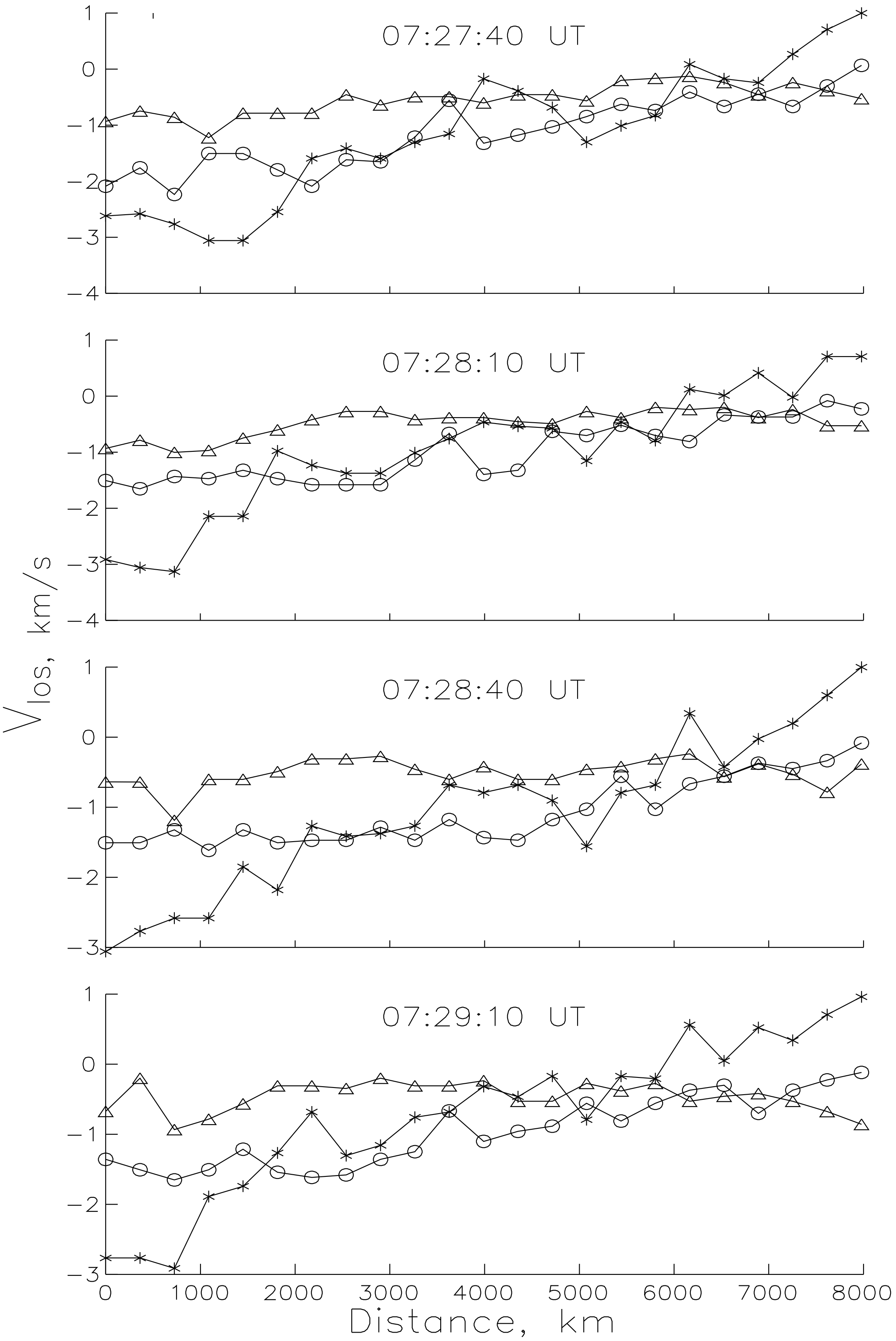

Figure 2. The same as Fig. 1 at 07:27:40 – 07:29:10 UT

the range from -1 to 0 km s^{-1} for all the moments are found from the Fe I λ 630.25 nm line formed in the upper photosphere and from -2 to 0 km s^{-1} from the Ti I λ 630.38 nm line (the middle layers of the photosphere).

