Effects of Extreme Upstream Asymmetries in Magnetopause Reconnection During Intense Magnetic Storms

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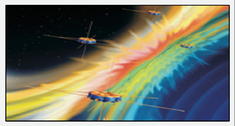
NASA's Magnetospheric Multiscale



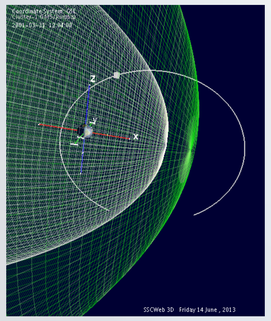
Motivation and Context

♦ The purpose of this poster is to report Cluster observations of a magnetopause crossing during a massive magnetic storm. Our research goal is to establish an observational basis for characterizing highly asymmetric reconnection.

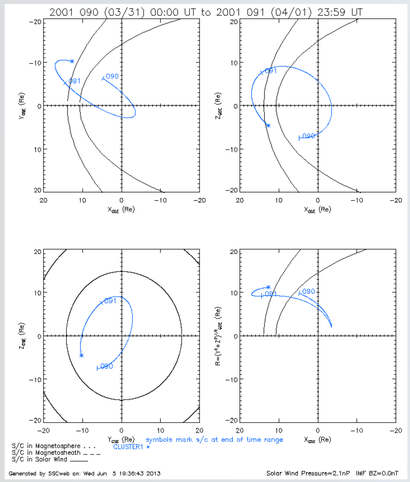
♦ Symmetric reconnection has been studied extensively, but in most astrophysical contexts, reconnection is *asymmetric*, with gradients in plasma parameters such as the density, temperature, and magnetic field strength across the reconnection plane [3,4,5]. Magnetic storms are times when we would expect these types of asymmetries to become extreme at the magnetopause. The event featured in this study exhibits a minimum Dst index of -368nT during a storm which lasted for about four days from 2001-03-31 to 2001-04-04 produced by two interacting CMEs [1].

Cluster Orbit:

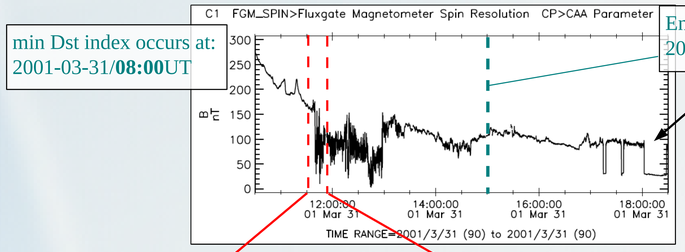
♦ The following figures show 3D and 2D views of Cluster's orbit from 2001-03-31/00:00:00UT to 2001-04/01/23:59:00UT with a theoretical location of the magnetopause and bow shock.



The 2D plots below show Cluster's orbit in the GSE Y-X, Z-X, and Z-Y planes and also Cluster's distance from the X-axis vs. X-position.



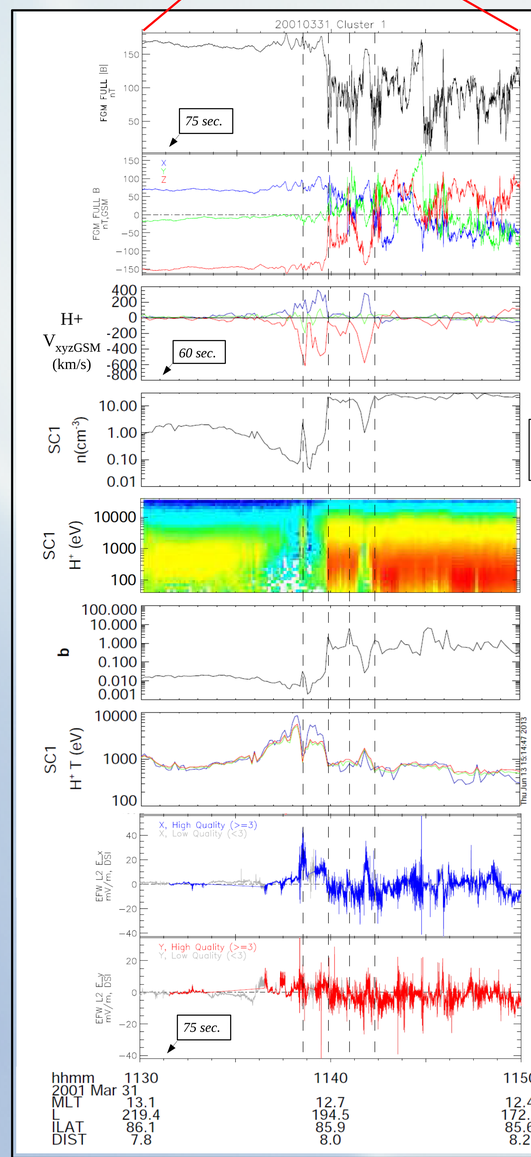
Reconnection Signatures During Massive Magnetic Storm (Dst ~ -368nT)



