MICRO-CMEs FROM SOLAR ACTIVE REGIONS

ADRIAN SABIN POPESCU

Astronomical Institute of the Romanian Academy
Str. Cuțitul de Argint 5, 040557 Bucharest, Romania
E-mail: sabinp@aira.astro.ro

Abstract. In this paper we will make a comparative study of velocities as they result from processing the images of a specific active region observed by two satellites: SOHO and STEREO A. The purpose of this study is the detection of micro-CMEs (Coronal Mass Ejections). The observed active region is accompanied by a complex filament (in chromosphere) and a sunspot pore (in photosphere) and it was registered by the Catania Observatory as AR 05, AxX.

Key words: Sun – active regions – filaments – micro-CME.

1. INTRODUCTION

In this paper we will determine the velocity of the phenomena present at the location of our active region (AR 05, AxX in the Catania Observatory notation) between 18 and 27 May 2009. This will be done by using the method described in Popescu and Mierla (2008) and Popescu (2009a,b). To have a mean of computing the velocity with a good degree of confidence and a way of comparison of our obtained results, the study was done on SOHO/EIT and also on STEREO/EUVI (only STEREO A satellite) images. Because of the poor cadence of the SOHO/EIT instrument in other than 195 Å we have used only this wavelength.

From the evolution of the respective active region on the given period, we had selected as possible candidates for micro-CME (Nisticò et al. 2009) occurring events the following three instants: 18.05.09 at 01:35 UTC, 21.05.09 at 14:05 UTC, and 27.05.09 at 15:15 UTC.

The other reason that dictated our choice was the position of the AR in the images of the two satellites:

(i) For 18.05.09 the SOHO images show the AR on the disk, while STEREO images shows it on the western limb;

(ii) For 21.05.09 both satellites catch the AR on the disk;

(iii) For 27.05.09 the SOHO images show the AR the eastern limb, while STEREO shows it on the disk, very close to its center (STEREO observes the AR on the center of the solar disk in 26.05.09).

2. VELOCITY DETERMINATIONS

Because by our method we are able to study only the velocity projection on the image plane, the above choice is useful in differentiating between the contributions summed into the velocity maps (see Figs.1–3).These contributions are: STEREO satellite relative velocity to the Sun, solar rotation velocity, plasma velocity in the AR loops, velocity of the matter inside the prominence, velocity of the micro-CME ejections.

The first important feature that we can observe in the velocity maps are the “blobs”, distinct features representing packets of matter from the solar corona moving in a confined velocity domain. In our velocity maps we had marked these features by gray and dark gray bands. In these blobs (but not only in them) we can distinguish some preferential velocity lines (the continuous lines). Very useful for the quantitative description of the different contributions to the overall observed velocity is the shift of the blobs in the STEREO velocity maps, relative to the SOHO maps. The new zero velocity for the STEREO images was marked by an interrupted line. We attribute this shift to the velocity of the STEREO satellite.

The velocity of the STEREO satellite was computed from the on-line JPL HORIZONS ephemeris (`http://ssd.jpl.nasa.gov/?horizons`). These velocities (that fall in the range of 30 km/s) correspond to the observed velocity shift (all position measurement in the velocity maps were done with a precision of 10^{-3} mm). When the observations were done at the limb (18.05.09 and 27.05.09) this is the only reason for the velocity displacement in the STEREO images, the solar rotation not entering in discussion, being perpendicular to the image plane.

Now, after scaling the images and having the km/s/mm quantity at each observed event, we can compute the displacement to the right due to the solar rotation when the AR is not anymore on the limb, but on the disk. For this we were fortunate to have our AR at low latitudes ($-30° < \varphi < -10°$), not being forced to take the differential rotation into account. In this case, the units corresponding to a rotation of 2 km/s have to be added to the displacement to the right.

Another quantity that we did not mentioned until now is the contribution to the displacement of plasma velocity in the AR loops. This can be done for the moment when the STEREO satellite observes the AR exactly on the center of the disk (26.05.09), where the total contribution is $v_{\text{satellite}} + v_{\text{rotation}} + v_{\text{AR}} = 3.427$ mm. In this particular case, any micro-CME does not enter into discussion, its velocity being directed toward the observer. The movement inside the prominence is present, but, on overall, not as a discrete value of velocity (even that we can distinguish particular preferential velocities) but as a continuous bulk motion; it will be analyzed when we will talk about the limits of the gray band. Returning to the AR displacement and knowing already the other two velocities we are able to compute the plasma velocity in the AR loops. The next step is the one about which we were talking a moment earlier: the plasma movement inside the prominence, identified as the blobs emphasized by gray bands.

