N87-20896

VERTICAL MOTIONS IN QUIESCENT PROMINENCES OBSERVED IN THE He I λ10830Å LINE

Oddbjørn Engvold
Institute of Theoretical Astrophysics
University of Oslo
P.O.Box 1029, Blindern
N-0315 Oslo 3, Norway

and

Stephen L. Keil
AFGL
Sacramento Peak Observatory
Sunspot, New Mexico 88349

INTRODUCTION

Movies of quiescent prominences seen in Hα show apparent downflow of matter (Dunn, 1960; Menzel and Wolbach, 1960; Engvold, 1976; Anzer 1978). The effect is confirmed by observations of downflows in the Ca II K line from large filaments/prominences (Kubota 1978). Several recent studies show evidence for the opposite case from observations in Hα, i.e. that there is a predominantly upward directed flow in prominences seen on the disk (Mein, 1977; Martres et al. 1981; Malherbe et al. 1981). The quoted results are slightly ambiguous because the observed Ca II K and Hα line shifts can be severely influenced by displacements of the chromospheric component of the line and by the line opacity and source function which generally are not well known. This problem is discussed by Beckers (1962), 1968) and Cram (1975) in connection with measurements of chromospheric velocities.

The implications of systematic vertical motions in and around prominences are important for understanding their formation and existence.

Pikel'ner (1971) proposed a siphon-type model in which hot matter is sucked up along the magnetic field lines into the 'cool' prominence region. Similar types of dynamic models have been investigated by Priest and Smith (1979), Uchida (1980), and Ribes and Unno (1981). Malherbe and Priest (1983) suggest that vertical motion is a result of lateral motion in the footpoints of the supporting magnetic fields. Recent studies by Jensen (1983, 1986) show that prominence matter may be supported by Alfvén-wave dissipation. This support mechanism is a stochastic process which will result in a local re-shuffling rather than a net transfer of prominence matter.

It is difficult to choose between the various dynamic models because the observational picture from Hα and the Ca II K line is still rather unsettled. We have therefore undertaken an observational program of prominences on the disk using the λ10830Å line of He I. The He I line is weak in the chromosphere but quite strong in prominences (Giovanelli et al. 1972) and Doppler shifts can be interpreted indubitably in terms of line-of-sight motions. Some conclusions from the study are reported here. A more detailed account of the work is given in Engvold and Keil (1986).

OBSERVATIONS

The observations contain two-dimensional spectral scans of a total of 17 different prominences on the solar disk from the period 3-9 May 1981, using the main spectrograph of the solar vacuum telescope at Sacramento Peak. A 100 x 100 CCD camera in the spectral focus covered 100 arcsec along the slit and 6.0Å in the spectral direction When properly adjusted the He I λ10830.330Å and λ10829.088Å, the Si I λ10827.109Å, and the atmospheric (H_2O) λ10832.109Å lines were record simultaneously. The water vapor line and the solar Si I line were used for calibration of the wavelength scale (cf. Breckinridge and Hall 1973). Each series of scans consists of 60 spectral frames recorded in rapid succession and stored on magnetic tape while the solar image drifted across the entrance slit of the spectrograph. Each series of spectral frames covered 60 x 99 arcsec^2 area on the Sun. The individual CCD frames were corrected for variable pixel sensitivity and large scale noise pattern, and subsequently used to generate images of continuum intensity, intensity and velocity in the He I and Si I lines. For more details on the observations and image processing the reader is referred to Engvold and Keil (1986).

VERTICAL MOTION IN QUIESCENT PROMINENCES

Figures 1, 2 and 3 show contour plots of three typical cases in our data. The upper frames are He I line center intensity. The darkest parts of the filament correspond to line depression of 18 per cent relative to continuum. The lower frames give the line-of-sight. Dotted contour lines are upward and solid lines to downward motions. No line shift is measured where the He I line is less than 4 percent deep, which is the case in the regular chromosphere.

The following conclusions may be drawn from the data:

1. Blue shifts are much more common than red shifts. In many cases more than 90 per cent of the projected prominence area is associated with blue shifts.

