Splinter Session 5: Electron-Only Reconnection

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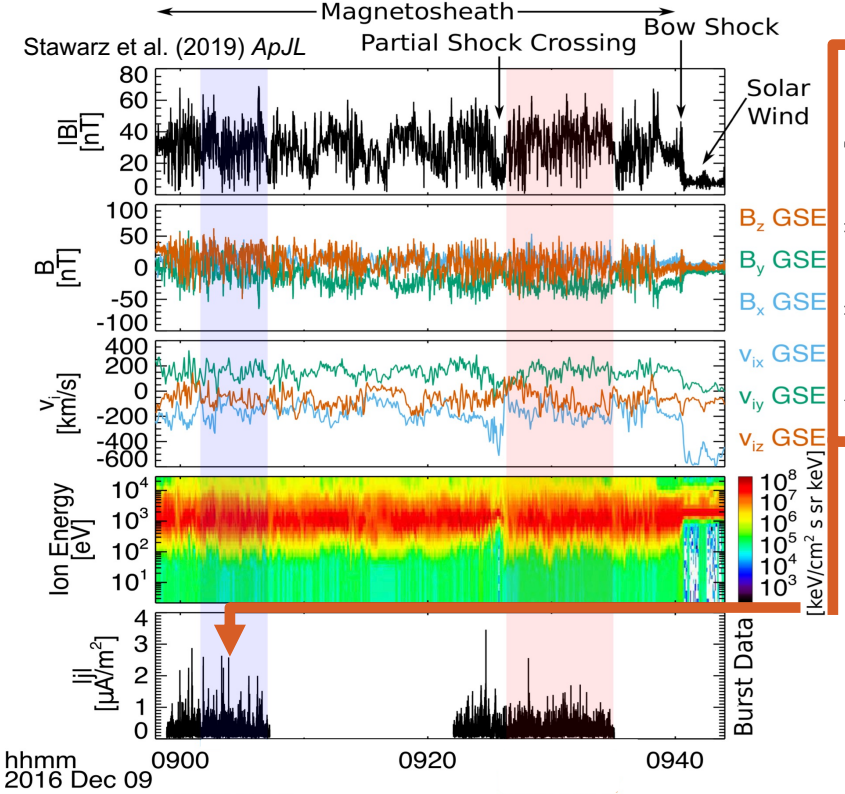
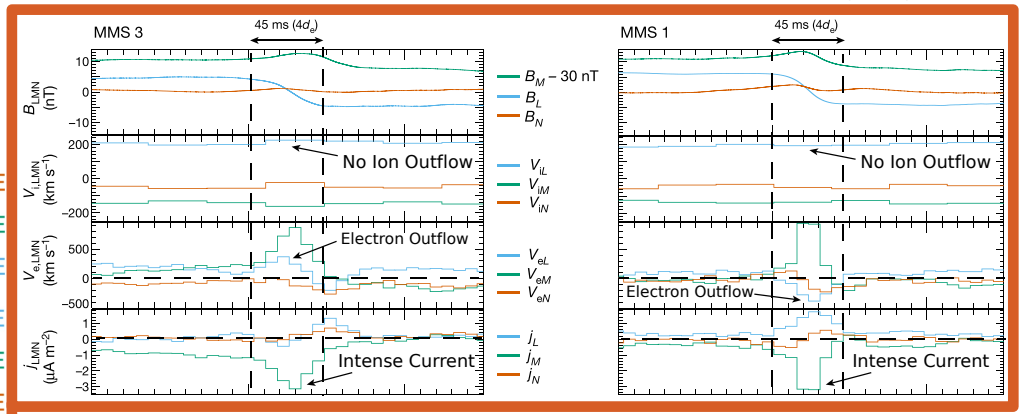
What is Electron-Only Reconnection?



