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Microarticle

What drives solar-EUV jets seen in equatorial coronal holes?

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ABSTRACT

Recent observations of jets in solar coronal holes that include multi-wavelength data such as EUV movies have shown that most of those jets are not driven in the way suggested by the standard model. The standard model proposes that new, closed magnetic field emerges from below the solar surface to interact with already-existing magnetic field that extends high into the corona. Evidence provided by the EUV movies however, shows that the jet is driven out along the ambient field by the eruption of stressed, closed field that has built up at the base of the jet and that the eruption carries a clump of relatively cool solar plasma (called a minifilament) in its core. Our research suggests that the stressed base field is both built up, and triggered to erupt by magnetic flux cancellation, not field emergence. The explosive field in many other solar eruptions of all sizes is built up and triggered in a similar way. We show one example of flux cancellation that leads to a jet in a coronal hole, using data from the Solar Dynamics Observatory (SDO).

Introduction

Jets have been observed on the Sun in the chromosphere and transition-region at many different scales [1,2]. In some cases, as seen in soft X-rays, it has appeared that bright points and jets in coronal holes happen when magnetic flux emerges through the photosphere, rises into the chromosphere and corona, and reconnects with the ambient unipolar open magnetic field [3]. Another explanation involves flux cancellation between opposite-polarity flux as the magnetic field is jostled in the photosphere [4,5, and others cited in these two examples]. A recent review article [6] enumerates observations of jets since the 1990s, their types, characteristics, and possible mechanisms of formation. To explore transition region/coronal jets, observations from the Solar Dynamics Observatory (*SDO*) on April 9, 2012 were used to examine the magnetic field of a small region inside a coronal hole close to disk center, in which a jet appears. This work shows this jet is another example of a jet in a coronal hole, resulting from flux cancellation and not flux emergence.

Data and analysis

Data include EUV images from *SDO* Atmospheric Imaging Assembly (AIA) and magnetic data from the Helioseismic and Magnetic Imager (HMI) [7,8]. The jet that we report here, includes features called macrospicules and erupting minifilaments. In AIA 304 Å images, a concentration of absorbing, cool material at 8:00 UT (Fig. 1a) is persistent at the site of a bright point that appears at 8:07. The AIA 193 Å data show a small jet at this time to the southwest (Fig. 1c). A filament erupts at 8:22 UT, 8:59 UT, and at 9:18 UT as seen in animations of AIA 304 Å data. Jetting material is also seen at 9:26 UT. At 9:15 UT, dark material seems to connect two bright points, one to the northeast, the other to the southwest. At 9:15, another filament moves over the brighter area (see Fig. 1b), with one footpoint between two bright points that are aligned north/south. At 9:17 UT, the dark material lifts and at 9:28 UT, a jet of material forms to the southwest, anchored between two bright points. At 9:40 UT, the region is quiet again. Fig. 1c and d show the jet in 193 Åat 8:00 UT and 9:29 UT with magnetic-field overlay at 4:00 UT and 9:29 UT. The jet at 9:29 UT expands to the southwest.

Animations of the HMI line-of-sight component of the magnetic field show some flux cancellation at about 4:20 UT. The negative polarity (yellow contours) in the center of the field-of-view (top arrow, Fig. 1 and that to the right of the bottom arrow have completely disappeared by 5:48 UT. The positive polarity to the south of the center of the field-of-view (Fig. 1c, green contours) divides at about 5:48 UT, to form two dipoles; the bottom arrow points to the beginnings of the western bipole, which will span much of the jet base. At 8:05 UT, the negative part of the westernmost bipole (yellow contours) alters shape

