Inconspicuous Minifilament Eruptions as the Source of Conspicuous Extreme Ultraviolet (EUV) Outflows in the Solar Atmosphere

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Abstract

We used EUV images from the Atmospheric Imaging Assembly (AIA) and magnetograms from the Hinode and Magnetogram Imaging Telescope (HMI) to search for the low-altitude counterparts of a few EUV brightened outflow events found by the EUV Imaging Spectrometer (EIS) on board Hinode. Five events were in the northern polar region and four were near the equator. For seven of the events, we find minifilament activity consistent with a minifilament eruption occurring at the time and location of the observed brightened EUV event, while the remaining two events were too feeble for us to make a determination. These minifilament eruptions are similar but less energetic than those previously found to cause coronal mass ejections. In three cases, we identify a jet-like spike emanating from the minifilament-eruption region, while in the other six cases such a spike is too faint to be detected or is absent. We find the eruptive minifilaments to have lengths of <5 km and proper motion speeds of ~10 km/s near their eruption onset time, values which are within the range of other events and values found for eruptive minifilaments in the photosphere. In one of these events we find evidence of a minifilament candidate that is too close to the background noise level to properly determine if it is the source of the EUV outflow, but if it is, it suggests that eruptive dynamics are a consistent feature across the lower solar atmosphere.

In 2020 the Sun was rastered and evidence of plasma outflows was found. Schwantz et al. (2021) observed the locations of fourteen localized and enhanced outflows using the Doppler data from this rastering and performed an initial assessment for the coronal sources of each of the events, only five had Hinode-X-ray imager data to allow for more detailed observations of these events. Sterling et al. (2022) investigated these five events in greater detail and found that they corresponded to inconspicuous X-ray jets that are formed from the eruption of minifilaments (EMFs), which is the same case for typical coronal jets (Sterling et al. 2015). Those five events were all in the solar polar region, and so it was not possible for detailed investigations of the magnetic field changes at the jet bases. Here we examine the nine Schwantz et al. (2021) that were not examined by Sterling et al. (2022). We use AIA imaging data to investigate whether these regions also might result from hard-to-detect coronal jets. Four of our nine events were at low altitude, allowing for investigation of magnetic field changes at the EUV-outflow locations. Properly understanding the source of this type of event is important because if there are many such events happening simultaneously on an even smaller scale, it is possible that it could be the source of the constant solar wind.

Background

In 2020 the Sun was rastered and evidence of plasma outflows was found. Schwantz et al. (2021) observed the locations of fourteen localized and enhanced outflows using the Doppler data from this rastering and performed an initial assessment for the coronal sources of each of the events, only five had Hinode-X-ray imager data to allow for more detailed observations of these events. Sterling et al. (2022) investigated these five events in greater detail and found that they corresponded to inconspicuous X-ray jets that are formed from the eruption of minifilaments (EMFs), which is the same case for typical coronal jets (Sterling et al. 2015). Those five events were all in the solar polar region, and so it was not possible for detailed investigations of the magnetic field changes at the jet bases. Here we examine the nine Schwantz et al. (2021) that were not examined by Sterling et al. (2022). We use AIA imaging data to investigate whether these regions also might result from hard-to-detect coronal jets. Four of our nine events were at low altitude, allowing for investigation of magnetic field changes at the EUV-outflow locations. Properly understanding the source of this type of event is important because if there are many such events happening simultaneously on an even smaller scale, it is possible that it could be the source of the constant solar wind.

Instrument and Data

The instrument used to image these events is the AIA and the HMI onboard SoHO. We used the AIA wavelengths 171, 193, 211, and 304 Å at a cadence of twelve seconds, and for the HMI magnetogram we used a standard deviation in location. Events 7 and 14 were consistent with an EMF eruption, and we were unable to properly measure them. For event 8 we found an EMF candidate but it was too feeble to detect. For event 7 we were unable to locate the minifilament or structure consistent with the presence.

Results

Our data suggests EMFs can be the sources of plasma outflow events like the ones found and recorded by Schwantz et al. (2021). More specifically, our data shows that these conspicuous events can be caused by plasma outflow jets and brightenings that are consistent with minifilament eruptions.

Discussion

Following this line of thought, it stands to reason that even more inconspicuous jets could occur on even smaller scales that cannot be detected. If this is the case, it is entirely possible that numerous, inconspicuous dynamic features, such as small-scale jet-like eruptions, in the lower solar atmosphere may create outflows. In turn this suggests that these types of dynamic features could be the elusive source of the solar wind (Raouafi et al. 2023) which may be fueled by these events.

Table 1: Table of dates, times, sizes, and locations of each of the outflow events. *From Table 2 of Schwantz et al. (2021).

Table 2: Table of attributes of each event including source appearances, size, and location of source event.

References


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References