Phan+ (2018) *Nature*



Phan+ [2018, *Nature*] identified multiple reconnection events in the turbulent magnetosheath

All occurred at **electron-scale current sheets** with **super-Alfvénic electron outflows** and **no ion outflows**

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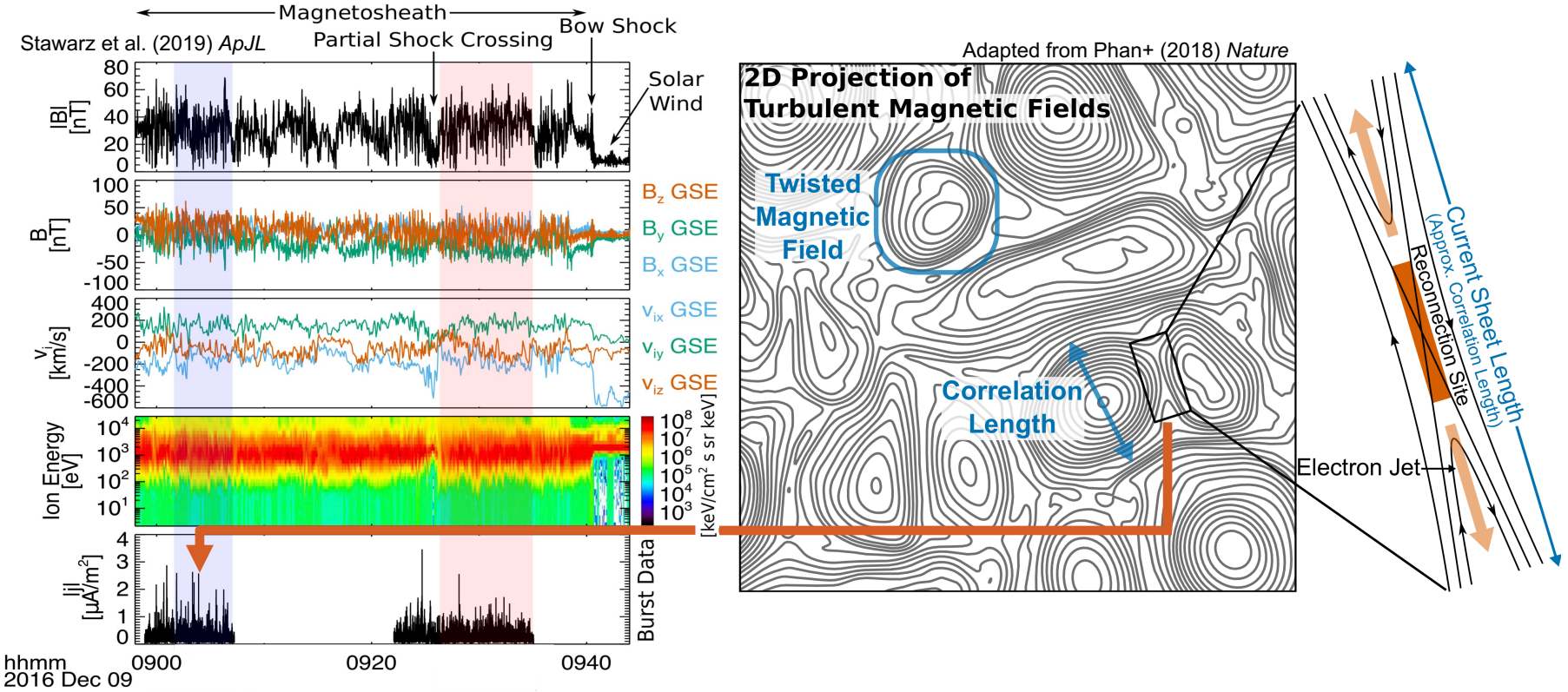
What is Electron-Only Reconnection?