2. The darkest prominence regions show the largest blue shift ($v < 3$ km s^{-1})

3. Red shifts are most commonly seen at prominence edges.

4. The general pattern of prominence velocity persists for several hours. On the scale of about 10 arcsec and less changes are detectable in the course of 2-5 minutes.

CONCLUDING REMARKS

The observed predominance of the blue shifts is largely in agreement with earlier results from Hα (cf. Martres et al. 1981).

It cannot, however, be concluded definitely that the observed shift really represents a net flow of matter. The situation could possibly be analogous to that of the solar transition region where lines such as C IV λ1548Å seem to indicate a net inflow, which can hardly be true, at velocities > 4 km s^{-1} in the quiet Sun (Athay et al. 1983; Gurman and Athay 1983). If the typical structure element of the prominence is sub-resolution, i.e. 2-3 arcsec or worse, as in the present case, an apparent net shift could result if the ascending and the decending elements have different temperature and/or pressure. Different lines could then indicate different flow velocities and even opposite directions. The stochastic support mechanism of Jensen (1986) could provide such conditions in prominences. The

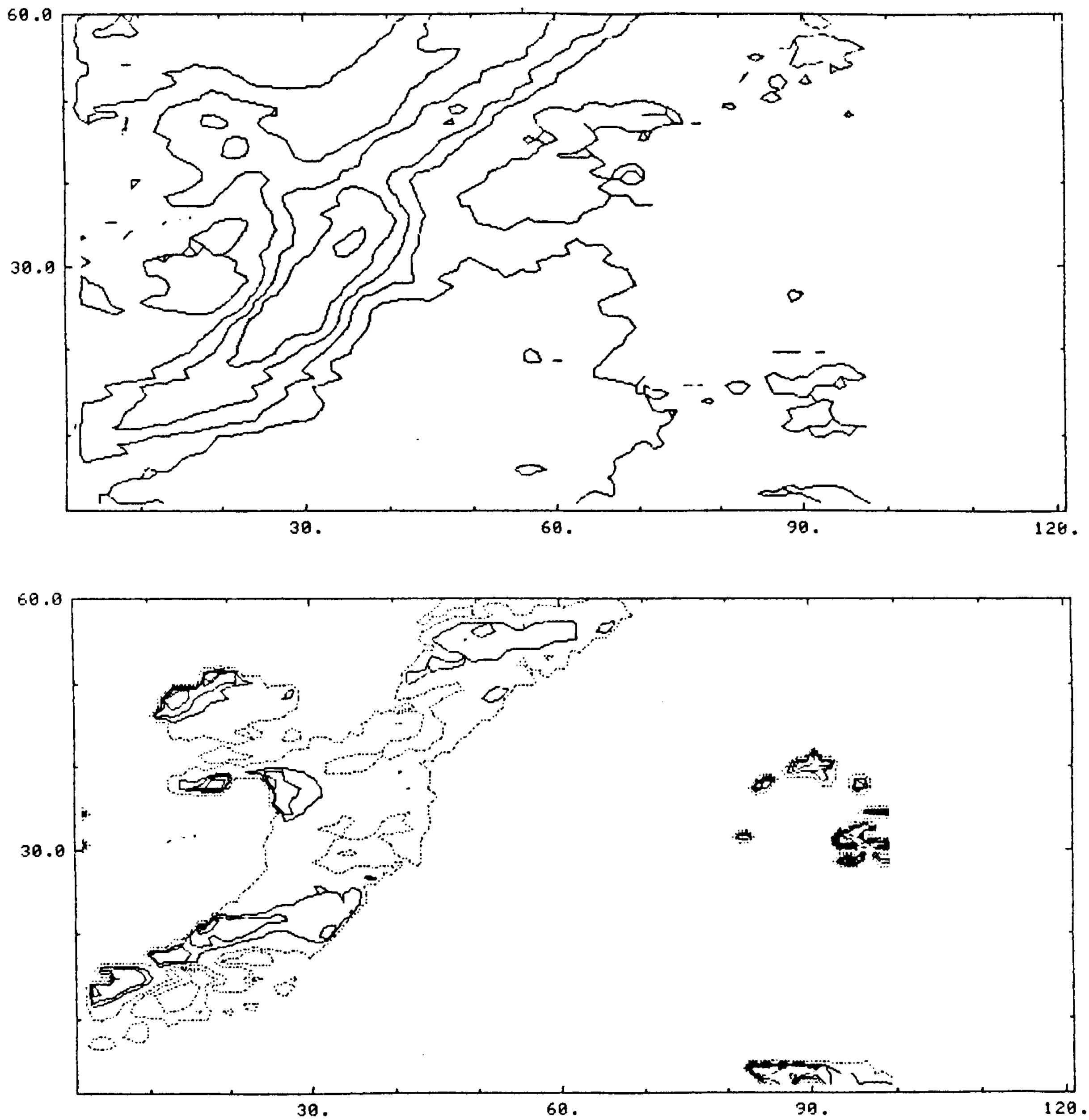

Figure 1. Contour plots of large quiescent prominence at S20 E24 observed May 4 1981 at 14:51 UT. The position of the prominence is seen in the image of He I central line intensity (upper frame). The lower frame shows the line shift. Dotted contour lines are blue and solid lines are red shift ($\Delta v = 0.5$ km s^{-1}). The numbers on the axes are in arcseconds.