The most pronounced difference between LOS velocities obtained from the different spectral lines is on the left side of the plots. This anomalous patch of 1000–2000 km length located near the spot exhibits negative LOS velocities of up to 3 km s^{-1} at a photospheric level of 203 km (derived from the Fe I λ 630.35 nm). The difference in velocities is less at the centre of the plage. The range of the velocity variations is 1.50 km s^{-1} there, the velocities are negative too. At the periphery of the plage region (at a distance of 6000–8000 km from the spot) the inversion of the velocity sign in a layer of 203 km takes place, positive velocity is up to 1.5 km s^{-1}. Figure 3 shows a high spatial velocity gradient at this photospheric level.

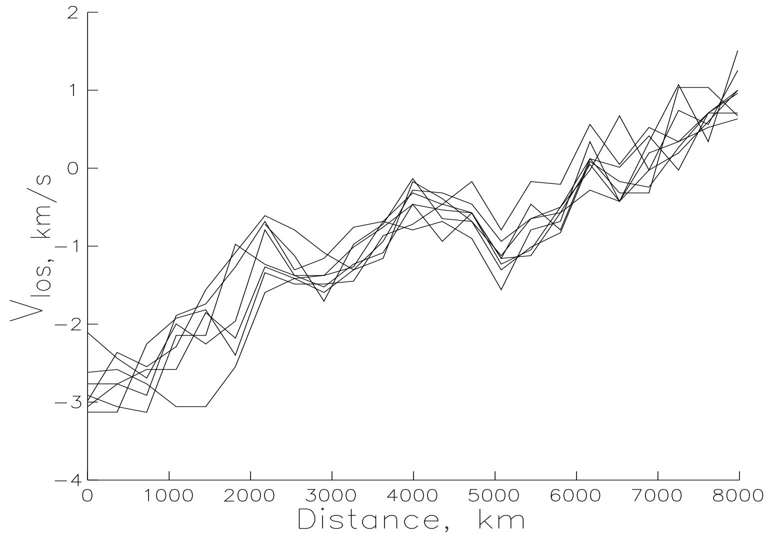

Figure 3. Variations of photospheric line-of-sight velocities derived from the Fe I λ 630.25 nm line on the plage surface at all moments of the observation

CONCLUSION

In this work, spatial and temporal variations of line-of-sight velocity at photospheric levels of 203, 240, and 515 km in a plage near the solar limb are studied. There are horizontal flows in the plage. Motions directed to an observer dominate on a considerable part of the plage. LOS velocity is up to 3 km s^{-1} in a photospheric layer of 203 km and decreases with height in the part of the plage adjacent to the sunspot. Another edge of the plage shows the motion of the matter directed from an observer at this photospheric level.

Acknowledgements. I thank O. V. Andriyenko and V. M. Efimenko for their help during the observations, V. M. Efimenko for the organization of the observations, and the staff of ICAMER for hospitality at the Terskol Observatory.

[1] *Bellot Rubio L. R., Ruiz Cobo B., Collados M.* Structure of plage flux tubes from the inversion of Stokes spectra. I. Spatially averaged Stokes *I* and *V* profiles // Astrophys. J.–2000.–**535**, N 1.–P. 489–500.

[2] *Gadun A. S., Sheminova V. A.* SPANSAT: Program for calculating spectral absorption lines in stellar atmospheres in the LTE approximation.–Kyiv: Inst. Theor. Phys. AS UkrSSR, 1988.–37 p.–(Preprint N 87P).

[3] *Rimmele T. R.* Plasma flows observed in magnetic flux concentrations and sunspot fine structure using adaptive optics // Astrophys. J.–2004.–**604**, N 2.–P. 906–923.

[4] *Steiner O., Grossmann-Doerth U., Knolker M., et al.* Dynamical interaction of solar magnetic elements and granular convection: results of a numerical simulation // Astrophys. J.–1998.–**495**, N 1.–P. 468–484.