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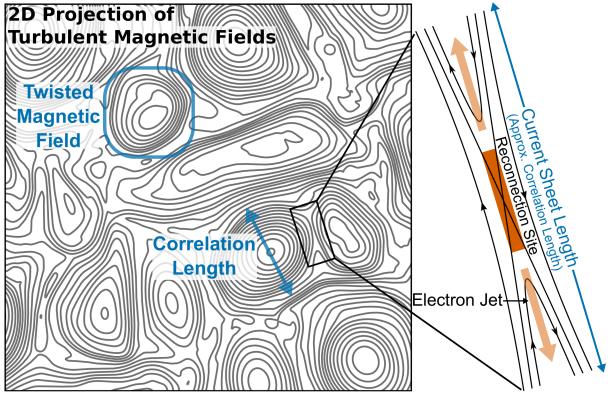
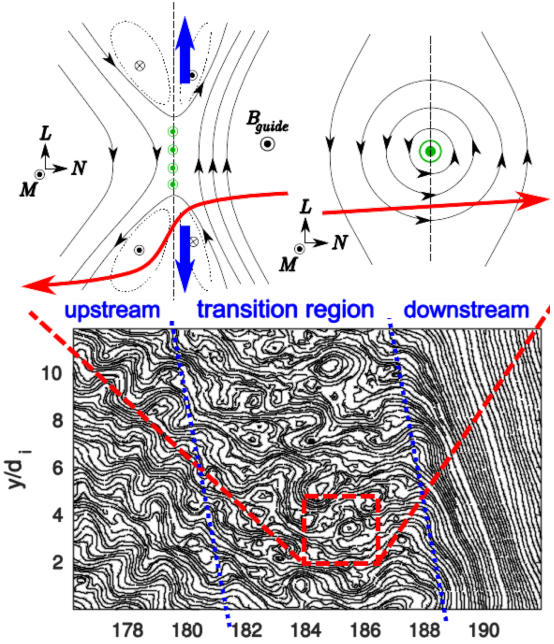
Electron-only Reconnection In Many Environments

Turbulent Magnetosheath



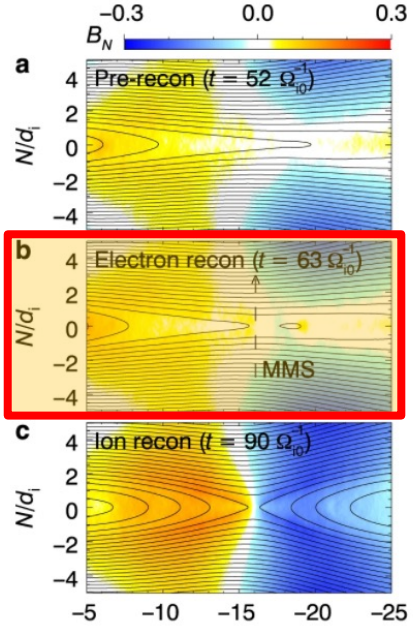
Adapted from Phan+ (2018) *Nature*

Bow Shock



Gingell+ (2019) *GRL*

Magnetotail



Lu+ (2020) *Nature Comm.*

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Steve Schwartz – Energy Conversion within Current Sheets in the Earth's Quasi-parallel Magnetosheath
Imogen Gingell – Electron-only reconnection at the bow shock
Mark Hubbert – Electron-Only Magnetotail Current Sheets and Their Temporal Evolution

Rick Wilder – Interactions between whistler waves and parallel electric fields in electron-only magnetosheath reconnection
Alex Chasapis – Electron-scale structures and electron acceleration in magnetosheath turbulence
Riddhi Bandyopadhyay – Dissipation in electron-only reconnection: insights from pressure-strain interaction
Julia Stawarz – Turbulence-Driven Reconnection in Earth's Magnetosheath
Naoki Bessho – Electron acceleration in electron-only reconnection in the Earth's quasi-parallel bow shock
Mikhail Sitnov – Electron and ion watersheds as precursors of the magnetotail reconnection: 3D PIC simulations and MMS observations
San Lu – Electron-only reconnection in the magnetotail: PIC simulations
Yi-Hsin Liu – The Effect of Thermal Pressure on Collisionless Magnetic Reconnection Rate
Kris Pritchard – Reconnection Rates and Guide Fields in the EDR
Prayash Pyakurel – Electron-only reconnection: Overview of simulations

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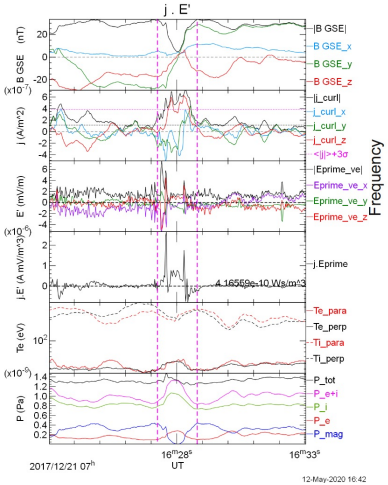
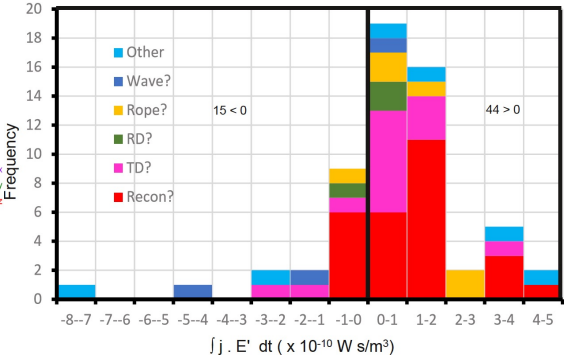
Reconnection in the Turbulent Magnetosheath

