



Cold ions of ionospheric origin in Solar wind – magnetosphere coupling

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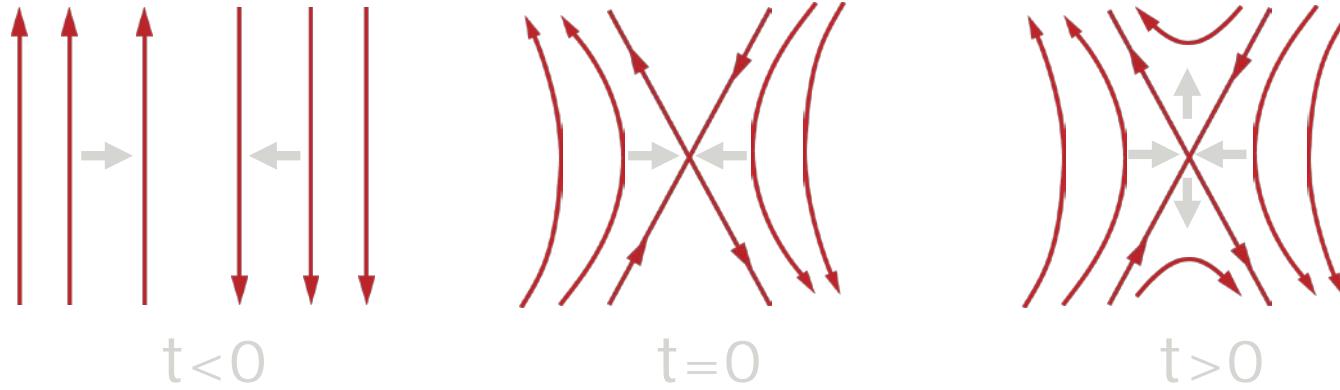
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(9) Laboratory of Atmospheric and Space Physics (LASP), Boulder, Colorado

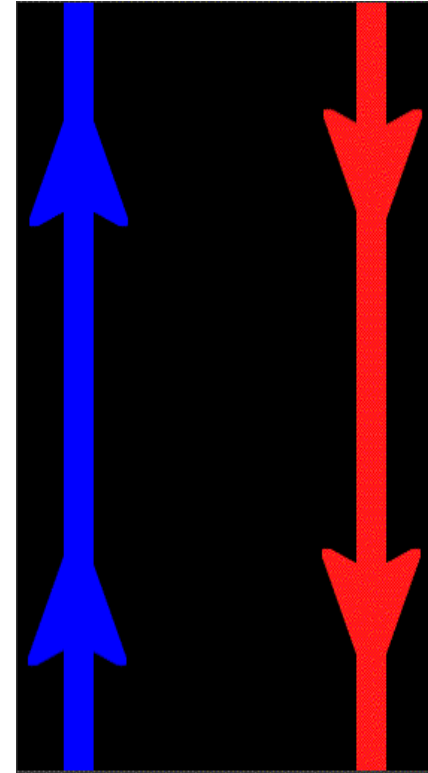
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Introduction: magnetic reconnection in plasmas

