Analysis of 'White-light' Jets using SDO/AIA and COSMO K-coronagraph data

Samaiyah Farid (UCAR/HAO), Chandler Jenkins (Washington State University), Aidan Halpin (Metropolitan State University of Denver)

Abstract

Coronal jets are small eruptions characterized by a narrow spire and a luminous loop base in EUV and X-ray observations. Soho-era white light observations showed that some coronal hole jets can extend far into the heliosphere, while the majority terminate in the lower corona. These and subsequent observations imply that extended coronal hole jets may contribute to the mass in the solar wind and/or be associated with the formation of polar plumes. In this study, we examine a white light jet using the COSMO K-coronagraph and the Atmospheric Imaging Array aboard the Solar Dynamics Observatory. Early analysis show that the extended jets are comparatively faster (~1200 km/sec) and hotter (~6.4 MK) than standard (coronal) jets, suggesting the presence of additional heating and acceleration mechanisms. Here we use the term 'white-light' to describe jets that extend into the outer corona.

While it is commonly accepted that magnetic reconnection is primarily responsible for jet formation (Shimojo1998), the relationship between reconnection and observed plasma parameters is not well understood. Furthermore, once the jet is formed, the plasma can be additionally heated and accelerated by secondary mechanisms throughout the transition region and corona including the mechanical energy from the tension released during magnetic reconnection, gas pressure gradients during chromospheric evaporation, the untwisting motion of the field lines, and/or Alfvenic waves that transverse along newly reconnected field lines (Yokoyama1995, Pariat2015, Pariat2014). Studies of white-light jets using LASCO-C2 suggest that jets that extend into the outer corona are considerably faster (~800-1000 km/sec) are associated with large amounts of twist, and exhibit wave-like motions, characteristic of acceleration by torsional Alfven waves (Wang1998, Moore2015). However, C2 observations were occulted from ~2.2 Rs – 3.0 Rs, so continuous observations were not available.

The Mauna Loa K-coronagraph (K-Cor): is an internally-occulted Lyot coronagraph with an effective focal length of 2 meters. K-Cor is capable of imaging the the outer corona from (1.05 to 3 solar radii) in 720 to 750 nm at a 15 second cadence with a 1024x1024 field of view. Because of the high cadence, K-Cor is well suited to to study the formation and dynamics of coronal mass ejections (CMEs), plumes and flows in the lower and middle corona. Here we examine the calibrated polarization of an extended coronal jet.

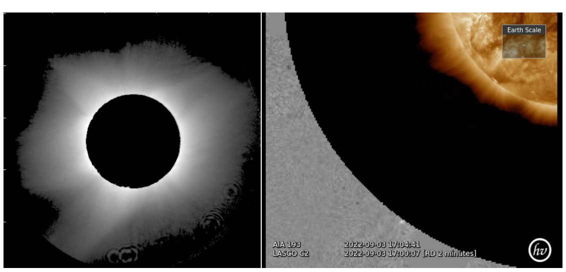
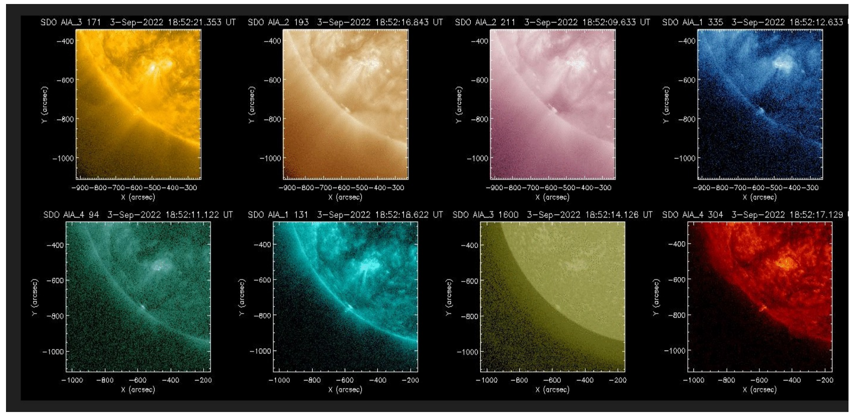


Figure 1. Images of polarized brightness from the K-coronograph (left). LASCO-C3 and AIA 193 combined images of the jet analyzed in this study on 09-03-2022.