Steve Schwartz

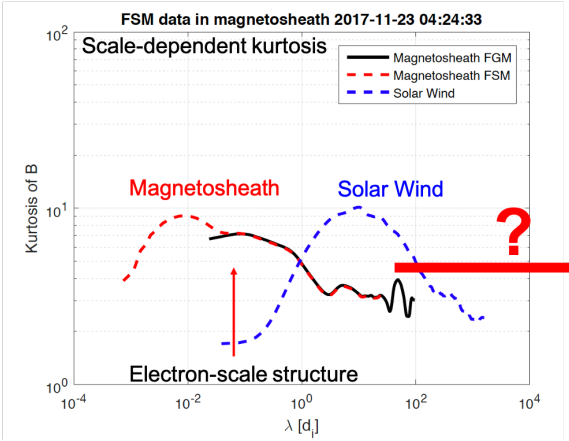




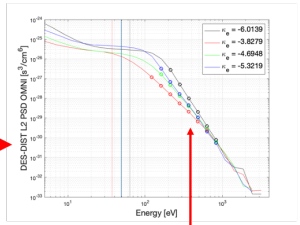
→ 3% of sheath volume

→ ~11% of solar wind ram energy

Alex Chasapis



Suprathermal tails of electron distributions observed in in the magnetosheath



Suprathermal tail

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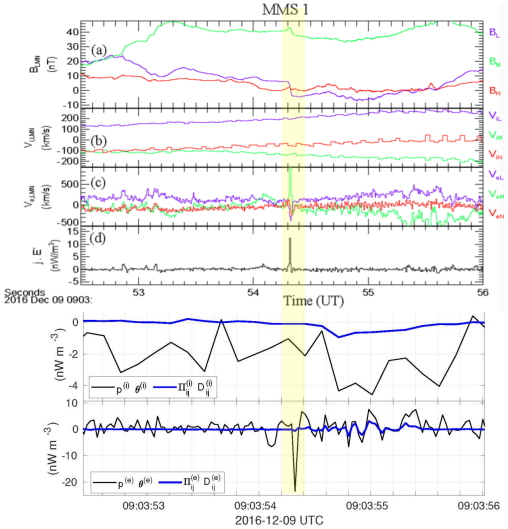
Reconnection in the Turbulent Magnetosheath

Riddhi Bandyopadhyay

Julia Stawarz

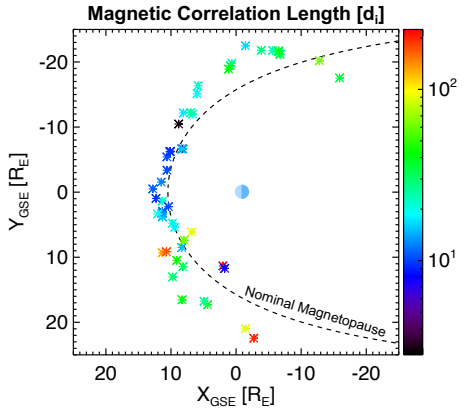


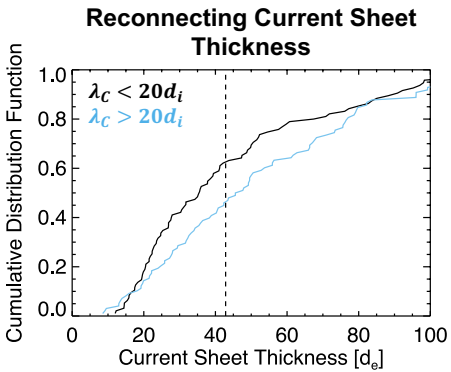
$$\partial_t \mathcal{E}^f_\alpha + \nabla \cdot (\mathcal{E}^f_\alpha \mathbf{u}_\alpha + \mathbf{P}_\alpha \cdot \mathbf{u}_\alpha) = (\mathbf{P}_\alpha \cdot \nabla) \cdot \mathbf{u}_\alpha + n_\alpha q_\alpha \mathbf{E} \cdot \mathbf{u}_\alpha \quad (1)$$

