A CME-Producing Solar Eruption from the Interior of an Emerging Bipolar Active Region

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Abstract

In a negative-polarity coronal hole, magnetic flux emergence, seen by the Solar Dynamics Observatory's (SDO) Helioseismic Magnetic Imager (HMI), begins at approximately 19:00 UT on March 3, 2016. The emerged magnetic field produced sunspots, which NOAA numbered 12514 two days later. The emerging magnetic field is largely bipolar with the opposite-polarity fluxes spreading apart overall, but there is simultaneously some convergence and cancellation of opposite-polarity flux at the polarity inversion line (PIL) inside the emerging bipole. In the first fifteen hours after emergence onset, three obvious eruptions occur, observed in the coronal EUV images from SDO's Atmospheric Imaging Assembly (AIA). The first two erupt from separate segments of the external PIL between the emerging positve-polarity flux and the extant surrounding negative-polarity flux, with the exploding magnetic field being prepared and triggered by flux cancellation at the external PIL. The emerging bipole shows obvious overall
left-handed shear and/or twist in its magnetic field. The focus of this poster is the third and largest eruption, which comes from inside the emerging bipole and blows it open to produce a CME observed by SOHO/LASCO. That eruption is preceded by flux cancellation at the emerging bipole's interior PIL, cancellation that plausibly builds a sheared and twisted flux rope above the
interior PIL and finally triggers the blow-out eruption of the flux rope via photospheric-convection-driven slow tether-cutting reconnection of the legs of the sheared core field, low above the interior PIL, as proposed by van Ballegooijen & Martens (1989) and Moore & Roumeliotis (1992). The production of this eruption is a (perhaps rare) counterexample to solar eruptions that result from external collisional shearing between opposite polarities from two distinct emerging and/or emerged bipoles (Chintzoglou et al. 2019).

The Region of Interest

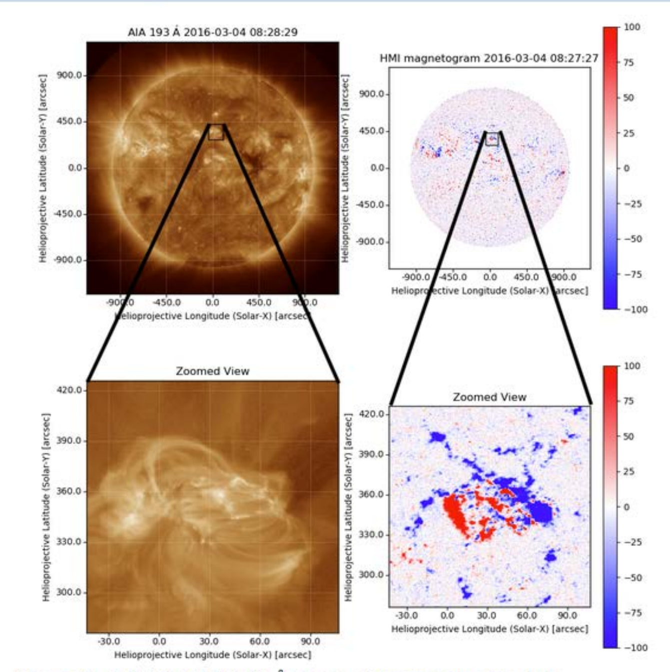


Figure 1: A full-disk AIA 193 Å image with corresponding HMI magnetogram. The region of interest marked by the box shows the area where a brightening was observed in multiple AIA wavelengths (e.g., 211 Å, 304 Å) that also corresponds to emerging magnetic flux. The bottom panels show the zoomed in field-of-view of the boxed region. The data are from 2016 March 4, 08:28:29 UT.

