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Coronal jet contribution to the slow Solar wind flux: preliminary results

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The solar wind is a continuous flux of charged particles that are ejected from the Sun's atmosphere. The sources of this flux have not been clearly identified yet. Coronal jets are proposed as a possible candidate. They are small collimated ejections of plasma seen in white-light coronagraph images. Using an existing catalogue, a sample of events during the period 2007-2008 was analysed, and ejected particle flux has been estimated. First results are now presented. As future work, all the jets contained in the catalogue will be analysed in order to obtain the average particle flux. The results will be compared to in-situ measurements in order to assess the coronal jet contribution to the solar wind.

Key words: Sun, Jets, Corona, Solar Wind

INTRODUCTION

Coronal jets are usually observed in coronagraph field of view as small collimated ejections of plasma [17]. It is widely believed that coronal jets are the result of magnetic reconnection phenomena happening in the solar corona [12, 14, 19, 20]. X-ray jets have been observed in soft X-rays by Shimojo et. al. [15]. Analysing jets in or near active regions they found that 68% of the jets appear in or near active regions. Ultraviolet observations of coronal jets revealed that jets could be sometimes associated with bright points (BP) on the solar disk. These jets are best observed inside the polar coronal holes where they are not obscured by the bright ambient coronal structures [11].

Many studies focus on jets associated with the polar coronal holes [2, 3, 8, 9, 13, 16]. Using data from the Large Angle Spectrometric Coronagraph (LASCO) [1] and the Extreme Ultraviolet Imaging Telescope (EIT) [4] on board the Solar and Heliospheric Observatory (SOHO) [5], Wang et al. [17] studied polar jets during the solar minimum activity. Later they extended the study to include jets occurring inside or near the boundaries of non-polar coronal holes near the maximum activity period [18]. They found that these jets have angular widths of around 3°–7°, as measured from the Sun's centre. Typical velocities of around 400 to 600 $\mathrm{km\cdot s^{-1}}$ were observed. It was also discovered that these jets have the tendency to be brighter and wider than the polar jets observed near the sunspot minimum.

Using the Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI) twin COR1 coronagraphs on board the Solar TErrestrial RElations Observatory (STEREO) [7] mission, more than 10 000 white-light jets have been observed and catalogued by Paraschiv et. al. [10] during the period 2007-2008. The latter are primary data sources for this study.

DATA DESCRIPTION

The base catalogue, consisting of more than 10 000 events, covers a two year time frame starting from January 2007 and ending in December 2008, during the near-minimum descending phase of the Solar Cycle 23. During this time the separation angle between the two spacecraft increased from 2° to 88°.

Images are taken from the STEREO Science Centre website[1]. The imaging cadence for the jets described in the catalogue is 20 minutes. In consequence, as a selection criteria, only jets with a life time greater than 20 minutes (meaning that they are visible in at least two frames) are considered in this study. Note that in this way short-living jets were ignored. We have also ignored any "jet-like" features with the angular width larger than 8° relative to the

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[1]`http://stereo-ssc.nascom.nasa.gov/cgi-bin/images`

Sun's centre.

The mass of a limited number of events (over 500) was determined. It was necessary to compute the difference between two total brightness images in order to eliminate background noise and other faint emissions. This was done by selecting an image prior to the eruption and another one in which the jet could be clearly seen. The jets were easily observed in the resulted difference. Using the `SolarSoft` package we selected the area containing the jet and calculated the ejected total mass, using the Thompson scattering of counted photons by the electrons in the jet.

DATA ANALYSIS

SPEED ANALYSIS

Using the data provided by STEREO we are able to assess the position of the jets in space and to determine its velocity. The behaviour of over 200 events observed simultaneously in COR1-A and COR1-B images was investigated.

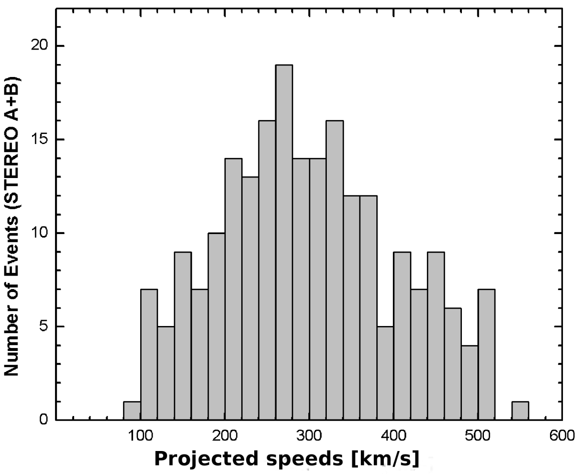

Fig. 1: The speed distribution of projected COR1 jets. Most events have speeds of approximately 300 km·s^{-1}

The estimation of the speeds of each jet was obtained by tracking the jet in successive time-lapse images in the COR1 field of view. A height-time (HT) diagram was built for each measured event and a linear fitting or a second-order polynomial fit was applied to obtain the outflow speeds. In most cases a linear fit was sufficient, implying that the jets were moving at a constant speed in COR1 FOV. Figure 1 shows that the majority of jets have speeds ranging from 200 to 400 km·s^{-1}, with an average of approximately 300 km·s^{-1} which is similar to the slow solar wind speed.