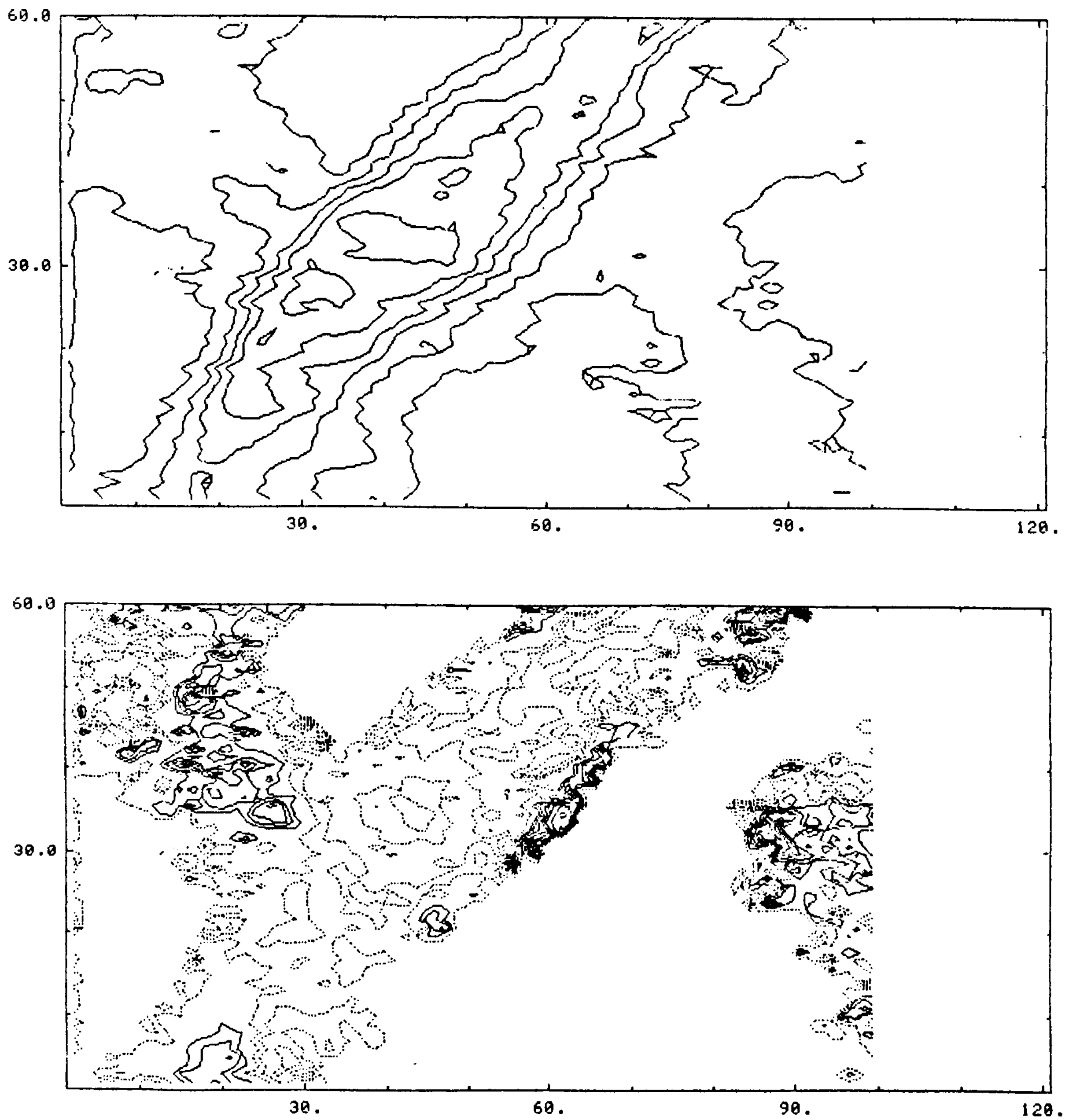

Figure 2. Same prominence as in Figure 1 observed at S20 W47 on May 9 1981 at 15:17 UT.

apparently conflicting results from the Ca II K and Hα and He I λ10830 could possibly be explained as an effect of spatially unresolved moving structures. More detailed and simultaneous observations in many lines are needed to settle the question.