The Third Eruption in Stills and Animation

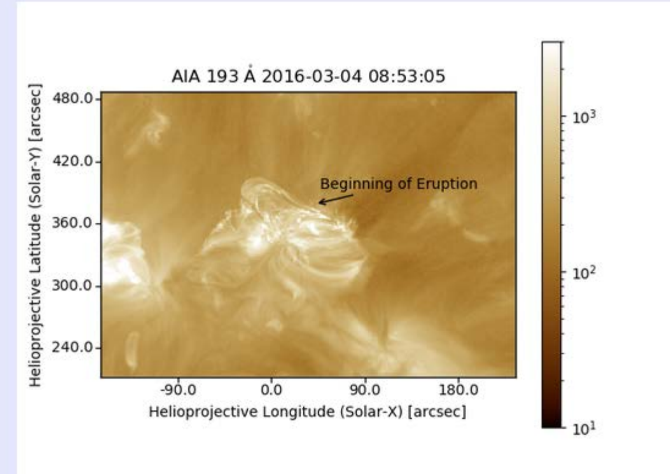


Figure 2: This image shows the region at the beginning of the eruption.

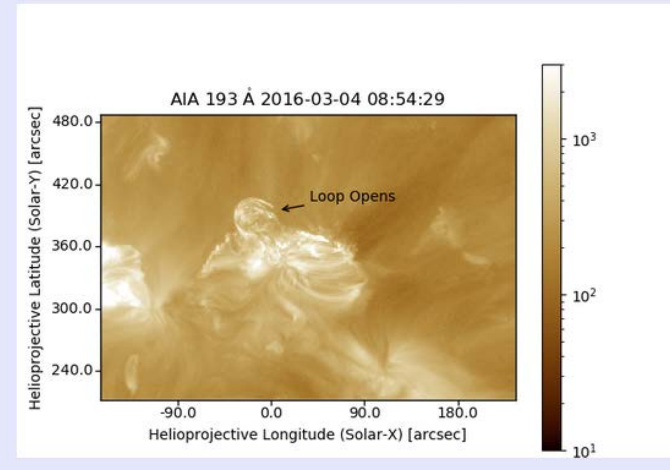


Figure 3: A little over a minute later, the loop opens.

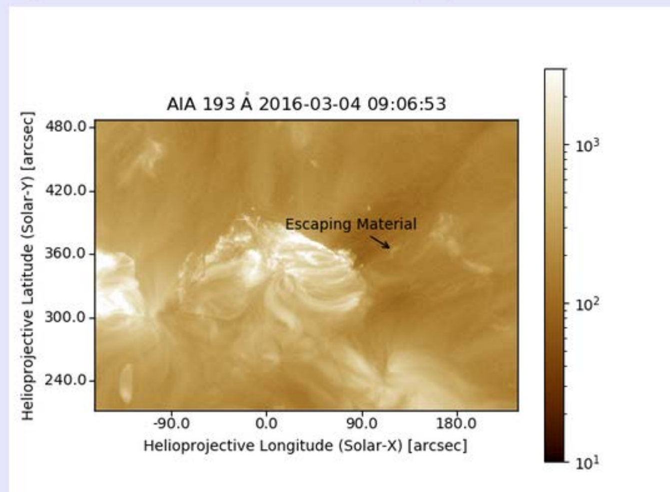
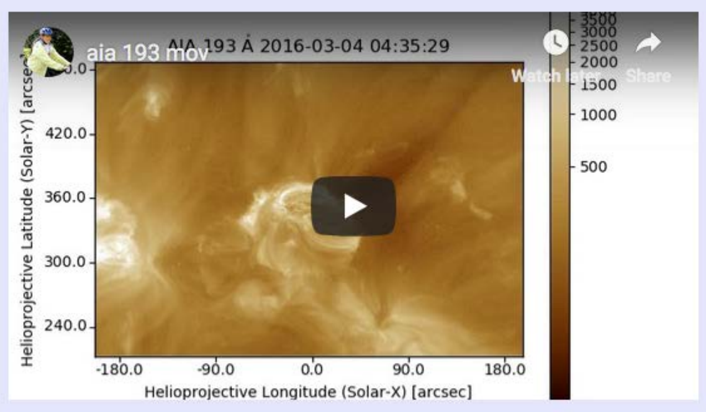


Figure 4: Approximately ten minutes later, material is seen to be funneled away by the open magnetic field.