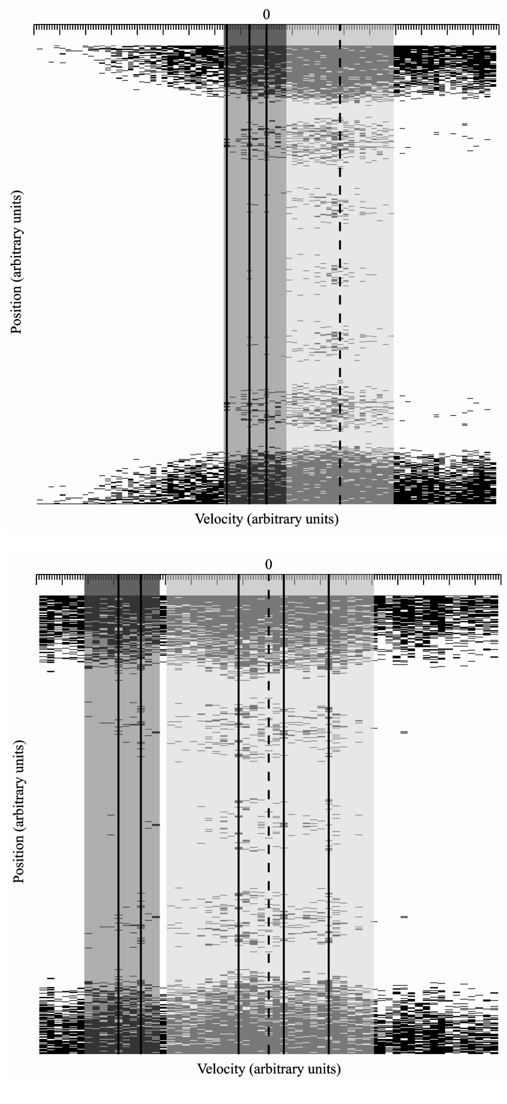


Fig. 1 – Velocity maps: (top) – of STEREO/EUVI images for 18.05.09 at 01:35 UTC; (bottom) – of SOHO/EIT images for 18.05.09 at 01:35 UTC.

