Creation & Classification of Magnetosheath Jet Database using Magnetospheric Multiscale (MMS)

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Introduction

Magnetosheath Jets are enhancements of dynamic pressure above the general fluctuation level, indicating a local plasma flow. They manifest in the region between the bowshock and the magnetopause of the Earth, called Magnetosheath.

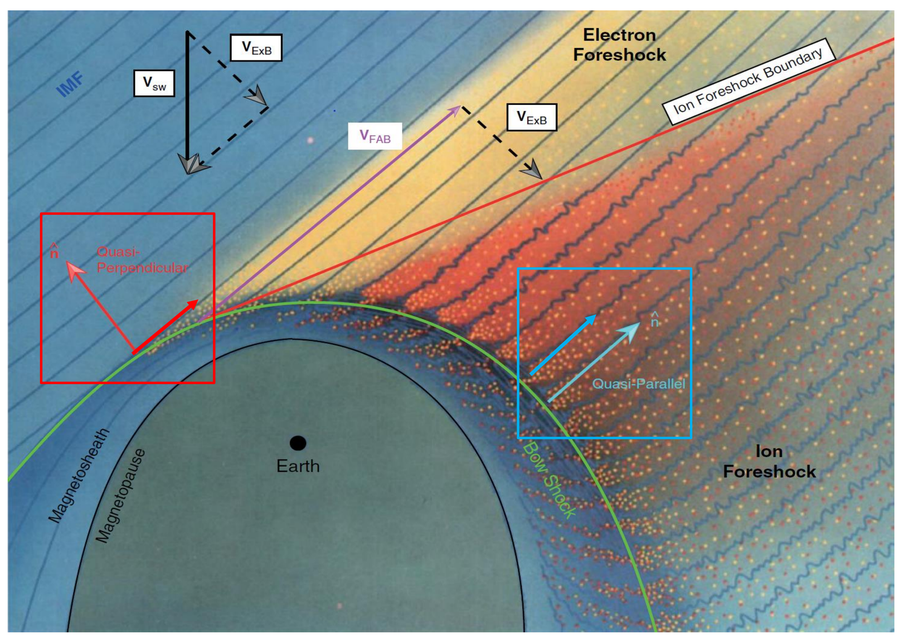

Figure 1: Visualization of the Quasi parallel and perpendicular region. The ion foreshock is much patchier and disturbed in the quasi parallel case. Figure Courtesy: L. B. Wilson (2016).

Jets are believed to be a key element to the **coupling** of the **solar wind and** the **magnetosphere** while possibly associated with other physical phenomena such as **magnetic reconnection**, **auroral features** and **radiations belts**. Finally, it is assumed that they are a universal phenomenon that can appear in other planetary and astrophysical shocks.

Magnetosheath Jets

Fluctuations of plasma moments are most commonly found in the patchier and turbulent **quasi-parallel shock** configuration ($\theta_{Bn} < 45°$). On the other hand, in the **quasi-perpendicular shock**, we have a much smoother situation, with less variance in magnetic field and plasma moments, which however still allows jet formation to occur.

Jets also appear at the **boundary** between quasi-parallel and quasi-perpendicular sheath. A special case of jet are the **encapsulated** ones. These jets appear very similar to quasi-parallel jets while the surrounding plasma is of quasi-perpendicular nature.