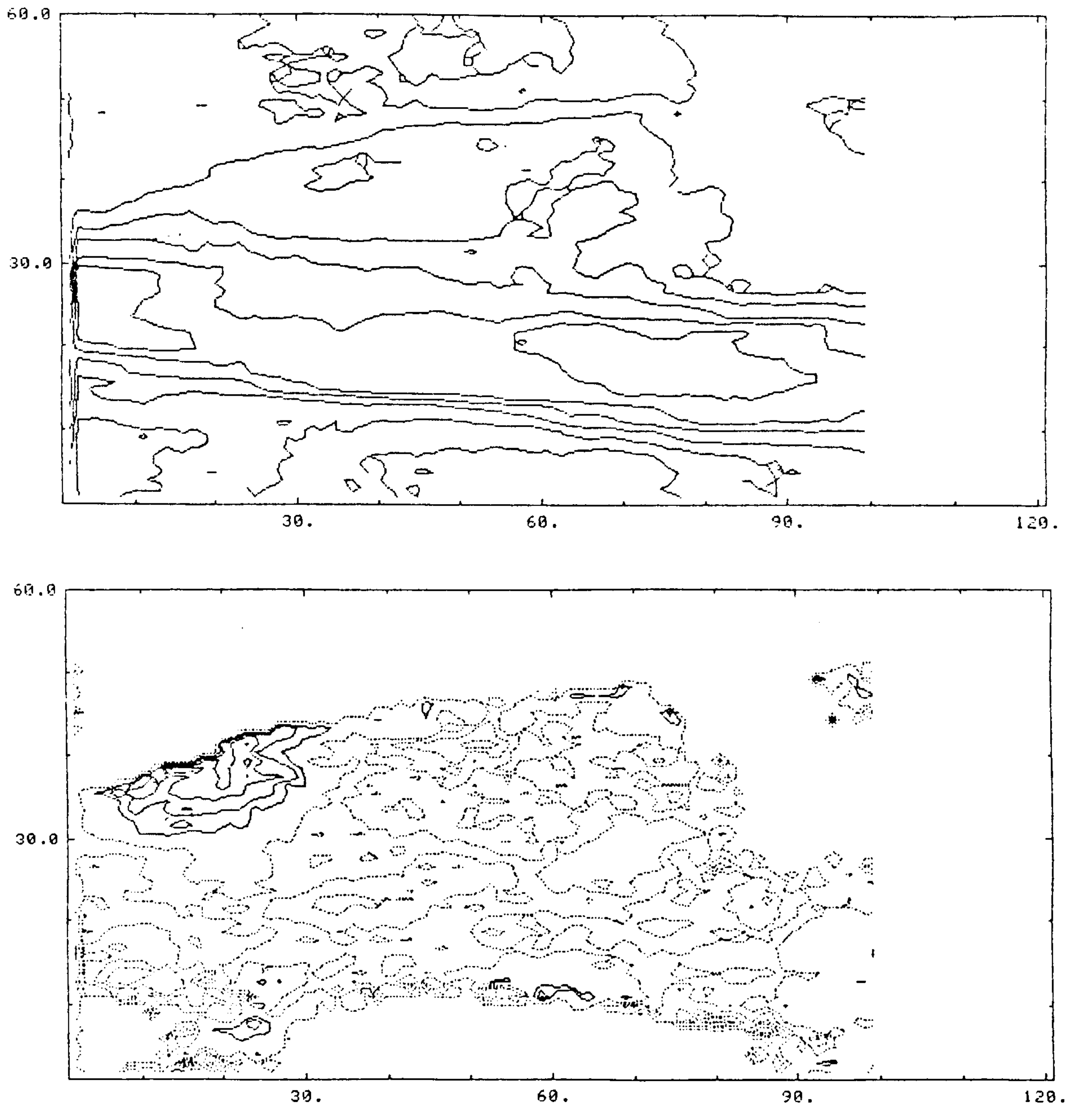

Figure 3. Contour plots of quiescent prominence at position N05 W22 observed May 9 1981 16:37 UT.

ORIGINAL PAGE IS OF POOR QUALITY

Acknowledgements

We are grateful to Phil Wiborg, Horst Mauter and Richard Mann for their enthusiastic support with the observations.

References

Anzer, U.: 1978, in "Physics of solar prominence", IAU Colloq. 44, Eds.: E.Jensen, P.Maltby, F.Q.Orrall, p. 322.

Athay, R.G., Gurman, J.B., Henze, W., and Shine, R.A.: 1983, Astrophys. J. 265, 219.

Beckers, J.M.: 1962, Austr. J. Phys. 15, 327.

Beckers, J.M.: 1968, Solar Phys. 3, 367.

Breckinridge, J.B. and Hall, D.N.B.: 1973, Solar Phys. 28, 15.

Cram, L.E.: 1975, Solar Phys. 42, 53.

Dunn, R.B.: 1960, Ph.D. Thesis, Harvard University.

Engvold, O.: 1976, Solar Phys. 49, 283.

Engvold, O. and Keil, S.L.: 1986, (In preparation).

Giovanelli, R.G., Hall, D.N.B., and Harvey, J.W.: 1972, Solar Phys. 22, 53.