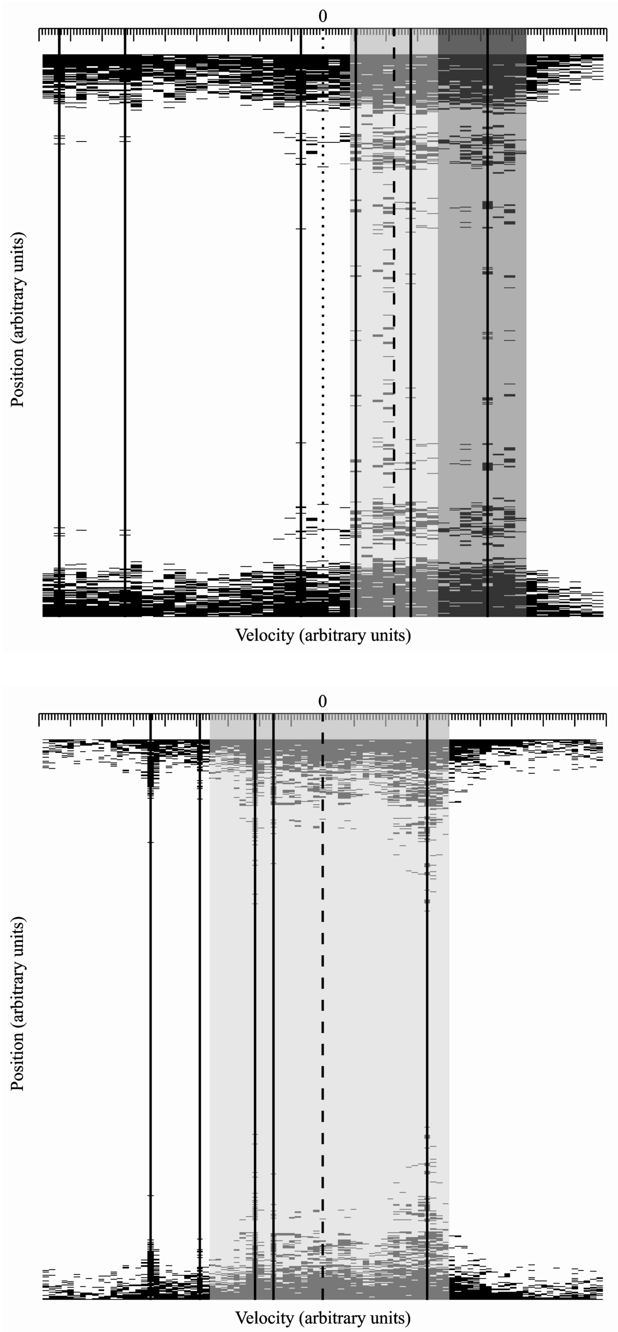
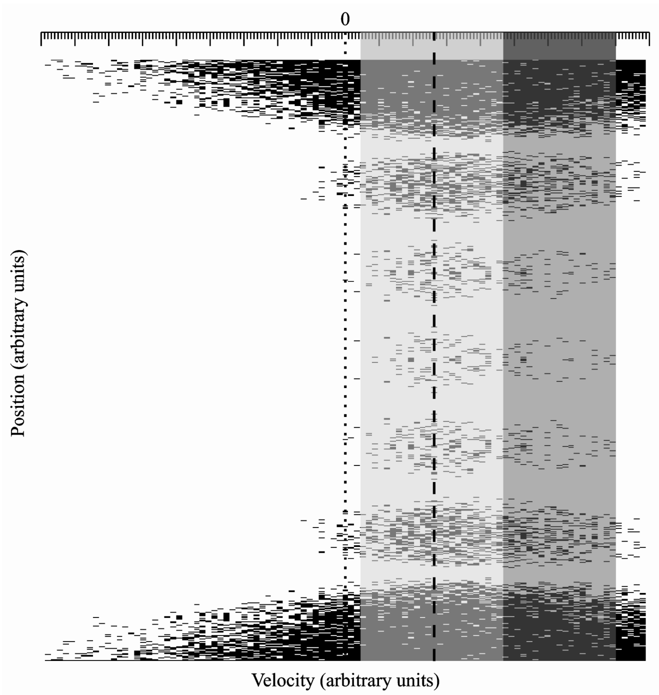


Fig. 2 – Velocity maps: (top) – of STEREO/EUVI images for 21.05.09 at 14:05 UTC; (bottom) – of SOHO/EIT images for 21.05.09 at 14:05 UTC.



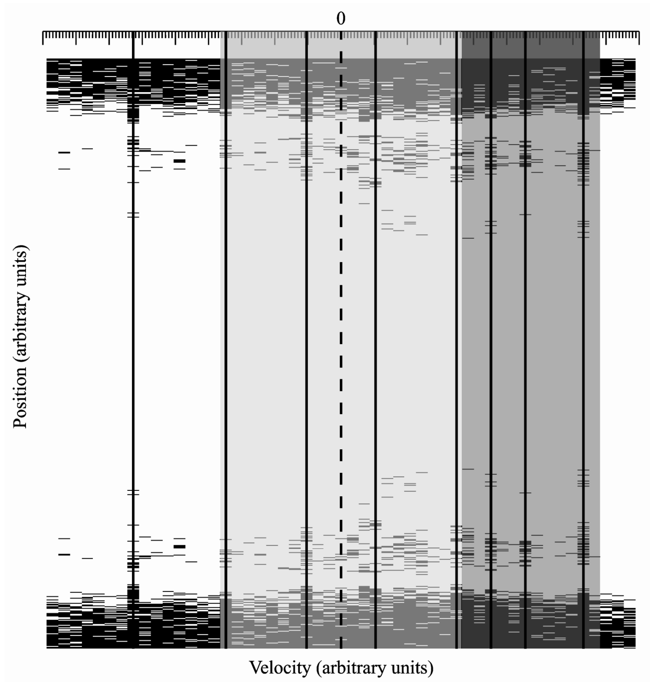


Fig. 3 – Velocity maps: (top) – of STEREO/EUVI images for 27.05.09 at 15:15 UTC; (bottom) – of SOHO/EIT images for 27.05.09 at 15:15 UTC.