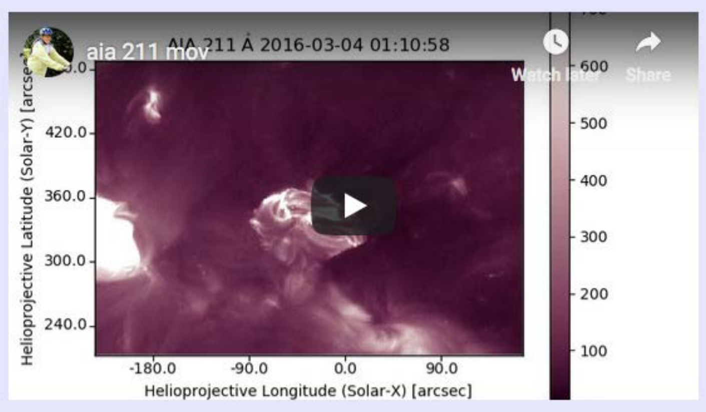
The animation below in AIA 193 Å shows 24 hours of data beginning with the pre-emergence coronal hole. Note that there are some data dropouts and missing data, especially on March 4 from 06:29:42 UT to 08:10:12

1



The animation below shows data from SDO's AIA 211 Å filter. Note at approximately 09:10 UT (March 4), the appearance of post-flare-like loops that span the bipolar PIL.

2



Magnetic Evolution: Time-Distance Plots, Animation

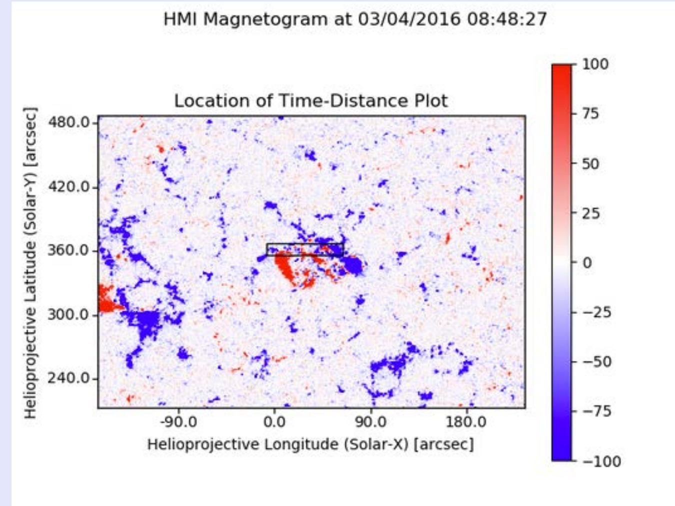


Figure 5: This image shows the location of the box within which the data were column averaged.

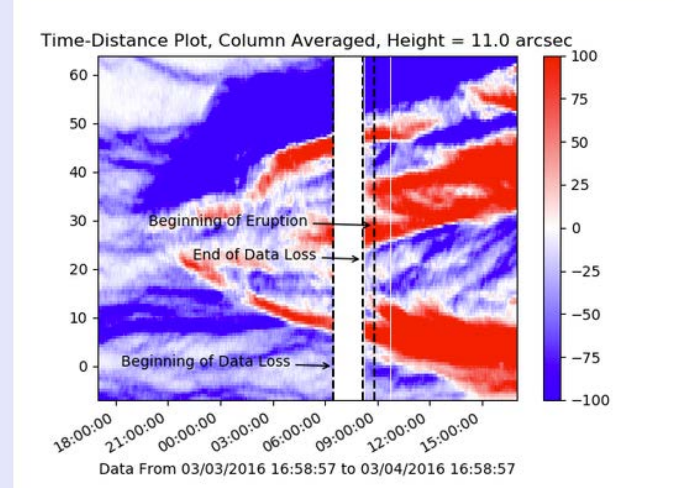


Figure 6: The time-distance plot clearly shows emergence and separation. Note also the blank area, which spans the time of data dropout. Unfortunately, this occurs just before the eruption of interest.

