Congruency Of Enhancement In Magnetic Partial Variance Of Increments And Dayside Magnetopause Reconnections

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Abstract

Magnetic partial variance of increments or PVI is a simple and yet a very effective tool to find the location of intermittent structures in the space plasmas. For plasmas with extreme non-Maxwellian velocity distribution functions, like those of reconnection jets, the value of PVI is often very high. Based on studies using simulation data such reconnection locations have been shown to have a PVI value of 6 or higher. However, except for a few case studies, this hasn't been fully verified for in-situ spacecraft data.

An inventory of a list of reconnection locations as measured by MMS spacecraft and the availability of high cadence magnetic field and ion-velocity data provides a wonderful opportunity to carry out a statistical study between the occurrence of reconnection and enhancement in PVI and verify the aforementioned theory.
In this study, we present preliminary results to show the association between PVI enhancements and the concurrent occurrence/observation of reconnection jets on the dayside of earth's magnetopause using MMS data.

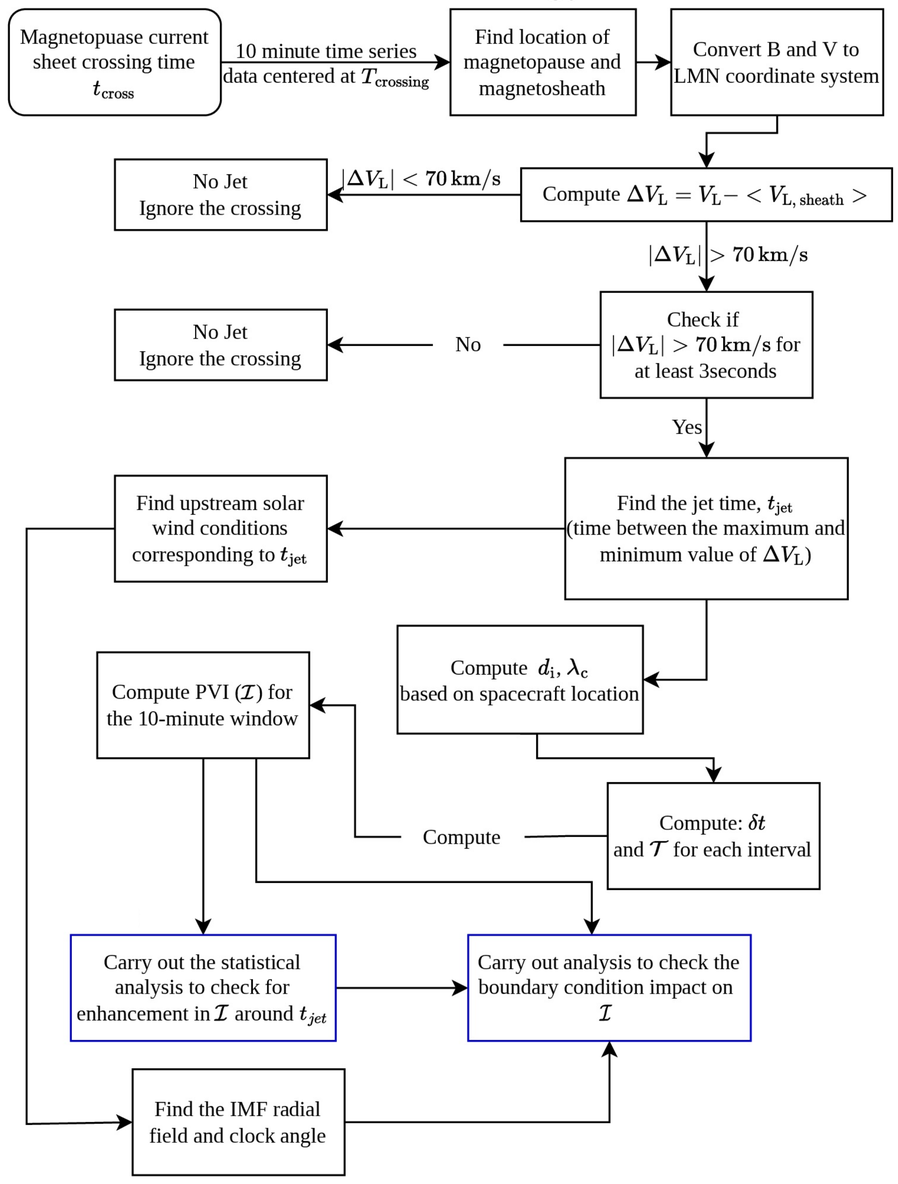
Introduction

The reconnection jets are very dynamic and not the most stable state of the plasma and thus are far from being in thermodynamic equilibrium. This makes the velocity distribution function (VDF) of such jets to be far from Maxwellian. In presence of such reconnection jets magnetic field often goes through large rotations. Consequently, the jets are very structured in magnetic field and supposedly have high values of intermittency.
One of the most widely used tool to identify the location of intermittent structures in the literature is the magnetic partial variance of increments (PVI). PVI is a measure of how structured the magnetic field is and is defined as :

$$\mathcal{I}(t,\delta t) = \frac{|\Delta \mathbf{B}(t,\delta t)|}{\sqrt{\langle |\Delta \mathbf{B}(t,\delta t)|^2 \rangle_{\mathcal{T}}}}$$

where,$\Delta \mathbf{B}(t,\delta t) = \mathbf{B}(t+\delta t) - \mathbf{B}(t)$ is the vector increment in magnetic field at any given time t and a time lag of δt . $\langle ... \rangle_{\mathcal{T}}$ is the ensemble average.
As the plasma deviates from the Maxwellian distribution, and magnetic field gets more coherent, the value of PVI increases. In the presence of highly structured regionslike current sheet and reconnection jets, the value of PVI can be as high as 6 or more.

