Relationship between CME source regions and coronal holes

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Abstract

Coronal holes are regions of monopolar magnetic field on the Sun where the field is considered to be ‘open’ towards interplanetary space. Magnetic bipoles emerging in the vicinity of this monopolar environment naturally interact with this surrounding ‘open’ magnetic field. We expect the active regions within or on the boundary of coronal holes will be more eruptive since reconnection removes field lines that stabilize potentially eruptive active region filaments/flux ropes. In this project, we begin to explore the relationship between CME source regions and coronal holes by looking at a case study of active region AR 10689.

Introduction

An active region is a localized region of the solar photosphere and atmosphere with an underlying area of concentrated magnetic fields. This underlying bipolar region contains roughly equal positive and negative flux quantities. The active region forms when bundles of magnetic field lines, or flux ropes, erupt through the solar photosphere. Loop structures of closed field lines are created (Figure 1).

A typical active region, AR 10689, erupted from the Sun’s photosphere on April 5, 2006. Its proximity to a low latitude coronal hole made it an ideal candidate for a case study of the relationship between CME source regions and coronal holes. AR 10689 emerged as a magnetic bipole oriented in an east-west direction i.e. with a north-south neutral line. (See Figure 3, top series). The active region’s negative polarity was located closer to the monopolar, positive magnetic flux environment of the coronal hole. Opposite alignment of the closed field lines of the active region and the open field lines of the coronal hole provided a favorable scenario for interchange reconnection (Crooker *et al*, 2002) to occur at the coronal hole boundary (Fisk & Schwadron 2001).

Interchange Reconnection

The closed loops in Figure 1 expand and push against the open field lines of the coronal hole leading to successive magnetic reconnection from the outside inwards at X in Figure 2. After reconnection, new closed ‘creeping’ loops are created between the positive coronal hole and negative pole of the active region. The coronal hole boundary begins to retreat during the process of successive reconnection events. In addition to creeping loops being created, open field lines of the coronal hole are displaced (Wang & Sheeley 2004; Attrill *et al*, 2006) to the far side of the active region, leading to areas of dimming. Dimming regions are formed as plasma no longer trapped by the closed field line structure of the active region flows along the displaced open field lines.

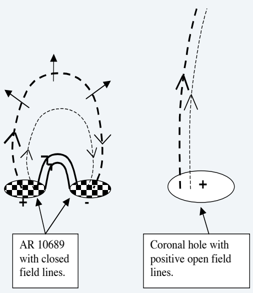


Figure 1 (Left) - Favorable field line orientation for interchange reconnection. Open coronal hole field lines are oppositely directed to the closed field lines of the active region.

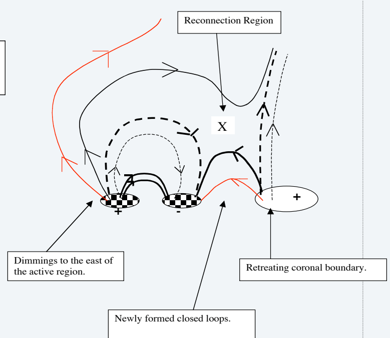


Figure 2 (Right) - Aftermath of interchange reconnection. New closed loops are formed and open field lines of the coronal hole are displaced to the opposite side of the active region. (Cartoons adapted from Attrill et al 2006).

