

SOME EVIDENCE FOR DOMINANTLY HORIZONTAL VELOCITIES IN THE PHOTOSPHERE

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The magnetic field of active regions is one of the most studied parameters in present day Solar Physics.

Less studied but as important is the study of the velocity field.

During the next years a lot of research will be directed toward the understanding of solar flares and their relation to the magnetic and velocity fields. It is necessary to well know the main properties of the two vectorial fields before studying the instabilities regions.

We are not able to observe all the physical parameters necessary to solve the problems. By necessity, we have to simplify the MHD equations, keeping only the most important terms.

For instance, the continuity equation, in the case of structures by far larger than the density scale height of the photosphere indicates that the mass flow must be dominantly horizontal. Such a result can be directly shown from observations.

What do the observations give ?

Let us consider the coordinate axis defined in Figure 1. The longitudinal component of the velocity vector V is given by :

$$V_L = V[\sin\psi \cos\phi \sin\theta + \cos\psi \cos\theta]$$

$$\text{or } V_L = V_H \cos\phi \sin\theta + V_Z \cos\theta$$

For $V \neq 0$, the longitudinal component will be equal to zero if :

$$\cos\phi = 1/\tan\psi \tan\theta$$

On the $V_L = 0$ line the ψ angle cannot take any values ($\pi/2 - \theta \leq \psi \leq \pi/2 + \theta$)

We are able to recognize the $V_L = 0$ line (when $V \neq 0$) anywhere on VL maps all over the sun surface but the observed structures depend of the θ and ψ values :