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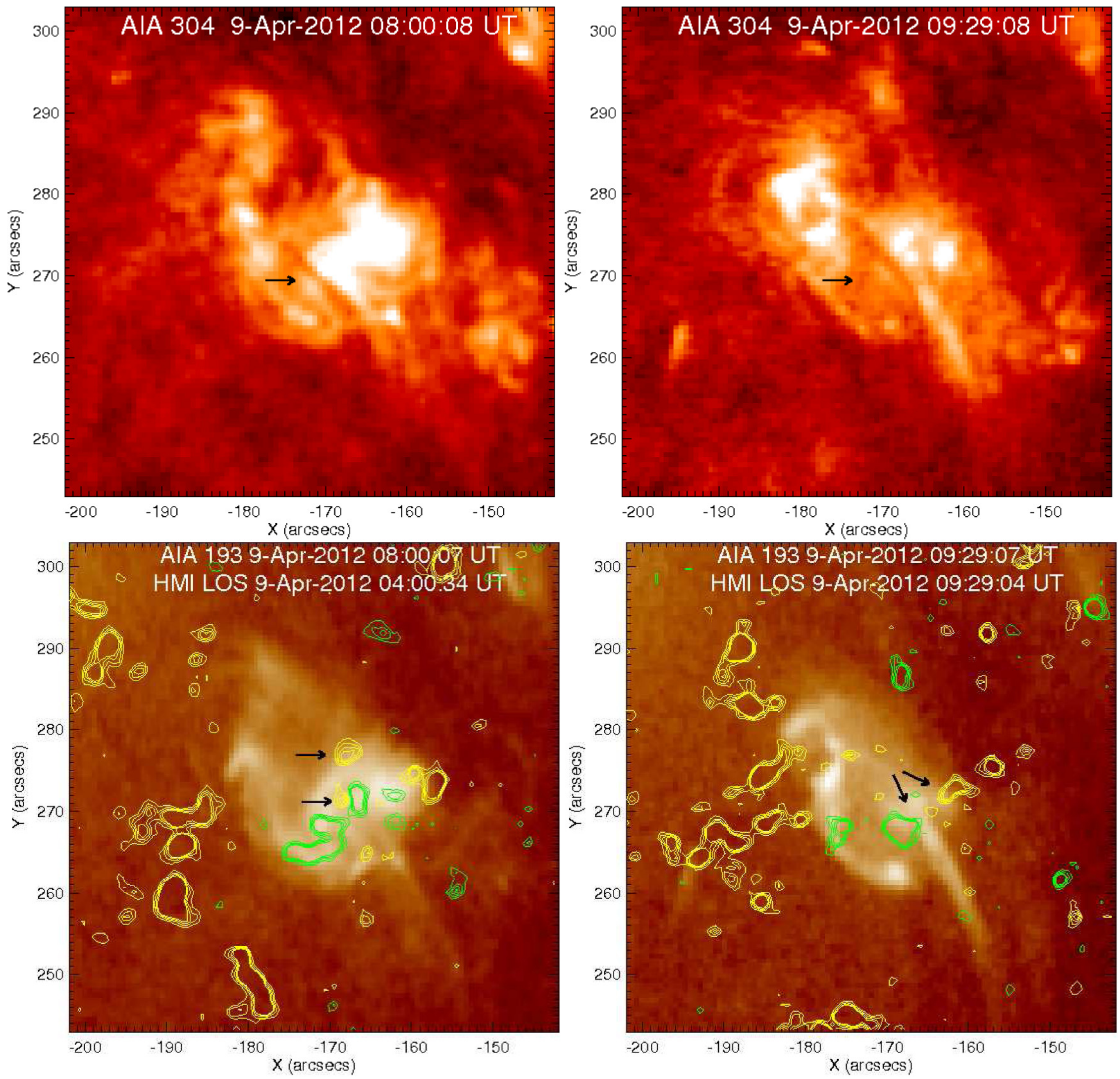

Fig. 1. Observations from AIA 304 Å and from AIA 193 Å with overlay of HMI line-of-sight magnetic field. (a) The arrow indicates a filament at 8:00 UT. (b) Shows the beginning of a jet to the southwest, an additional filament has appeared since 8:00 UT. (c) Shows the jet to the southwest in AIA 193 Å. Contours of HMI's line-of-sight component of the magnetic field have values of ±20, 30, 40, and 50 Gauss. Arrows show locations where the magnetic field reduces over the next several hours. Yellow contours are negative, green are positive. (d) AIA 193 Å with HMI magnetic field overlay, arrows show the jet straddled by a bipole centered approximately at (−160, 270) arcsec. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

significantly and is reduced in size up to 9:06 UT. However, by 9:29, as Fig. 1d shows, magnetic elements have coalesced to form a slightly larger patch of flux.

Conclusion

We report here another example of a jet resulting from magnetic cancellation and not flux emergence. A minifilament eruption is also involved in this activity. As the minifilament rises into the open magnetic field of the coronal hole, reconnection occurs following the model proposed in [5], driving a jet seen in AIA 193 Å. Flux cancellation however, begins many hours before the minifilament and jet erupt, implying that energy from cancellation of the magnetic field builds up over time before reaching a critical value. More work needs to be done to determine what this critical value might be, how pervasive is this mechanism of jet formation, and what other mechanisms might lead to jet formation.

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