The effect of solar observables on magnetic reconnection activity in the solar wind

Bjorn Larsen1,2, Stefan Eriksson1
1 Laboratory of Atmospheric and Space Physics, University of Colorado, Boulder
2 California State University, Chico

Magnetic reconnection jets

Instabilities in current sheets present in the electrically conductive plasma of the solar atmosphere and solar wind allow for the creation of plasma jets resulting from magnetic reconnection.

- An "X-point" instability results in the breaking and mending of magnetic field lines. At the X-point, magnetic field energy is converted into plasma kinetic energy and thermal energy.
- Within a 2D current sheet, X-points are better represented as X-lines, with magnetic field lines pulled inward towards the X-line and plasma jets ejected outward along the current sheet.

Solar wind dynamics

The left figure shows a simulation of a small (~100 km) region of the ambient turbulent solar wind. Thin current sheets (red/blue) are commonplace within this turbulence, capable of creating many reconnection X-lines within a small region.

Many of these X-lines can support reconnection jets, influencing the surrounding solar wind structure and energy distribution.

Determining the jet source locations

Wind never detects a jet until after it has traveled through the solar wind. Do they truly come from the solar wind or have they traveled all the way from the Sun? Using just a few assumptions this upstream source distance (D\textsubscript{1}) can be estimated using Wind data.

\[ \text{mean}(D_1) = 143 \text{ Re} = 6.10 \times 10^3 \text{ AU} \]
\[ \text{max}(D_1) = 1540 \text{ Re} = 6.57 \times 10^3 \text{ AU} \]

Result: Solar wind jets at 1 AU are born far from the Sun.

ICME jets

- ICMEs constitute a different physical environment from the ambient turbulent solar wind.
- Our data: Jets are no more likely to appear within ICMEs than within the ambient solar wind.

Correlation analysis with solar observables

Early investigation indicates jet activity decreases as solar wind speed increases, especially for thin jets outside ICMEs.

For this study, we are using 931 unique reconnection jets over a 3-year timespan from mid 2004 to mid 2007.

Discussion

- The solar wind acts as an extensive source of magnetic reconnection jets which have been largely unstudied as of yet.
- The reconnection dataset used for this study is unfinished but has elicited some interesting preliminary results, namely:
  - ICMEs are just as likely to produce jets as the ambient solar wind.
  - There is no correlation between solar wind reconnection activity and ICMEs.

Jet signatures:
- Rotation of in-plane magnetic field
- Velocity spike at Alfvén speed

Acknowledgements

This research was supported by the National Science Foundation REU program, award #1659878. This project was conducted virtually as a part of the Boulder Solar Alliance REU program through the University of Colorado, Boulder during the summer of 2020. Thank you to Martin Snow, Claire Rafferty, and Yujian Zhu for doing a fantastic job coordinating the REU program. Thank you to Stefan Eriksson for accepting me into his research team and providing me guidance into the research world beyond just the scope of my own project.

References:

4. GOES X-ray sensor: https://www.ngdc.noaa.gov/stp/satellite/goes/index.html

Detection of reconnection jets from Wind

We use data from the Wind spacecraft located at the L1 Lagrange point to identify reconnection jets in the solar wind. Wind can only take measurements at a single location, so we can’t image an entire jet, but we can identify them by their cross-sectional signatures.