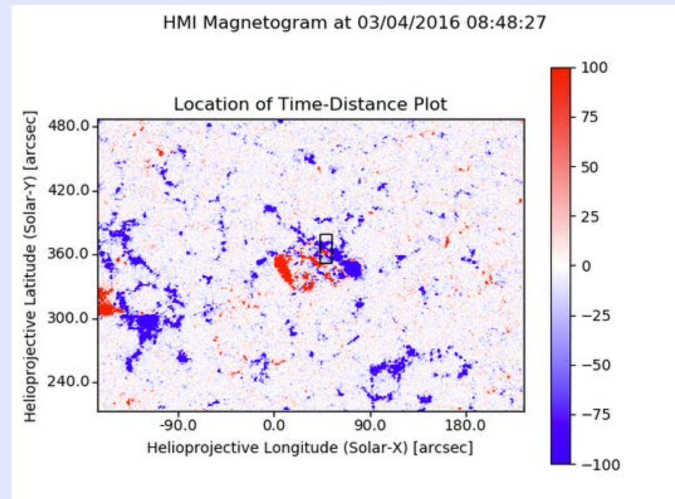


Figure 7: A vertical cut was made through the bipole from which the eruption began and those data were row averaged.

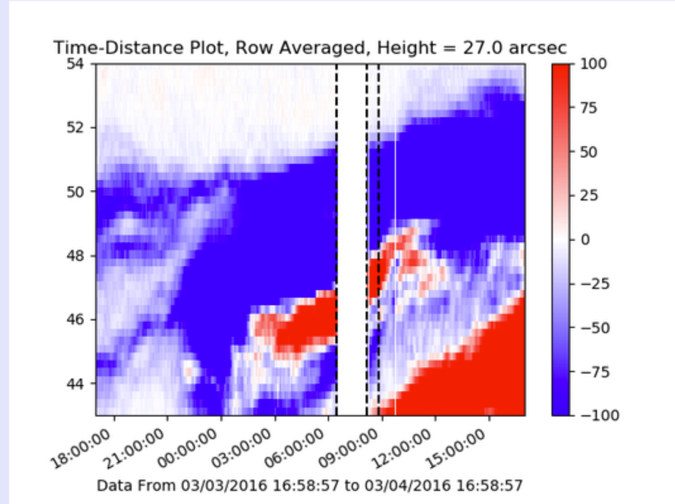
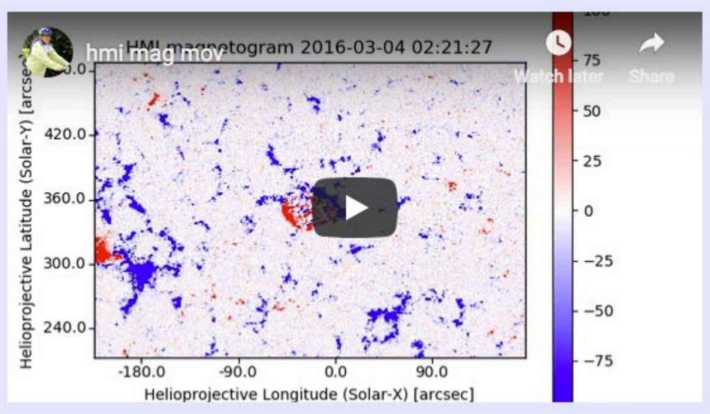
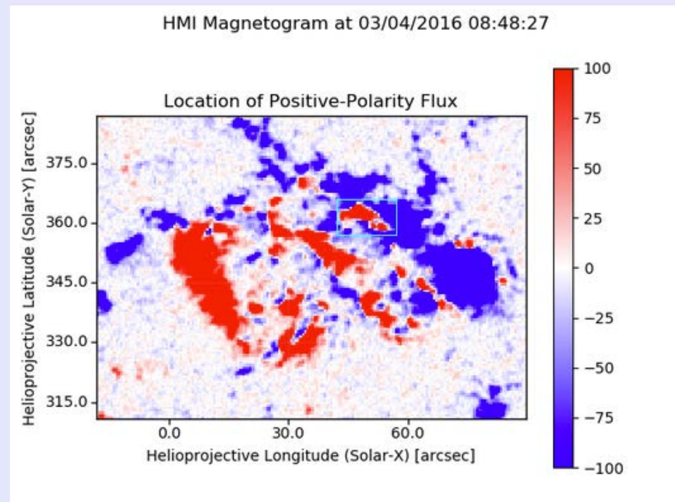