Gurman, J.B. and Athay, R.G.: 1983, Astrophys. J. 273, 374.

Jensen, E.: 1983, Solar Phys. 89, 275.

Jensen, E.: 1986, This proceedings.

Kubota, J.: 1980, in Proceedings of "The Japan-France Seminar on Solar Physics", Eds.: F. Moriyama and J.C. Henoux, p. 178.

Malherbe, J.M., Schmieder, B., Ribes, B., Mein, P.: 1983, Astron. Astrophys. 119, 197.

Malherbe, J.M. and Priest, E.: 1983, Astron. Astrophys. 123, 80.

Martres, M,-J., Mein, P., Schmieder, B., and Soru-Escaut, I.: 1981, Solar Phys. 69, 301.

Mein, P.: 1977, Solar Phys. 54, 45.

Menzel, D.H., and Wolbach, J.G.: 1960, Sky and Tel. 20, 252 and 330.

Pikel'ner, S.B.: 1971, Solar Phys. 17, 44.

Priest, E. and Smith, E.A.: 1979, Solar Phys. 64, 217.

Ribes, E. and Unno, W.: 1981, Astron. Astrophys. 91, 129.

Schmieder, B., Malherbe, J.M., Poland, A.I., and Simon, G.: 1985, Astron. Astrophys. 153, 64.

Uchida, Y.: 1980, in Proceedings of "The Japan-France Seminar on Solar Physics" Eds.: F.Moriyama and J.C. Henoux, p. 169.