Methodology



Results and Discussion

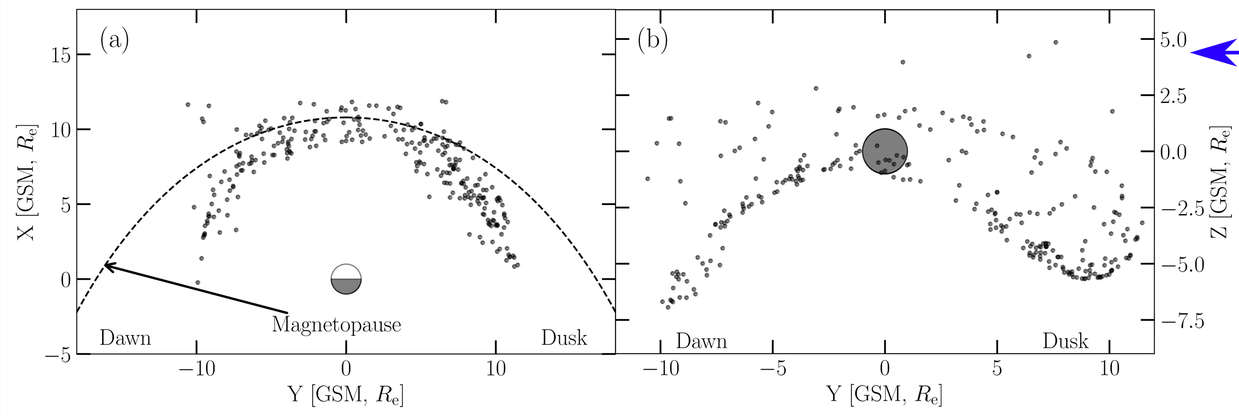


Figure 1. The figure shows the location of around 400 reconnection jets at the magnetopause crossings. In panel (a) the average location of magnetopause, as computed using Shue1998 model, is marked by the dashed black line (Qudsi+, 2023)

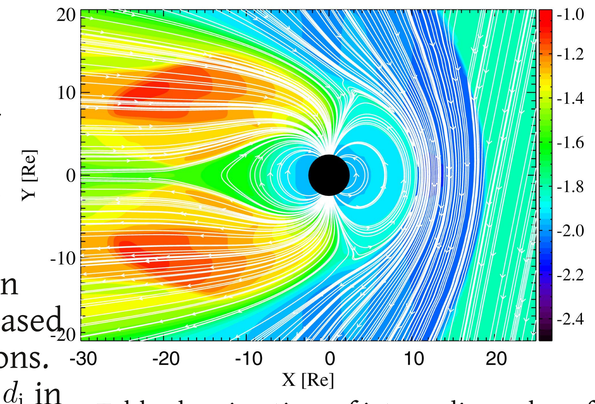
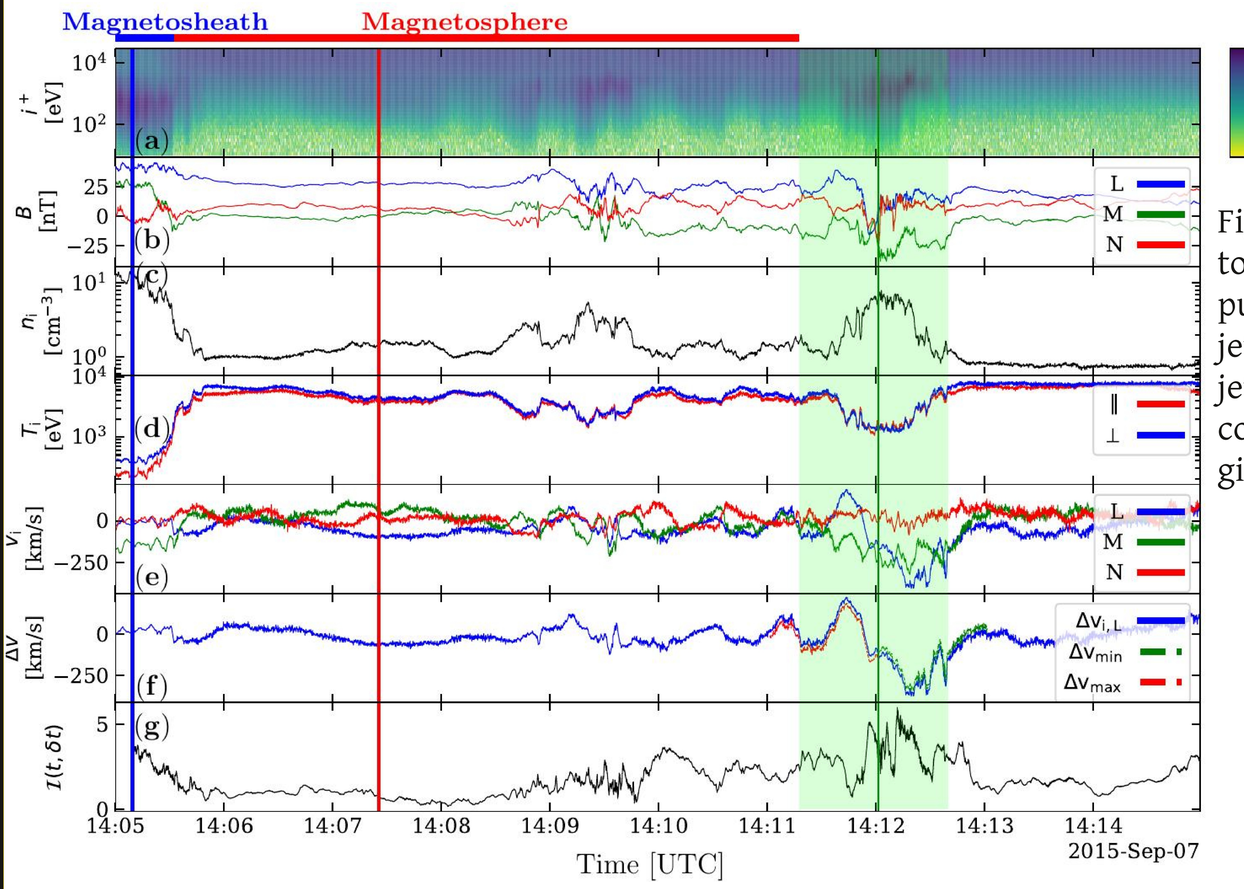