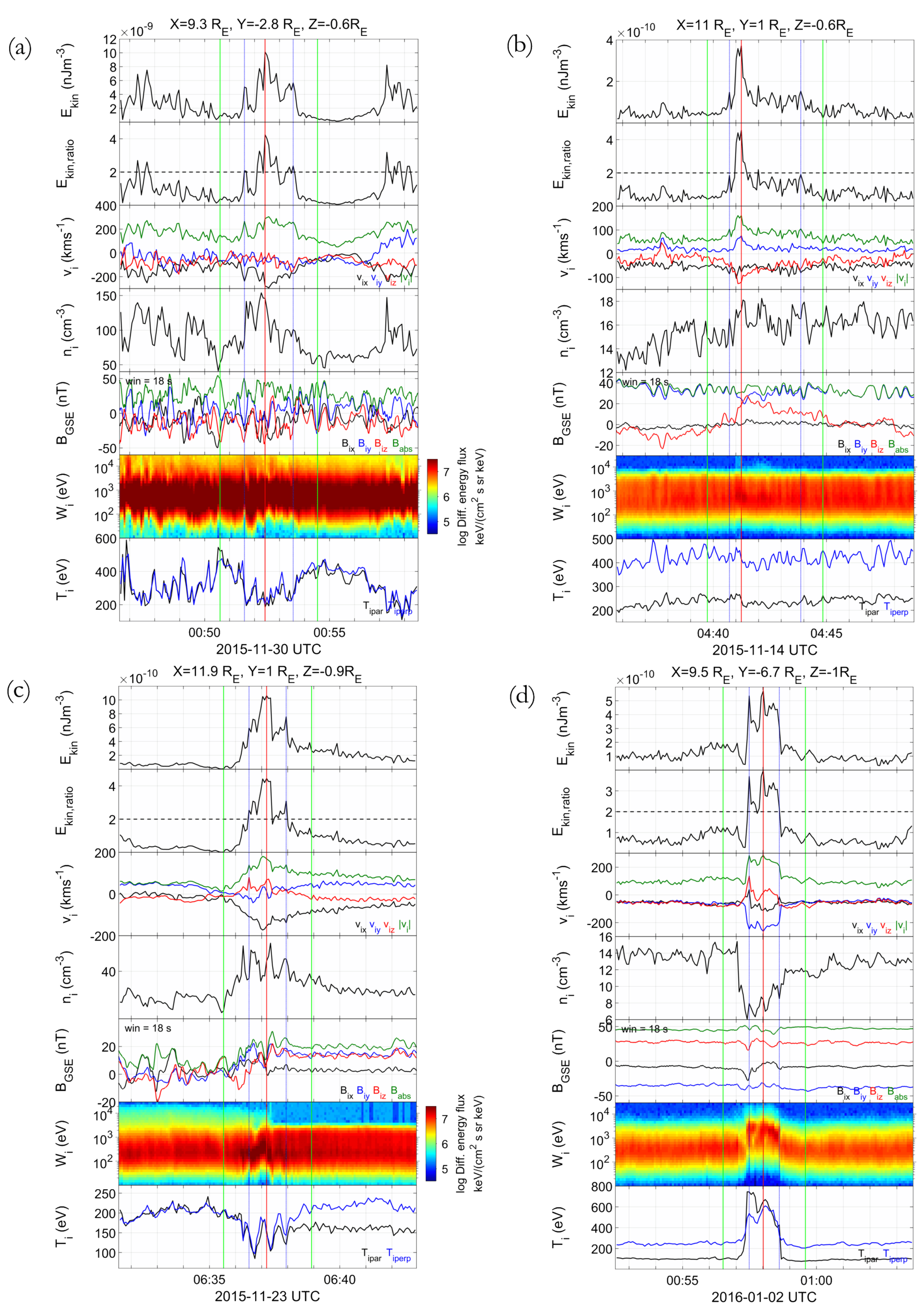

Figure 2: Examples of a **Quasi-parallel**, a **Quasi-perpendicular**, a **Boundary** and an **Encapsulated jet**. The plasma properties and the associated fields on each class and on the surrounding magnetosheath exhibit very different properties.

Simplified Algorithm

Step 1: Classifying MMS measurements

Based on statistical properties:

Magnetosheath / Solar wind / Magnetosphere

Step 2: Finding Jets in magnetosheath region

$$\frac{P_{dyn,}}{\langle P_{dyn}\rangle_{\pm 5\,min}} > 2 \qquad (1)$$

Where,

$$P_{dyn} = m_p n_i V_i^2 \qquad (2)$$

Step 3: Combining adjacent Jets (1, 2, … ,n)

$$t_{end,i} - t_{start,i+1} < 60 \text{ sec} \qquad (3)$$

Step 4: Generating High energetic jet database

$$P_{dyn,max} > 1 \text{ nPa} \qquad (4)$$

Step 5: Subcategories

1. Quasi Parallel Jets
2. Quasi Perpendicular Jets
3. Boundary
4. Encapsulated
5. Border Jets
6. Unclassified/Unknown Jets
7. Data gaps