Figure 8: As in the figure above, the vertical white areas are regions of missing or bad data. Note that immediately after the data gap, the positive-polarity region close to the center of the image is reduced in size as compared to before the data gap.

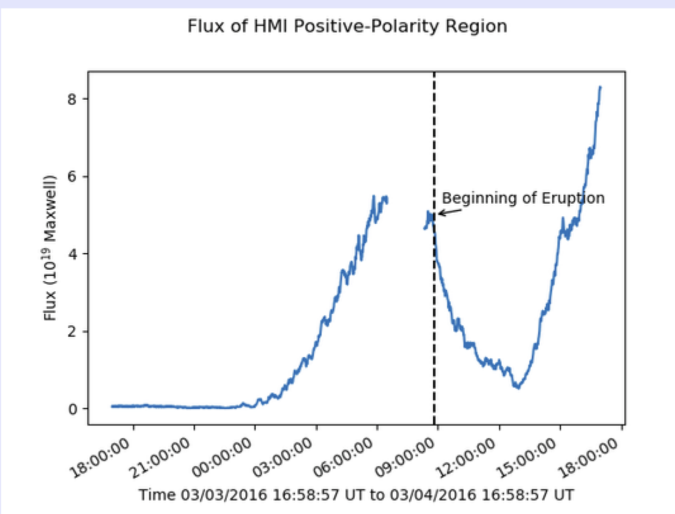
3



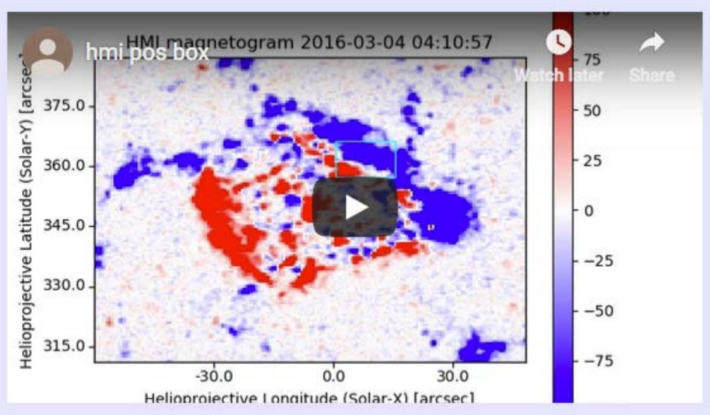
The animation above shows negative-polarity magnetic field emergence beginning at approimately 18:39 UT on March 3. Positive polarity is soon seen as well, and elements can be seen in the interior moving about and disappearing. The bipolar region continues to expand througout the observation window of 24 hours. Again there are missing and bad data in this sequence.



Figures 9 and 10: The image above shows a box marking the location of positive-polarity magnetic field from where the eruption occurred. Positive values within this box were used to calculate flux and to construct the plot below, which shows a decrease around the time of the featured eruption.



4



The animation above shows the location of the region of interest and although some magnetic field moves into and out of the box early and late in the video, around the time of the eruption, from approximately 06:00 UT until approximately 11:00 UT, the box isolates the positive polarity field.