Figure 4. Variation of ion-inertial length d_i in and around the terrestrial magnetopause based on a combination of MHD and PIC simulations. The color bar shows the value of measured d_i in base-10 logarithm in the units of R_e.[Toth2017]



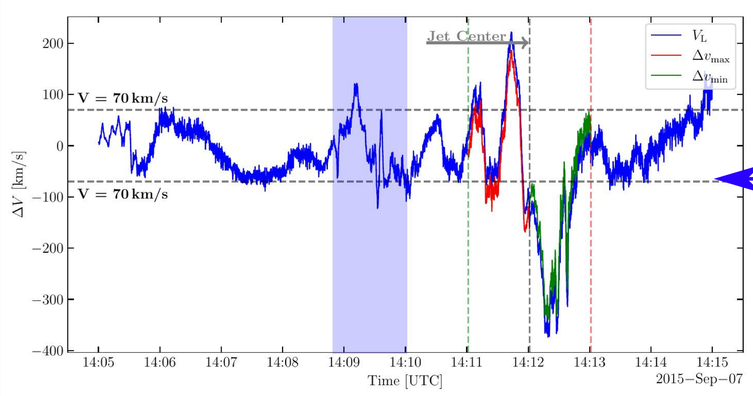


Figure 3. The figure shows the time series of V_L and ΔV_L luring a reconnection jet event. The green and red dashed lines marks the 1-minute mark (before and after respectively) from the center of the jet, which is marked by dashed gray line.

Table showing time of jet, median value of PVI during the 10-minute window, maximum value of PVI computed using fixed lag and averaging period and maximum value of PVI computed using space dependent values of lag and averaging period

Time of Jet [UTC]	$\mathcal{I}_{all,median}$	$\mathcal{I}_{jet,max}$	$\mathcal{I}_{jet,max,modified}$
2015-09-20 11:39:18	0.87	5.76	8.52
2015-09-07 14:12:01	1.52	5.99	6.88
2015-09-02 16:47:34	2.3	6.58	9.57

Figure 2 shows the full time series data from MMS spacecraft (MMS-3) corresponding to the jet detection shown in Figure 3. The PVI values, shown in panel (g), are computed for the 10-minute window. The PVI values (panel g) are enhanced during the jet event reaching a maximum value of ~ 6. The median value of PVI (excluding the jet duration) was computed to be 1.52. This is a clear indication of presence of strong coherent structures during the jet event as well as enhancement in PVI in that region.

Future Work

In this study, PVI values are computed using a fixed value of lag and ensemble average time. Varying values of those two parameters, the median PVI values are ~ 8.08 during the jet and 1.38 and 2.96 before and after. We saw similar peak values of PVI during 3 other jet events. Table 1 shows the time of jet, median value of PVI, maximum value of PVI computed using fixed lag and averaging period and maximum value of PVI computed using varying values of lag and averaging period. The maximum value of PVI computed using space dependent values of lag and averaging period is higher than the value computed using a fixed value of lag and averaging period for the whole time series. In future version of the study, we will use the space dependent values of lag and ensemble averaging and thus expect the enhancement in PVI to be more pronounced and well correlate.

References

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