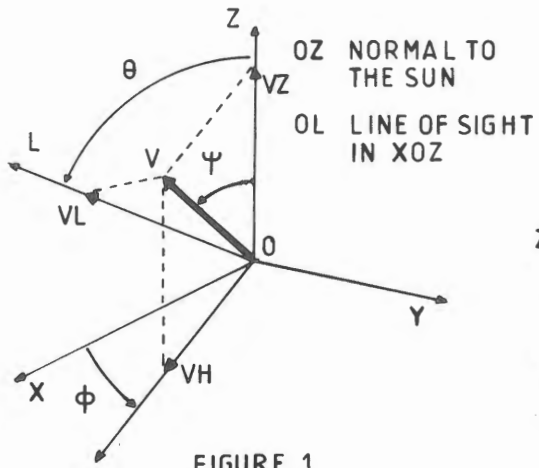


FIGURE 1

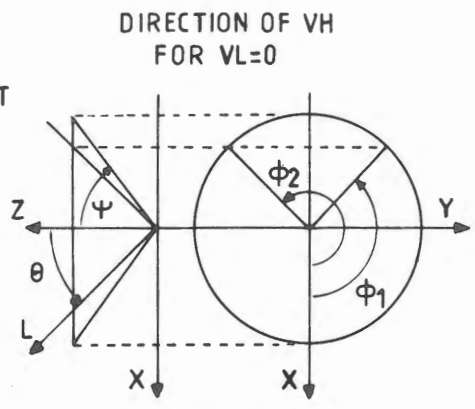


FIGURE 2

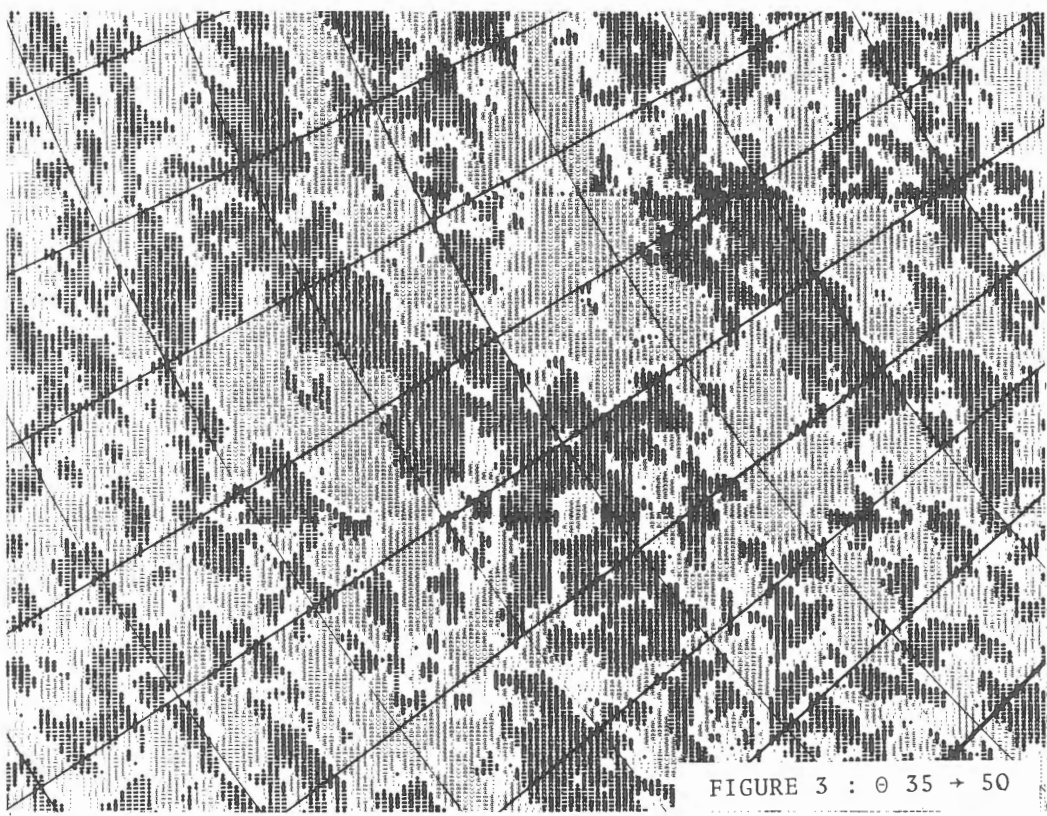
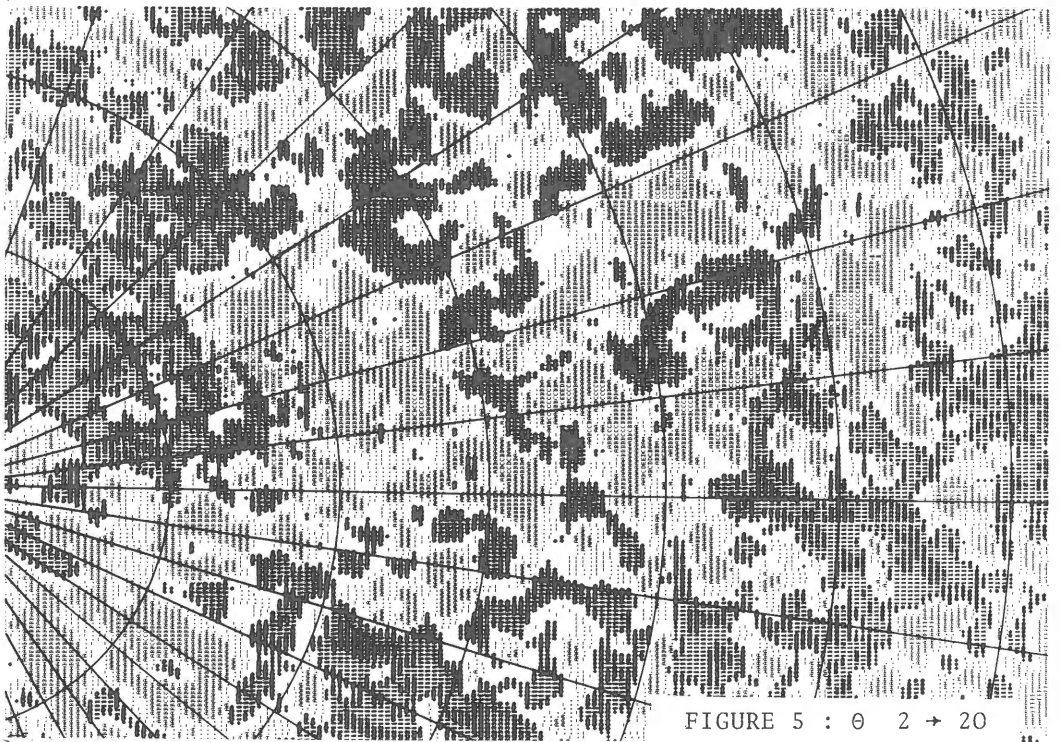
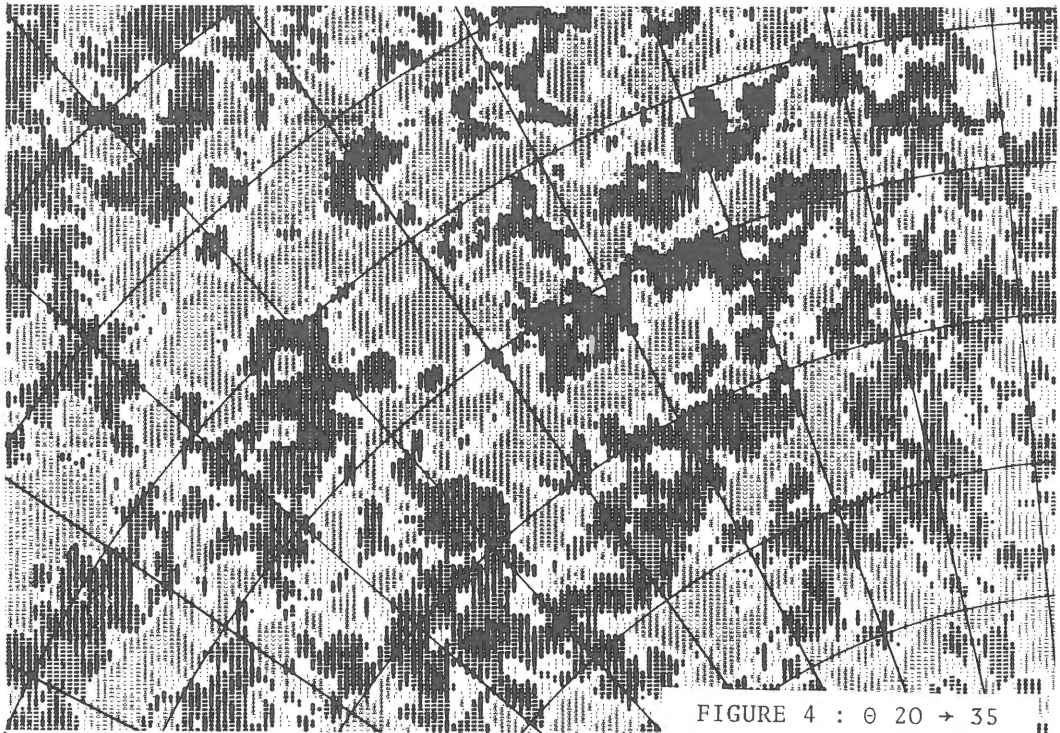