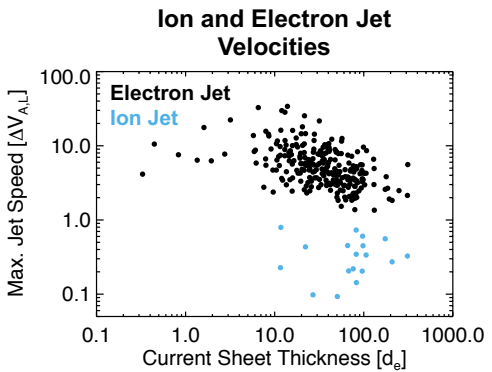
$$\partial_t \mathcal{E}^{th}_\alpha + \nabla \cdot (\mathcal{E}^{th}_\alpha \mathbf{u}_\alpha + \mathbf{h}_\alpha) = -(\mathbf{P}_\alpha \cdot \nabla) \cdot \mathbf{u}_\alpha \quad (2)$$

$$\partial_t \mathcal{E}^m + \frac{c}{4\pi} \nabla \cdot (\mathbf{E} \times \mathbf{B}) = -\mathbf{E} \cdot \mathbf{J} \quad (3)$$

Add internal energy: dissipation







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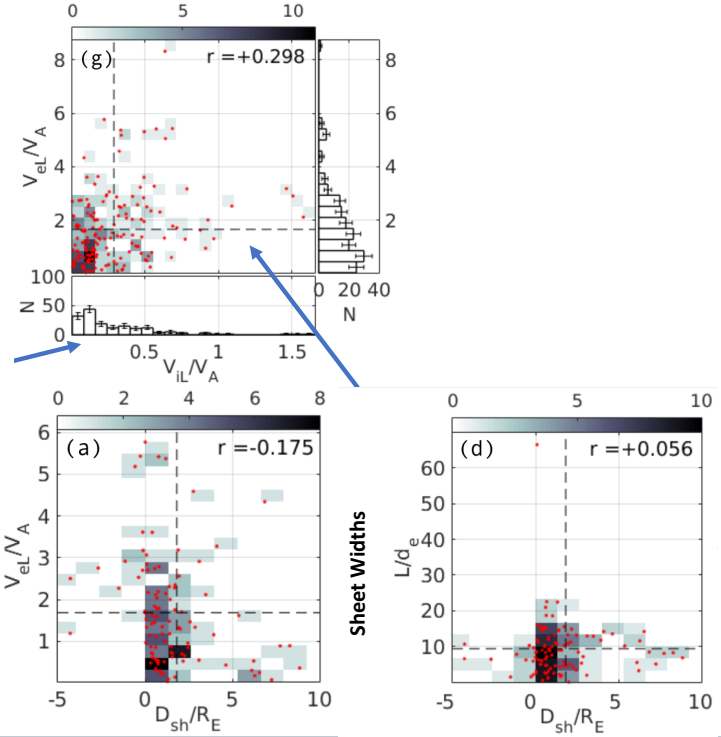
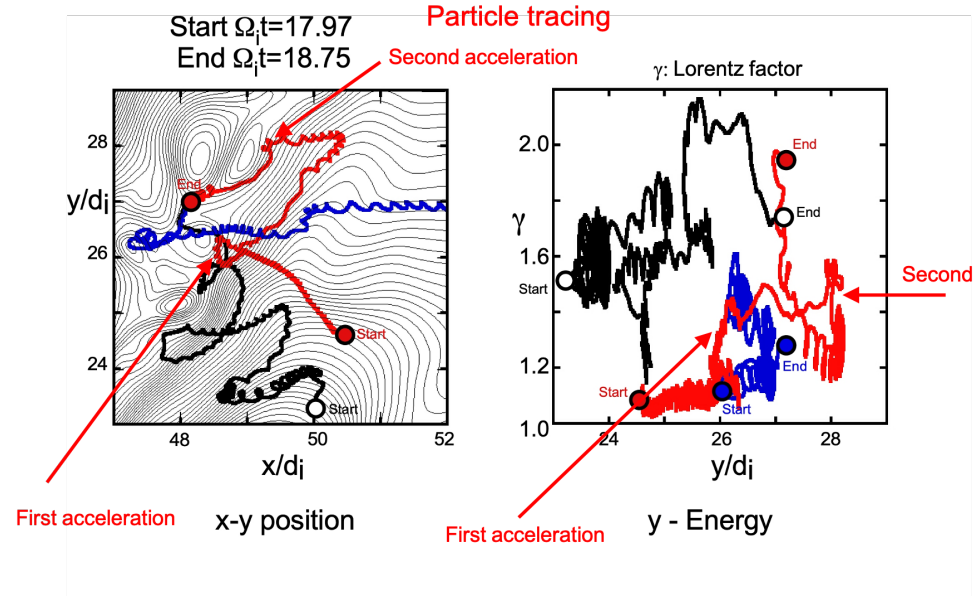
Bow Shock Reconnection