These gray bands are centered on the interrupted line, the STEREO images' zero velocity displaced by all the other effects discussed until now. Relative to this line and knowing the km/s/mm conversion quantity, we can determine the lower and the upper limits for the velocity of the blobs representing the prominence. The same can be done for the blobs emphasized on the velocity maps by blue bands and representing the micro-CME events.

Now, knowing the bulk motion velocity in the prominence from STEREO images, we can scale the SOHO images by them, obtaining a new km/s/mm scaling value with which we can check the micro-CME blobs velocity observed in SOHO images and compare the results with the micro-CME velocity obtained from the STEREO images. These results are summarized in Table 1.

Table 1

Micro-CME blobs velocity

	Date		18.05.09	21.05.09	27.05.09
STEREO	$v_{satellite}$ [km/s]		30.211	30.536	30.540
	Scaling factor [km/s/mm]		1.0618607	1.3534195	1.1908459
	v_{AR} [km/s]		-28.572	-27.898	-28.459
	$v_{prominence}$ [km/s] relative to zero (interrupted line)		± 22.04	± 18.888	± 25.125
	$v_{micro\text{-}CME}$ [km/s]	Lower	- 22.04	18.888	25.125
		Upper	- 47.776	56.888	64.805
SOHO	Scaling factor [km/s/mm]		0.5481839	0.4970564	0.6909297
	$v_{micro\text{-}CME}$ [km/s]	Lower	- 23.16	-	25.13
		Upper	- 39.156	-	54.029

3. DISCUSSION AND CONCLUSIONS

In Table 1 we observe that the velocity associated with the horizontal plasma motion in the prominence is around 20 km/s, the velocity inferred by the literature (Athay et al. 1980). Second, the velocity in the loops of the AR is, as expected, the same for all three dates and oriented in opposite direction to the solar rotation.

The problem appears when we try to compare the upper velocity limit for the two satellites. This does not fit and the reason is the poor resolution of the SOHO images relative to the STEREO ones. This can be inferred just by looking at SOHO velocity maps, in which the blobs do not appear (as in 21.05.09 case) or, when they do, they are too faint to establish correctly their superior limit (when this limit is in the map, for 27.05.09 this velocity being out the range). Some features are too faint or too low in resolution to be observed and recognized as so. The other source of imprecision for SOHO image determinations is the size of a pixel as compared to the size of a pixel in a STEREO image, their ratio being between 1.7 and 3. As an example, for 27.05.09 the ratio between STEREO scaling factor and the SOHO scaling factor is 1.72, this making easier to do mistakes in selecting the important velocities or limits from SOHO maps.

In conclusion, the STEREO results are more of confidence for accurate determinations than the SOHO results.

A problem that we did not touch at all here is the apparent spatial periodicity (on *y* axis of the velocity maps). This can be related to an oscillatory, periodic behavior of the matter in the prominence (Jing et al. 2006), or it can be just an artifact on the STEREO images.

Acknowledgments. This work was performed within the framework of the PECS C98055 ESA contract. We also acknowledge for the use of SOHO and STEREO satellites data. SOHO is a project of international cooperation between ESA and NASA. The author thanks Ştefan Sorescu-Surdu for his help with graphics.

REFERENCES

Athay, R. G., White, O. R., Lites, B. W., Bruner, E. C.: 1980, *Solar Phys.*, **66**, 357.
Jing, J., Lee, J., Spirock, T. J., Wang, H.: 2006, *Solar Phys.*, **236**, 97.
Nisticò, G., Bothmer, V., Patsourakos, S., Zimbardo, G.: 2009, *Solar Phys.*, **259**, 87.
Popescu, A. S., Mierla, M.: 2008, *Amer. Inst. Phys. Conf. Proc. Ser.*, Vol. **1043**, 309.
Popescu, A. S.: 2009a, *IAU Conf. Proc.*, **259**, 239.
Popescu, A. S.: 2009b, *Rom. Astron. J.*, **19**, 133.

Received on 28 January 2010