The CME

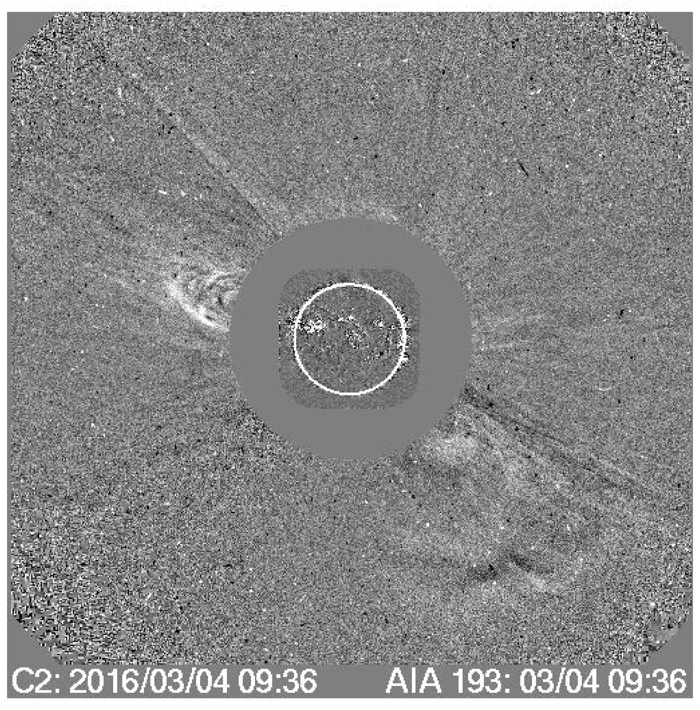


Figure 11: This running difference image shows the start of the CME, focus on the north-pole region.

Figure 12: The CME is seen emerging from the edge of the occulting disk (north pole).

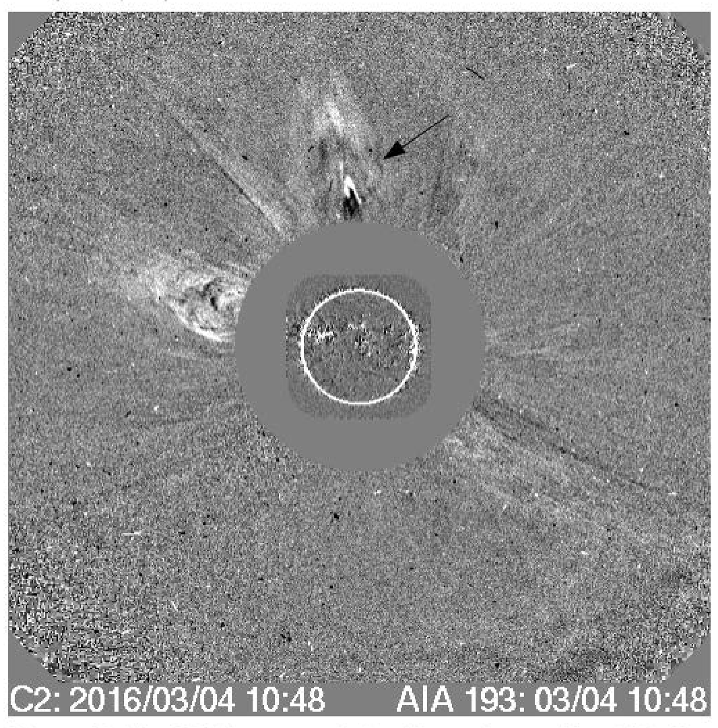


Figure 13: The CME has extended well past the occulting disk of SOHO/LASCO C2.

Summary

We have seen the emergence of the line-of-sight component of the magnetic field in a small coronal hole, which produced several eruptions, one of which is highlighted in this poster. This eruption occurred on the **inside** of the emerging-flux region, was triggered by flux cancellation there, and produced a flare and CME. Future work will involve searching for other examples of this behavior.

Movie 1: https://youtu.be/Xa1kDFT8KAU

Movie 2: https://youtu.be/aisLhjbkFNo

Movie 3: https://youtu.be/zP_I6pZSIDw

Movie 4: https://youtu.be/ZRK53N2dojU

Poster Submission: https://aas234-aas.ipostersessions.com/default.aspx?s=B4-13-EA-4C-06-B0-08-64-3A-D4-22-AE-89-F5-FF-39