Step 5: Thresholds & Classification Quantities

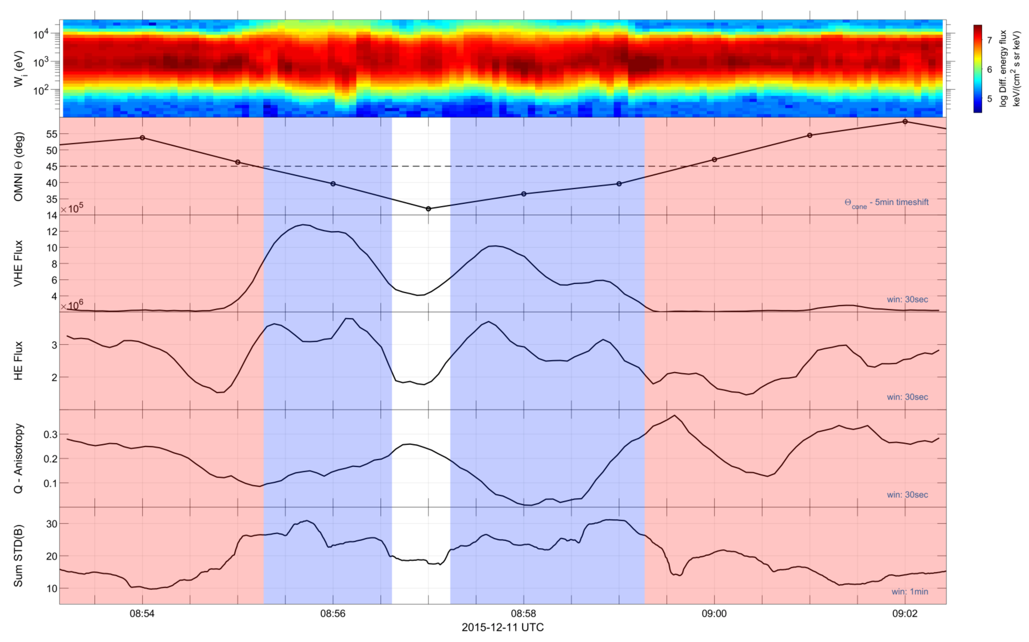

Figure 3: Visualization of associated changes between Qpar and Qperp magnetosheath. Blue shaded region represent Qpar regions while red show Qperp ones.

The quantities used for classifying:

Averaged "very high" differential energy flux $$F_{VH} = \frac{1}{3}\sum_i^{30:32} F_i \qquad (A1a)$$

Averaged "high" energy differential flux $$F_H = \frac{1}{3}\sum_i^{27:29} F_i \qquad (A1b)$$

Averaged "medium" energy differential flux $$F_M = \frac{1}{5}\sum_i^{18:22} F_i \qquad (A1c)$$

Summed magnetic field standard deviation $$\sigma(\vec{B}) = \sum_j^{1:3} \sigma(B_j) \qquad (A1d)$$

Temperature anisotropy $$Q = \frac{T_\perp}{T_\parallel} - 1 \qquad (A1e)$$

Total high / medium energy flux ratio $$C = \frac{F_{VH} + F_H}{F_M} \qquad (A1f)$$

Resulted Database

Table 1. Initial dataset of the magnetosheath jets for the period 10/2015 - 04/2019.

Subset	Number (n)	Percentage (%)	Criteria
All	16034	100	Eq. (1)
Combined	8499	53	Eqs. (1), (3)
High energy	4369	27	Eqs. (1), (3), (4)

Table 3. Classified dataset of the magnetosheath jets for the period 10/2015 - 04/2019. Using as initial dataset the downsampled jets of Table 1.

Subset	Number	Percentage (%)
Quasi-parallel	2284	26.9
Best cases	860	10.1
Quasi-perpendicular	504	5.9
Best cases	211	2.5
Boundary	744	8.8
Best cases	154	1.8
Encapsulated	77	0.9
Best cases	57	0.7
Other	4890	57.5
Uncertain	3499	41.2
Border	1346	15.8
Data Gap	45	0.5

Saving data for every jet (currently: $n = 8499$)

Direct properties – MSH/Jet (MMS)

- Jet time intervals $- t_{start}, t_{end}$
- Magnetic Field $- B_x, B_y, B_z, |B|$
- Electric Field $- E_x, E_y, E_z, |E|$
- Ion Velocity $- V_x, V_y, V_z, |V|$
- Ion Density $- n_i$
- Ion Temperature $- T_\parallel, T_\perp$

Solar Wind associated properties (OMNIweb)

- SW Magnetic Field $- B_x, B_y, B_z, |B|$
- SW Velocity $- V_x, V_y, V_z, |V|$
- SW Density $- n$
- SW Temperature $- T$
- SW Cone Angle $- \theta_{cone}$
- SW Mach Numbers $- M_A, M_M$
- SW Electric Field $- E$
- SW Beta parameter $- \beta$

Calculated Properties (MMS/OMNIweb)

- Class $- C\ (1-7)$
- Dynamic Pressure $- P_{dyn}$
- Magnetic Field rotation angle $- \theta_B$
- Velocity rotation angle $- \theta_V$
- Plasma Pressure $- P_{th}$
- Magnetic Pressure $- P_{mag}$
- Beta parameter $- \beta$
- Distance from BS $- X, Y, Z, R$

Summary & Discussion

- Generated magnetosheath jet database using MMS .
- Database includes several measured and calculated properties per jet.
- Classified jets based on indirect information of the angle of the bow shock's normal vector and IMF (Θ_{Bn})
- Solar wind measurement from OMNIweb have been associated per jet and were included.
- Database can be used for investigating space weather phenomena (enhancements of radiation belts, aurora development, magnetopause etc.) .

*See **Poster 13.p12** for an application of the presented dataset on a predictive classification using Neural Networks.

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