Magnetosheath high speed jets observed simultaneously by Cluster and MMS


1ESA/ESTEC (The Netherlands), 2SwRI (USA), 3IRAP, CNRS, UPS, CNES, Université de Toulouse (France), 4Helsinki U. (Finland), 5Bergen U. (Norway), 6MPS (Germany), 7LPP (France), 8Physics Department "E. Fermi", University of Pisa and CNISM, Pisa, Italy, 9IC London (UK), 10Southampton U. (UK), 11Beihang U. (China), 12UNH (USA), 13IRF-U (Sweden), 14KU Leuven (Belgium), 15GSFC/NASA (USA), 16MSSL (UK), 17UCLA, Department of Physics and Astronomy (USA), 18MPE (Germany), 19RAL Space, UKRI-STFC (UK), 20IWF/OEAW (Austria), 21ESA/ESAC (Spain), 22Instituto de Geofísica, Universidad Nacional Autónoma de México, Mexico, 23Denali Scientific (USA), 24Department of Electromagnetism and Electronics, University of Murcia, Murcia, Spain, 25UCLA, Department of Earth, Planetary and Space Science (USA)
High Speed jet questions

- Origin (discontinuities, bow shock ripples, nanodust)
- Shape, size and frequency
- Effect on the magnetopause

=> Cluster-MMS conjunction in magnetosheath/magnetopause to address these questions
Cluster-MMS positions on 7 Feb. 2017

Cluster Tetrahedron: 3700 km
4h BM1 (2 ions + 4 e− high res.)

XYZ_{GSE} = [9.9,0.3,7.1] \, R_E

MMS Tetrahedron: 50 km
4x10 min. BM intervals on Mpause crossings

XYZ_{GSE} = [7.7,−8.0,0.7] \, R_E
Cluster-MMS positions on 7 Feb. 2017
OMNI shifted to BS

- IMF around 4 nT at beginning and end of interval, decreased and very small (0.4 nT at 01 UT) in the middle

- Pure Bx component (2 nT) between 00:40-01:10 => dayside quasi parallel shock

- SOHO and THEMIS-B data added for complementarity
Cluster-MMS data

- Cluster and MMS most of time in magnetosheath (black bar)
- Magnetosheath is turbulent with strong Vx negative flows (red line)
- High speed jets shown in Vx in panels b, e and h
- A few magnetopause crossings
- In panel h:
  - Dust impacts in red dashed lines
  - Bursts mode in black line
High Sped Jet:
• around same time on Cluster and MMS (24 s overlap)
• size:
  – Cluster : 1.9 Re
  – MMS: 2.8 Re
=> Larger at MMS due to higher speed and longer event
• If assume ratio para/perp of 0.5 from Plaschke et al. 2016, we get:
  – Cluster: 1.9 x 3.8 Re
  – MMS: 2.8 x 5.6 Re
HSJ position and size: two different at Cluster and MMS

Cluster

MMS

HSJ average: 1.3Re
(Plaschke et al., 2016)
Cluster-MMS data

- **C1**: 21 HSJs in 65 min.
- **MMS1**: 12 HSJs, but intervals of magnetosphere and boundary layers
HSJs characteristics 1

Vx (max Vx)

Vy (max Vx)

Vz (max Vx)

Vt (max Vx)
HSJs characteristics 2

$P_{Vx} \ (\text{max } Vx)\n
\text{Duration (s)}\n
\text{Size parallel (R}_E\text{)}$
Cluster-MMS magnetopause crossing

- Opposite crossing:
  - Cluster inbound
  - MMS outbound

- Cluster: sharp and short MP (4s)

- MMS wide and long (70s)

- C1 and MMS1: low B field on sheath side (asymmetry)
<table>
<thead>
<tr>
<th>SAT</th>
<th>Time (UT)</th>
<th>Method</th>
<th>Speed (km s(^{-1}))</th>
<th>Normal X,Y,Z(_{(GSE)})</th>
<th>Normal model X,Y,Z(_{(GSE)})</th>
<th>Angle data-model (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMS</td>
<td>01:06:24 O</td>
<td>4 S/C timing</td>
<td>-83</td>
<td>0.99, -0.03, 0.10</td>
<td>0.79, -0.61, 0.06</td>
<td>35</td>
</tr>
<tr>
<td></td>
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<td>MVAB MMS1, MMS2, MMS4</td>
<td>-37, -43, -42</td>
<td>0.95, -0.30, 0.11, 0.95, -0.27, 0.14, 0.95, -0.27, 0.13</td>
<td>&quot;</td>
<td>22, 25, 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFR+MVAV 1, MMS2, MMS4</td>
<td>21, 2, 36</td>
<td>0.27, -0.94, 0.22, 0.15, -0.95, 0.27, 0.00, -0.89, -0.45</td>
<td>&quot;</td>
<td>37, 47, 55</td>
</tr>
<tr>
<td>CL</td>
<td>01:06:24 I</td>
<td>4 S/C timing</td>
<td>142</td>
<td>0.53, 0.23, 0.82</td>
<td>0.84, 0.02, 0.53</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MVAB C1, C4</td>
<td>41</td>
<td>0.76, -0.04, 0.65</td>
<td>&quot;</td>
<td>11</td>
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<tr>
<td></td>
<td></td>
<td>MFR+MVAV C1, C4</td>
<td>36, 108</td>
<td>0.75, 0.54, 0.39, 0.54, -0.03, 0.84</td>
<td>&quot;</td>
<td>32, 23</td>
</tr>
</tbody>
</table>

Speed very different at Cluster and MMS
Large angle between observations and model of magnetopause normal
Four dust impacts (two shown)
Angle $\Theta_{Bn}$: IMF – shock normal

Cluster: HSJs observed
MMS: no HSJ

Cluster: HSJs
MMS: HSJs
HSJs possible extent
Summary and conclusions

- Many HSJs were observed at two very large separation over the dayside of the magnetosheath;
- Two HJSs were observed simultaneously at Cluster and MMS and given their characteristics and size, they would most likely be two separated HSJs;
- Strong indentation of the magnetopause in the 8 crossings;
- One inbound magnetopause crossing observed by Cluster was observed simultaneous to an outbound magnetopause crossing of MMS;
- Four dust impacts were observed as a short pulse of the spacecraft potential between 00:45 UT and 01:10 UT on MMS2 and MMS3. None of these impacts are occurring simultaneously with the observation of HSJs.
- Quasi parallel shock more favorable for generation of HSJs
- Future conjunctions between 2021-2022 should give more double and triple simultaneous measurements with Cluster, MMS and THEMIS