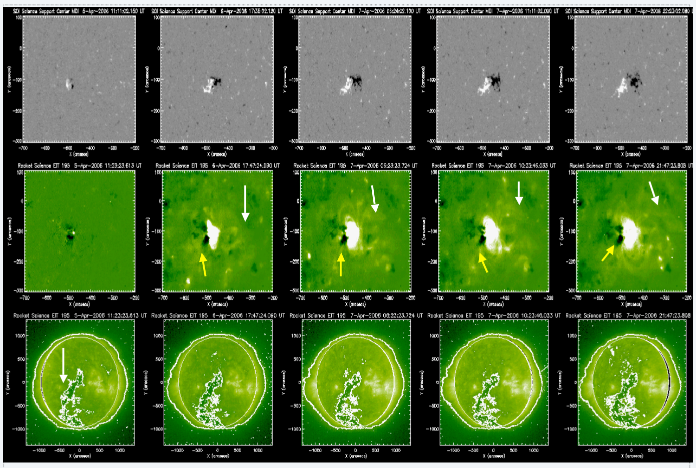


Figure 3 - Top row - SOHO/MDI Magnetogram images show the emerging flux of the AR 10689. Middle row- SOHO/EIT 195 Å full-disk derotated base difference images show the newly created ‘creeping’ loops (white arrows) to the west towards the coronal hole and dimming to the east of the active region (yellow arrows). Bottom row - EIT 195 Å images over-plotted with coronal hole boundary contours demonstrate how the ‘creeping’ loops eat away the coronal hole boundary.

Data Analysis and Results

SOHO/MDI full-disk magnetograms and SOHO/EIT 195 Å full-disk images (Scherrer *et al*, 2005 and Delaboudiniere *et al*, 1995, respectively) were used to analyze the interaction of AR10689 with the coronal hole boundary. The EIT 195 Å images were differentially rotated to the same time of early flux emergence (11:59 UT on April 5, 2006). Base difference images were used to capture details of the interaction. This series of images displayed in Figure 3 provides the following evidence for interchange reconnection:

1. Dimming to the east of the active region can be seen in the EIT images of the middle row of Figure 3 (yellow arrows).

2, ‘Creeping’ loops to the west in the direction of the coronal boundary are evident in the base difference images of the same series (white arrows).

3. The maps with a coronal hole boundary overlay (Figure 3 - bottom row) clearly show the ‘creeping’ loops eating away at the boundary.

Active region - coronal hole boundary interaction is demonstrated in the 2D plot of intensity over time (Figure 4a) along an east-west line from the core of AR10689 to inside the coronal hole (Figure 4b). Each physical process of the interaction is quantitatively demonstrated in the 2D time series plot as shown below.

Figure 4a - 2D Plot of intensity over time along the line shown in 4b.

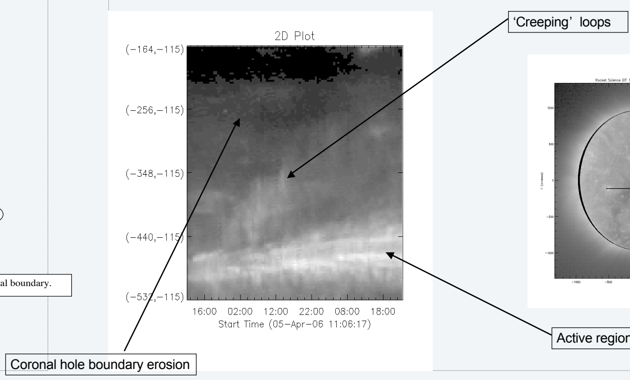
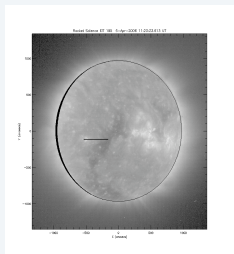


Figure 4b - line from active region core to inside the coronal hole,



References

Attrill, G., Nakwacki, M.S., Harra, L.K., van Driel-Gesztelyi, L., Mandrini, C.H., Wang, J.: 2006, *Sol. Phys.*, **238**, 117

Crooker, N.U., Gosling, J.T., Kahler, S.W.: 2002, *J. Geophys. Res.*, **107**, 1028

Delaboudiniere, J.P. et al.: 1995, *Sol. Phys.*, **162**, 291

Fisk, L.A. and Schwadron, N.A.: 2001, *Astrophys. J.*, **560**, 425

Scherrer, P.H.: 2005, *Sol. Phys.*, **162**, 129

Wang, Y.-M. and Sheeley,, N.R.,Jr.: 2004, *Astrophys. J.*, **612**, 1196