HIGH-SPEED JETS IMPINGING ON THE EARTH’S MAGNETOSPHERE: A STATISTICAL STUDY ON WHERE AND WHEN THEY OCCUR

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1. MOTIVATION

- Testing a model of a jet generation mechanism based on bow shock ripples that are inherent to the quasi-parallel bow shock
- How often do these jets occur?

2. INTRODUCTION

- Plaschke et al. (2013): In the sub-solar magnetosheath, jets occur predominantly when the cone angle \( \alpha \) [in degrees, \( \theta_M \geq 30^\circ \)] between the IMF line and the Earth-Sun line (the \( \theta_M \)-axis) is small (\( \alpha < 45^\circ \)).
- The cone angle \( \alpha \) approximates the angle \( \theta_M \) between the bow shock normal and the IMF.
- \( \theta_M < 45^\circ \) quasi-parallel part of the bow shock
- A foreshock region is formed upstream of the quasi-parallel shock by the interaction of the solar wind with particles reflected from the shock. This is an inherent feature of the bow shock.
- Hietala et al. (2009): Jet formation mechanism based on bow shock ripples that are inherent to the quasi-parallel shock are discussed.
- The locations of the quasi-parallel and quasi-perpendicular areas depend on the IMF orientation as shown in Fig. 2.

3. DATA

- THEMIS spacecraft measurements from 2008-2011
- 9,003,850 MSH observations in a Sun-centered 30° wide cone with its tip at Earth
- 2,859 of those were HSJs (see Fig. 3)
- SW data: averages of OMNI measurements from the preceding minutes
- Selection criteria for jets:
  - Dynamic pressure of a HSM in the anti-sunward direction (the \( -X_{GSM} \)-direction) is over half of the SW dynamic pressure [assuming protons only]:
    \[ P_{dy, km,k} = \frac{1}{2} \rho_{kms,HSM} \cdot V_{kms,HSM}^2 \]
  - \( \theta_M \), the moment of highest ratio between MSH and SW dynamic pressures in the jet and the time of the jet observation in our data set
- The full list of criteria in Plaschke et al. (2013)
- An example jet in Fig. 4

4. METHODS

- Three jets by cone angles:
  - \( \alpha \geq 45^\circ \), \( \alpha \leq 30^\circ \) and \( \alpha \leq 30^\circ \), \( \alpha \leq 60^\circ \), \( \alpha \geq 60^\circ \)
- We normalize the HSM distribution by the MSH distribution to account for the time spent under certain conditions
- 2D maps: model BS by Merka et al. (2009) and model MP by Shue et al. (1998), all positions normalized to the mean \( P_{dy,SW} \) of each zone
- To measure whether a jet is on the quasi-parallel or the quasi-perpendicular area, we form a new coordinate system (Fig. 5):
  - Position vector \( \mathbf{r} = \mathbf{r}_1 + \mathbf{r}_2 + \mathbf{b}_1 + \mathbf{b}_2 \), where \( \mathbf{r} \) is the \( X_{GSM} \)-axis unit vector and \( \mathbf{b}_1 \) and \( \mathbf{b}_2 \) unit vector parallel to the \( Y \)-projection of the IMF line
  - \( \mathbf{b}_1 \) points towards the side that the cone angle \( \alpha \) opens to when \( \alpha \) is facing upstream
  - The quasi-parallel area is mostly on the side where \( R_1 > 0 \) as \( \theta_M \) gets smaller with increasing \( R_1 \) because of the bow shock curvature

REFERENCES

- Plaschke et al., J. Geophys. Res. Space Physics, 121, 3240-3253 (2016)

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