min Dst index occurs at: 2001-03-31/**08:00**UT

End Fast Recovery Phase: 2001-03-31/**15:00**UT

Bow shock crossings



*C1 moves from magnetosphere (MSP) (steady, large amplitude |**B**|), crosses the magnetopause (MP) at least three times (Bz and Bx reversals), and enters the magnetosheath (MSH) (density ~20cm^{-3}, more active H+ flows, increase in H+ energy flux).*

***Bz:** -150 nT on MSP side, +50 nT on MSH side.*

***H+ flow**: Vz ~ -600km/s, Vx ~ +400km/s. Such strong southward (-z) flows would indicate reconnection occurring northward of C1's location.*

***H+ density**: jumps from 0.05 to 20cm^{-3}, almost three orders of magnitude, within ~1 minute.*

***H+ energy spectrogram**: shows crossings between many different storm-time regions not typical of more quiet time MP crossings. Note: we see beam-like 3keV field-aligned (pitch angle ~0°, not shown) ions giving rise to the first ~600km/s Vz peak.*

***Plasma ion beta (b):** shows a jump from 0.01 to 1.0, two orders of magnitude.*

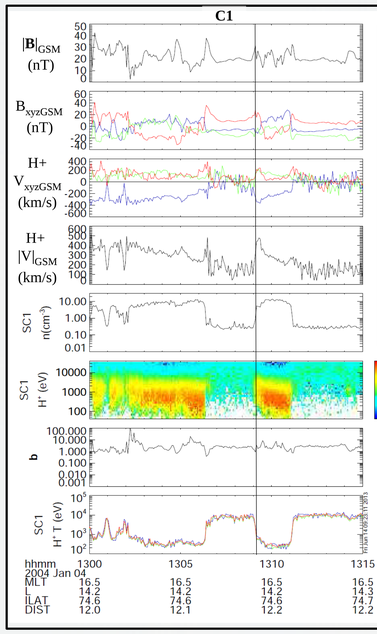
***H+ temperature:** order of magnitude decrease from 10keV to 1keV.*

***E-fields:** fluctuations of 20mV/m to 40mV/m during the strong outflows.*

Asymmetry ratios:
$|Bz_{MSP}| / |Bz_{MSH}| = 3$
$n_{MSP} / n_{MSH} = 0.0025$

Jet strength:
Vz = -600km/s

Reconnection During Quiet-Time (Dst ~ -20nT)



On 2004-01-04 for the magnetopause crossing at 13:09UT, results of the Walén test to check for reconnection locally are positive, indicating reconnection occurring sunward from the spacecraft [2].

***Quiet time**: |B|~20nT, steady MSH flow (Vx~300km/s), clear H+ signatures (density, energy spectrogram, temperature), steady ion plasma beta (**b**).*

Asymmetry ratios:
$|Bz_{MSP}| / |Bz_{MSH}| = 1$
$n_{MSP} / n_{MSH} = 0.03$

Jet strength:
Vz = +200km/s

Conclusions and Future Work

♦ The asymmetries during the storm time event are more extreme and are associated with significantly stronger outflow jets.

♦ Simulations of asymmetric reconnection are required in conjunction with further observation studies to establish effects of extreme upstream asymmetries in magnetopause reconnection.

♦ Walén test and LMN coordinate transformation to locally check for reconnection.

♦ Continue to analyze storm-time events to quantify the extent of the upstream asymmetry and its effect on asymmetric magnetopause reconnection.

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ACKNOWLEDGEMENTS:

Research at UNH is supported in part by NSF grants PHY-0903923 and AGS-1202537. This work is also supported by a UNH CEPS Graduate Fellowship. We wish to thank CIS, FGM, EFW, and PEACE teams and the ESA Cluster Active Archive for providing data.