# Reconnection Rates at the Earth's Magnetopause and in the Magnetosheath

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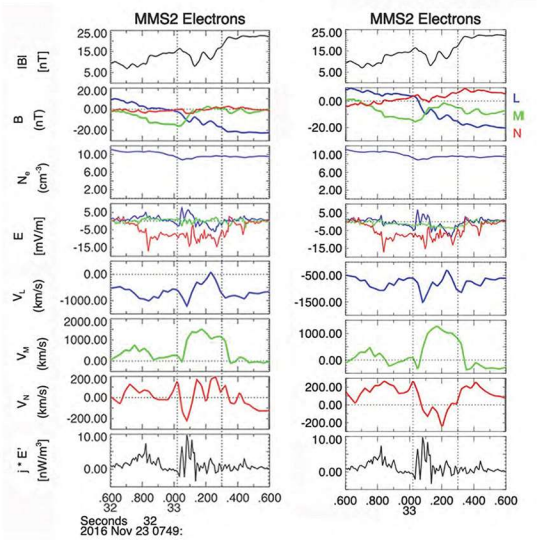
## Abstract – Key Points

1) Used a 3-D Optimized LMN Transform 'Burch Method' to eliminate contamination of $E_{L,N}$ from $E_M$ to attain a more reliable reconnection electric field.
2)The average normalized reconnection rates for 14 events is 0.15 with significant variability within relatively small spatial and temporal ranges.
3) By analyzing 47 individual normalized reconnection rates, we find no correlation with external parameters.
4) By averaging over all spacecraft, we find that the reconnection electric field is positively correlated with solar-wind dynamic pressure in the magnetosheath.

## 1) Methodology

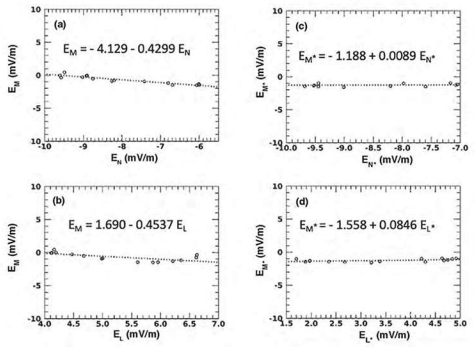
**MMS2 data for a Magnetopause Reconnection event on 23 November 2016 Boundary Selection and Optimized Transformations.**




LMN transform from Webster et al. (2018):
$L = (0.317, 0.078, 0.945)_{GSE}$
$M = (0.264, -0.964, -0.009)_{GSE}$
$N = (0.917, 0.254, -0.306)_{GSE}$

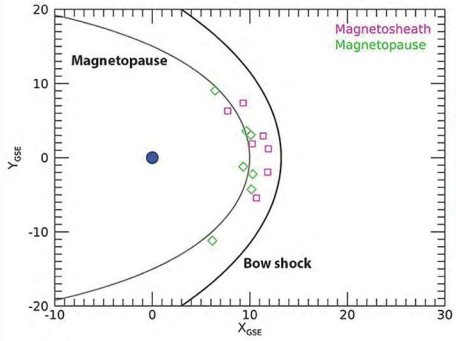
Optimized LMN from Pritchard et al. (2023):
$L^* = (0.368, 0.489, 0.796)_{GSE}$
$M^* = (0.605, -0.772, 0.204)_{GSE}$
$N^* = (0.714, 0.406, -0.559)_{GSE}$

**Linear fits and slope before and after optimized transform**




$$RR = \langle E_M \rangle / (v_{AeL}\ B_{Lasym}) = 0.24 \pm 0.07$$

## 2) Data Set




**All 14 events used in this study:**
**7 magnetosheath events in pink.**
**7 magnetopause events in green.**

| Event Date | Avg RR | Avg <Em> |
|---|---|---|
| 11/4/15 | 0.16 | 12.1 |
| 12/9/15 | 0.14 | 3.9 |
| 11/1/16 | 0.1 | 4.0 |
| 11/24/16 | 0.34 | 6.1 |
| 12/9/16 | 0.25 | 2.6 |
| 12/27/16 | 0.04 | 1.6 |
| 1/28/17 | 0.04 | 5.8 |

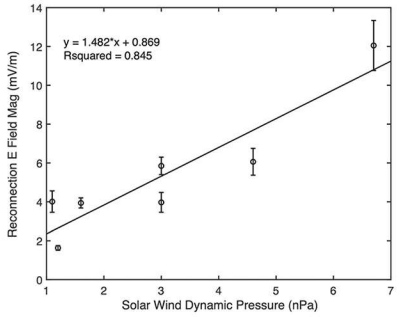
| Event Date | Avg RR | Avg <Em> |
|---|---|---|
| 12/14/15 | 0.19 | 2.2 |
| 10/22/16 | 0.09 | 2.7 |
| 11/23/16 | 0.2 | 2.4 |
| 11/28/16 | 0.17 | 1.3 |
| 12/29/16 | 0.09 | 2.0 |
| 1/27/17 | 0.19 | 1.7 |
| 4/15/18 | 0.1 | 2.4 |

## 3) Results

**Parameters of RR calculations for 27 January 2017**

| S/C | $\langle E_M \rangle$ (mV/m) | Asym $v_{AeL}$ (km/s) | Asym $B_L$ (nT) | Normalized RR |
|---|---|---|---|---|
| MMS1 | -1.19 ± 0.15 | 2881 | 7.4 | 0.06 ± 0.02 |
| MMS2 | -1.15 ± 0.36 | 2303 | 5.0 | 0.10 ± 0.05 |
| MMS3 | -2.82 ± 0.26 | 1972 | 3.6 | 0.40 ± 0.15 |

**$|\langle E_M \rangle|$ , SW $P_{dym}$ in the Magnetosheath**




## 4) Reconnection Rate Summary

1) **Normalized reconnection rates between 0.02 and 0.48 were determined with average values in the range of theoretical predictions for steady-state reconnection (0.1 - 0.2).**
2) **20 normalized reconnection rates were determined for the 7 magnetopause events with a mean of 0.14 and a standard deviation of 0.09.**
3) **27 normalized reconnection rates were determined for the 7 magnetosheath events with a mean of 0.16 and a standard deviation of 0.12.**
4) **These results show variations of over an order of magnitude between the fastest and slowest reconnection rates.**
5) **For the magnetosheath events, the reconnection electric field is directly correlated with the solar-wind dynamic pressure.**

## 5) Acknowledgements

This work was supported by NASA contract NNG04EB99C at SwRI. The OMNI data were obtained from the GSFC/SPDF OMNIWeb interface at https://omniweb.gsfc.nasa.gov.

## 6) Future Work

1) **Successfully defend my PhD thesis on July 14th 2023.**
2) **Use 3-D spacecraft separation to further probe structural conditions.**
3) **Further quantify boundaries of the EDR and conditions that govern this structure.**