CORONAL JET MASS DISTRIBUTION

A sample of events was selected for the ejected mass measurement. The jets could be affected by the large scale projection effects and as a consequence the analysed sample contains only events which appear to be in the sky plane. Figure 2 shows the coronal jet mass distribution, for approximately 500 events. Jets with a lifetime of less than 20 minutes which appear in only one frame were not considered in this first estimation because they can not be clearly distinguished from the background. As a result the left part of the distribution is missing. The graph was fitted with a Gaussian function. The maximum of the Gaussian fit, $1.851 \pm 0369 \cdot 10^{12}$ g, thus represents an estimation of the average mass that is ejected during an event. The result is consistent with other similar studies [6].

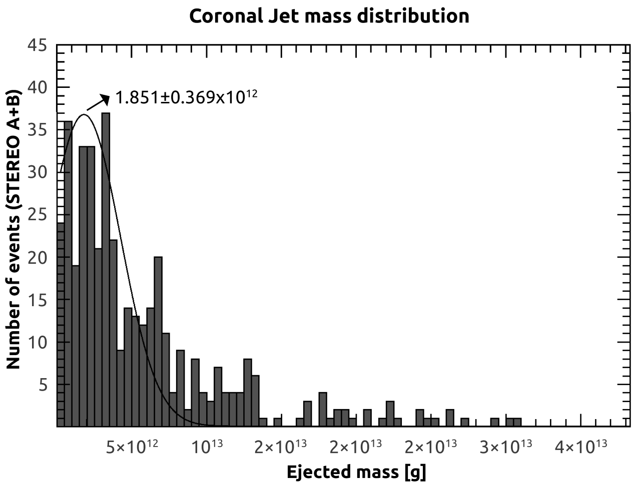

Fig. 2: Coronal jet mass distribution for all the jets analysed so far.

MEASUREMENT ERRORS FOR JET EJECTED MASS ESTIMATION

Stereoscopic reconstruction was not done in this first estimation of the ejected mass. We have assumed that all the jets are in the plane of the sky. This is not always the case since one-point observations are affected by projection effects. These effects influence the measured average ejected mass which could differ from the true mass.

One test jet was processed several times in order to compute the magnitude of the individual measurement errors. The deviation percentage does not exceed 20%. The plots were made for COR1A and COR1B. As it can be seen in Fig. 3, the computed mass slightly differs from the two vantage points.

Taking this into account, all further analysis will require stereoscopic reconstructions of the jets in order to obtain their true trajectory and use it to obtain more accurate results.

CONCLUSIONS AND THE FUTURE WORK

Reconstructed 3D speed distribution for the coronal jets was computed. These results indicate that the jets are a good candidate for a source of the slow solar wind.

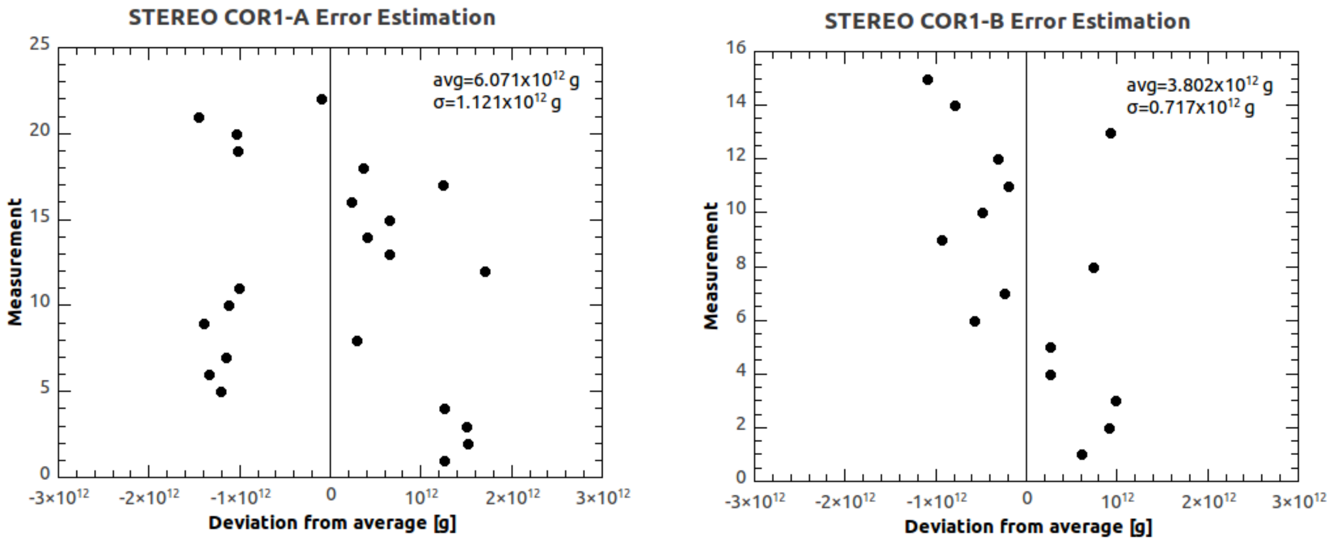

Fig. 3: Measurement errors for jet ejected mass estimation: from the COR1-A (left) and the COR1-B (right) perspective. The vertical line shows the average mass value of the given jet and the scattered points correspond to individual measurements.

All further analysis will require stereoscopic reconstructions of the jets in order to obtain their true trajectory and use it to obtain more accurate results. The averaged ejected mass of the coronal jets was calculated and the results are consistent with other measurements.

In order to estimate the contribution to the solar wind flux statistically, all jets contained in the catalogue have to be analysed, using stereoscopic reconstruction wherever possible, by comparing the flux of jet ejected particles with the total particle flux of the solar wind measured by other in-situ observatories (ACE).

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