FIGURE 3 : θ 35 \rightarrow 50



High θ values ($\theta > 35^\circ$) : Most of the VL = 0 lines are perpendicular to the disk centre direction and some of them are directed toward it. Figure 3.

Mean θ values ($15^\circ < \theta < 35^\circ$) : Many VL = 0 lines are directed toward the disk center Figure 4.

Small θ values $\theta < 15^\circ$: A new kind of structures appears - "horse shoe structures". Figure 5.

The peculiar VL = 0 line directions and the center to limb effect on the visible structures show us that the mass flow in active regions is built up with "Vortex" or "Star type" horizontal motions with a weak vertical component.

How does such motions appear ?

The appearance of longitudinal structures ("Vortex" and "Star" motion) depends both of the θ and ψ values (Figure 2). If $\theta < \pi/2 - \psi$, then the observed structures do not show any inversion line VL = 0. For $\theta \simeq \pi/2 - \psi$ we have the already defined "horse shoe" structures and for $\theta > \pi/2 - \psi$ two VL = 0 appear the angle between them increasing with θ .

Figure 6 shows that for a constant θ value (10°) the same results occur with ψ variations. Figure 7 shows the observed structures for the four elementary "Vortex" and "Star" motions. (clockwise, counter clockwise, convergent or divergent flow). The absence of observed "horse shoe structure" anywhere on VL maps for high θ value (Fig. 3 and 8) proves that the mass flow in active region is dominantly horizontal.