Imogen Gingell



Naoki Bessho



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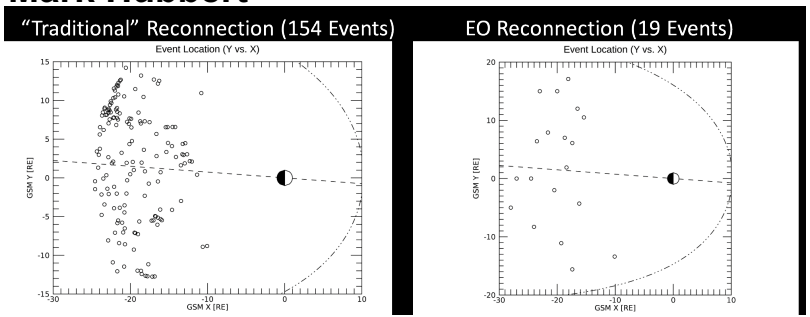
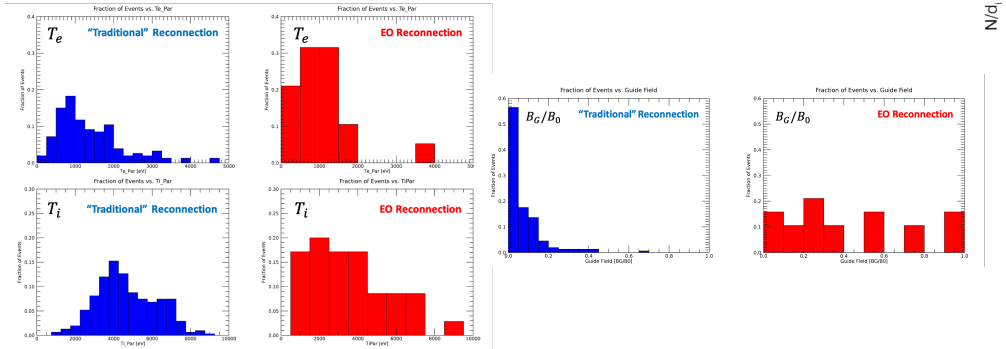
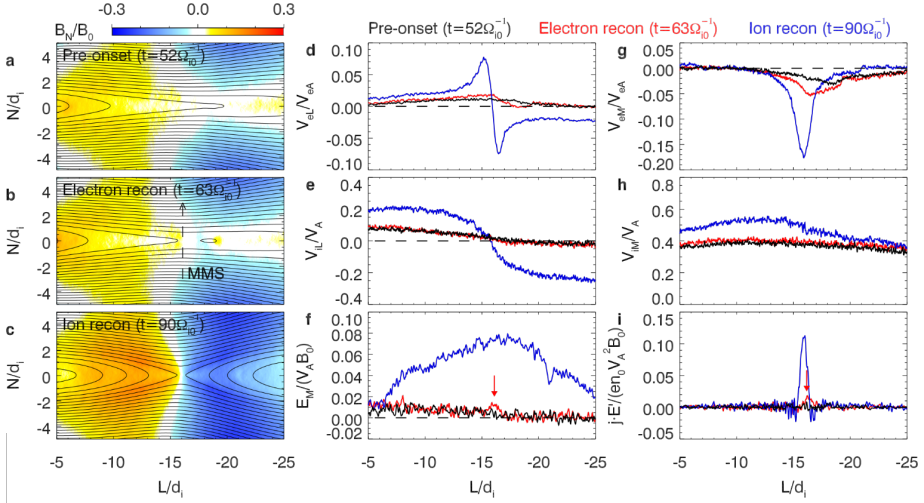
Electron-Only Magnetotail Reconnection