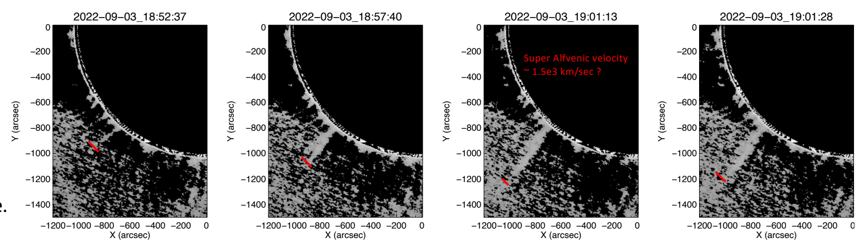
Data Processing: We utilize level 2 data that has already been processed by the K-cor team and is available on the website: (https://mlso.hao.ucar.edu/mlso_data_calendar.php?calinst=kcor)
All publicly data has been corrected for camera non-linearities and dark current subtracted. Level 2 data available includes polarization demodulation matrix and additional sky polarization corrections, alignments, and coordinate transformations were applied (See KCOR instrument paper for complete description) Emission is measured in (pB) in units of B/Bsun, where Bsun is the brightness of the solar disk.

Observations AIA + K-Cor (2022- Sep 03 18:42 -19:05 UT, Peak time (EUV) 18:52 UT)

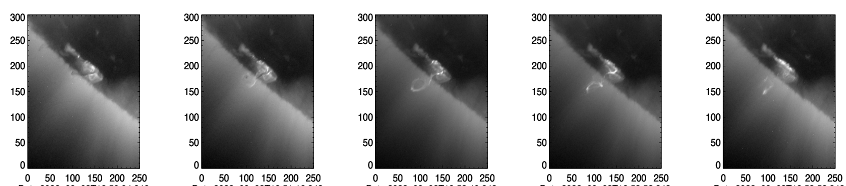
Solar Dynamics Observatory/ AIA Observations: Solar Dynamics Observatory's (Pesnell2012), Atmospheric Imaging Assembly (Lemen2012, Boerner2012) provides continuous observations of the full solar disk with 0.6 arcsec per pixel resolution. AIA is capable of imaging each channel at a 12 second cadence with a 4096 x4096) pixel CCD. In this study we use six AIA channels, sensitive to coronal temperatures from LogT 5.5 to 7.0. 2 second cadence. In this initial study, we calculate the line of sight velocity of K-cor and AIA data. We also estimate the temperature using a Differential Emission Measure (DEM).



Evolution of Coronal Jet Using COSMO K-Cor Images V~ 1.5e3 km/sec

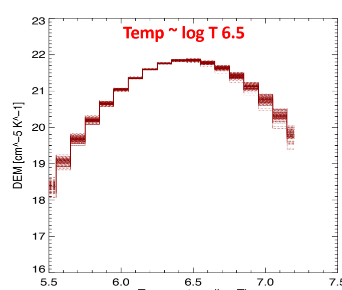


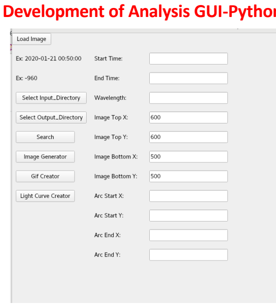
Evolution of Coronal Jet Using AIA 193 A Images: Highly Twisted Structure



We use the DEM solver package, (xrt_dem__iterative2} {Weber2004} to calculate DEM along the spire. The program uses Monte Carlo iterations over the range of the observational error to calculate the variation in the DEM. Observational error is calculated as the square root of emission.

Development of Analysis GUI-Python





AIA Figures courtesy of C. Jenkins. A. Halpin is developing a GUI using the analysis software developed in this work. The GUI will be publicly available and can be used for classroom and outreach purposes. Additional functions will be implemented (velocity, temperature, etc.).

In this initial analysis, we find the jet is considerably more energetic than a coronal jet that terminates in the lower corona. K-cor speeds ~1.5e3 km/sec, Log T 6.5. The jet is highly structured. In EUV it appears as a failed eruption with very little emission. However in the K-cor data, we see an extended structure. More work is need to understand the heating mechanisms of this jet.

DOI: **10.5065/D69G5JV8** K-cor data is *Courtesy of the Mauna Loa Solar Observatory, operated by the High Altitude Observatory, as part of the National Center for Atmospheric Research (NCAR). NCAR is supported by the National Science Foundation.* **Special thanks to the HAO COSMO team. In particular, Joan Burkpile, Giuliana de Toma, and Lisa Perez-Gonzalez.**