Conclusion : The observations show a large scale organized horizontal mass flow which is of the greatest interest because it governs the evolution of active regions superimposed with it, small scale vertical motions, such as downward flow in magnetic tubes and local oscillations are also visible but it's not the object of this paper.

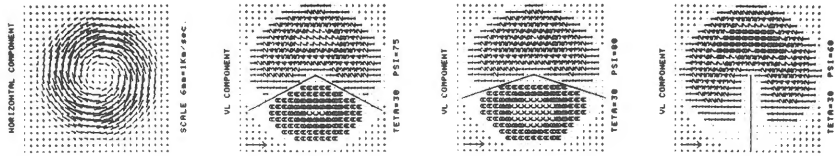


FIGURE 8

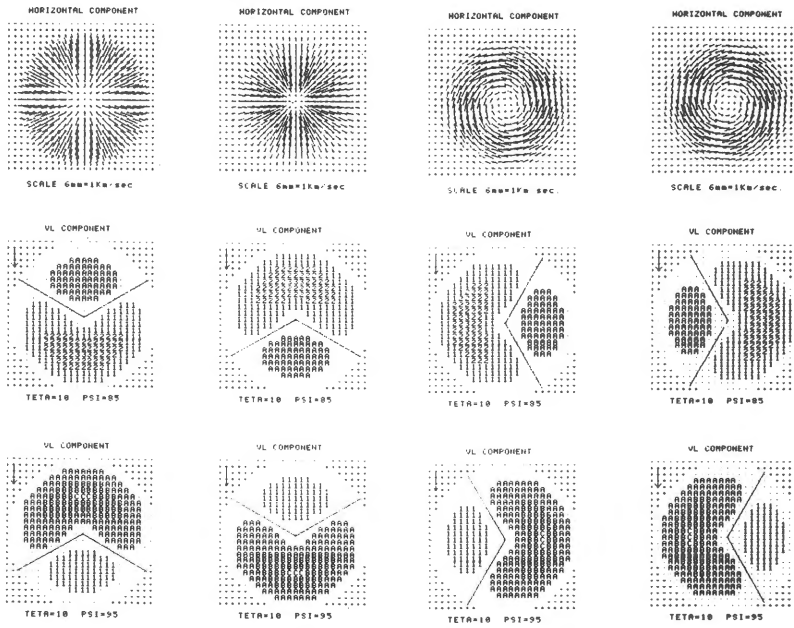


FIGURE 7

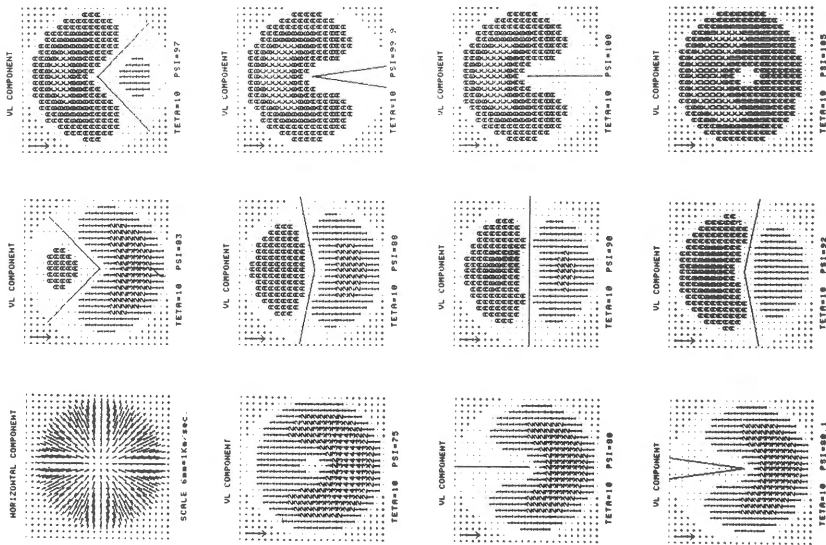


FIGURE 6