Mark Hubbert

San Lu







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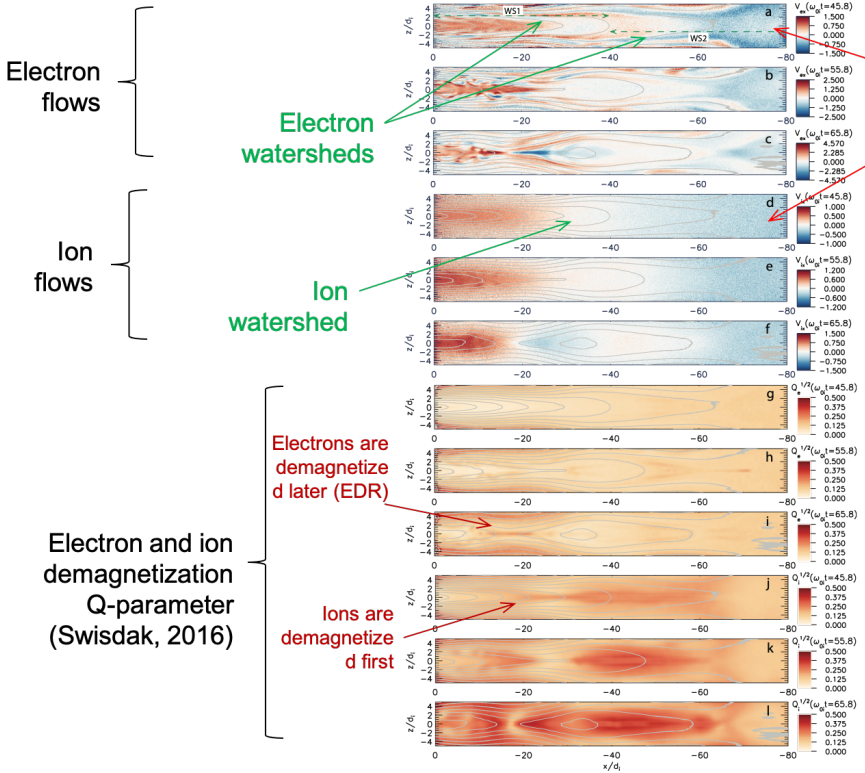
Electron-Only Magnetotail Reconnection

Mikhail Sitnov



Similar works on plasma watersheds preceding/driving reconnection:
Lin & Swift (2002),
Siscoe et al. (2009),
Tanaka et al. (2019)

Similar works on non-reconnection instabilities (kink, torus) preceding/driving reconnection:
Török & Kliem (2005)

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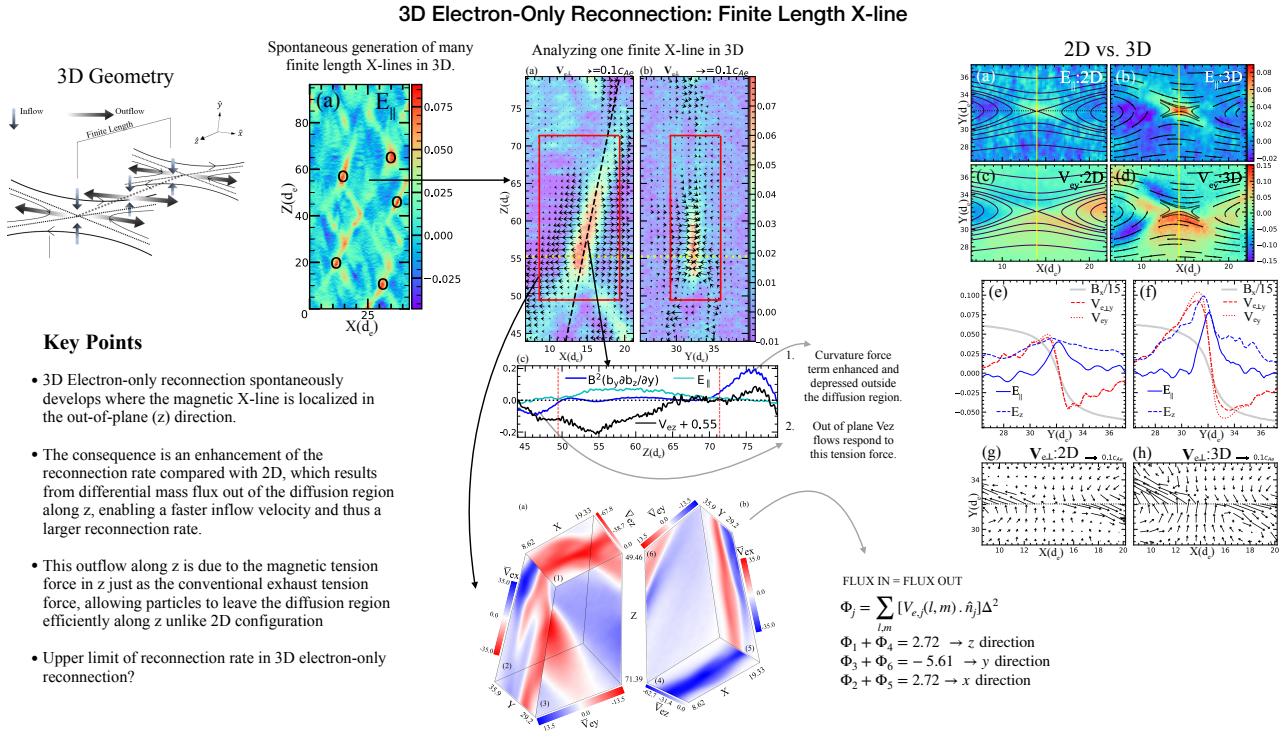
Simulations of Electron-Only Reconnection

Prayash Pyakurel



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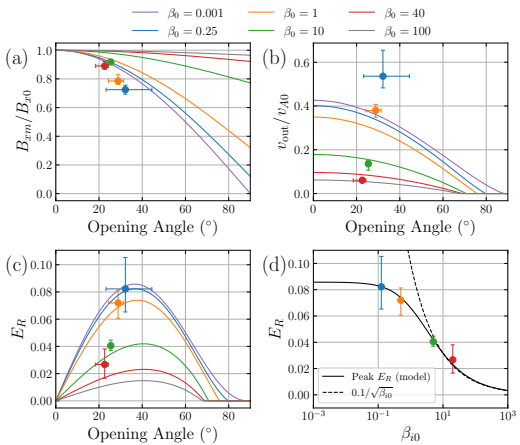
Reconnection Rates

Yi-Hsin Liu

Predicted reconnection rate in the high-β limit (step 4)

$$E_R = B_{zm} V_{\mathrm{out,m}} / (B_{x0} v_{A0})$$

as a function of the opening angle ($\equiv 2\theta$)



(X. Li & Liu, APJ 2021)
arXiv:2104.00173

- The predicted reconnection rate $R \simeq 0.1/\sqrt{\beta_i}$ in the high-β limit.

Kris Pritchard

Using electric field observations to extract the reconnection rate for a number of reconnection events
(including Phan et al. electron-only event)

Looking into how reconnection rate is dictated by plasma parameters

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Summary & Open Questions

The study of electron-only reconnection is currently an active area of research that is being looked at in different context and from different points of view

Electron-only reconnection fundamentally involves short length and/or time scales making measurements from MMS the ideal tool to study it

MMS is providing us an unprecedented opportunity to explore the interplay between turbulence and magnetic reconnection, the interplay between shocks and reconnection, and reconnection onset

Discussion Questions (Zoom discussion is copied into the Slack channel)

- → How do we distinguish between the diffusion region and electron-only reconnection?
- → How does electron-only reconnection energize particles?
  Does the lack of ion jets mean that ions can't be heated (even through secondary processes)?
- → What implications does electron-only reconnection have for reconnection onset and magnetotail dynamics?
- → What is the relationship between shock -driven reconnection and magnetosheath turbulence-driven reconnection?

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