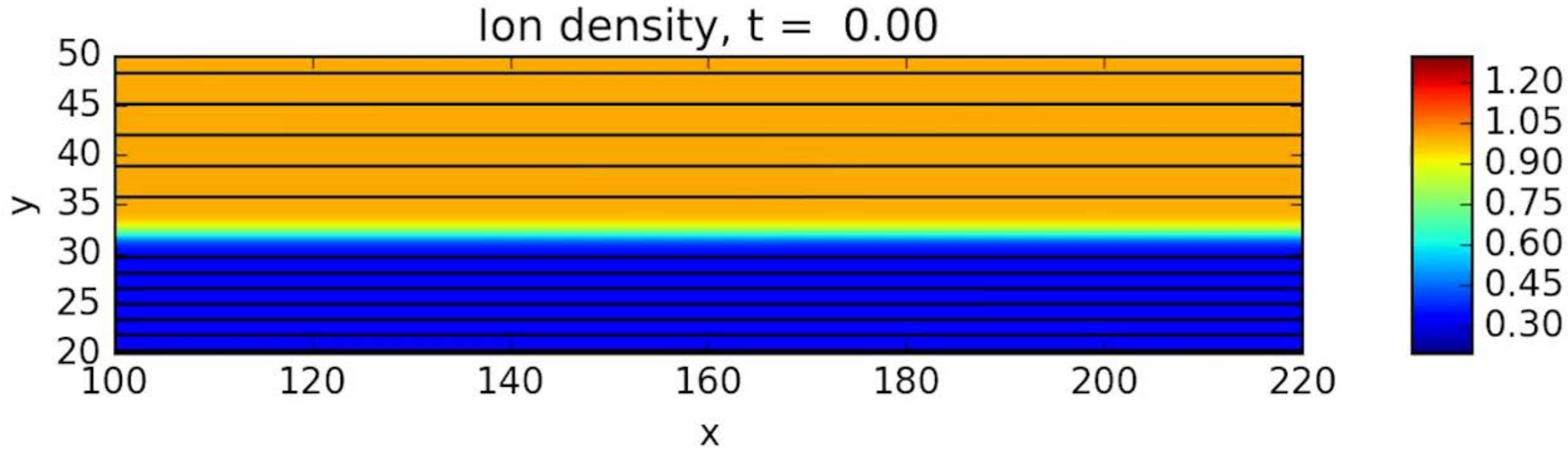


Magnetic reconnection in plasmas changes the **topology** of the magnetic fields, relaxing them and **transferring the energy** resulting into the particles (acceleration and heating).

Interconnects different plasma regions, allowing the **exchange of mass and energy** between them.

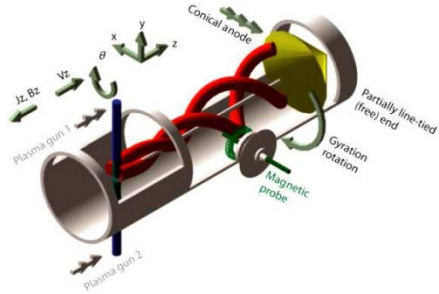


Magnetic reconnection simulation



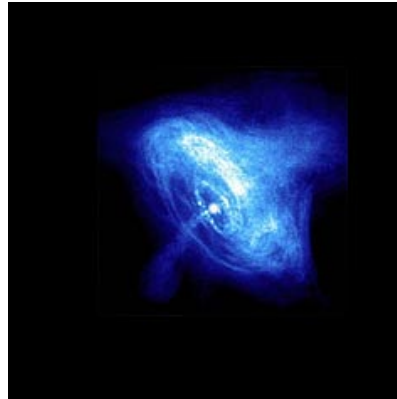
Full Particle-In-Cell simulation, Dargent+, JGR (2016)

Ubiquity of magnetic reconnection



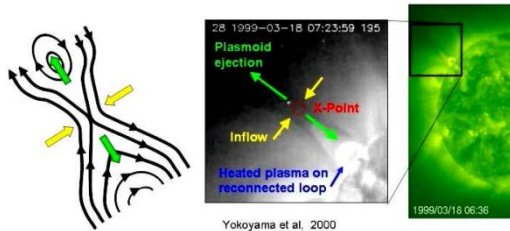
Intrator+, Nature Physics (2009)

Fusion reactors: tokamaks



Uzdensky+, ApJ (2011)

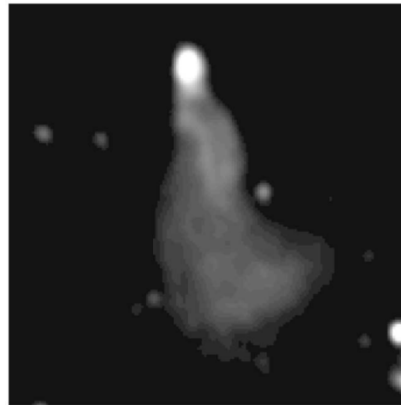
Crab nebula observed by Chandra



Yokoyama et al. 2000

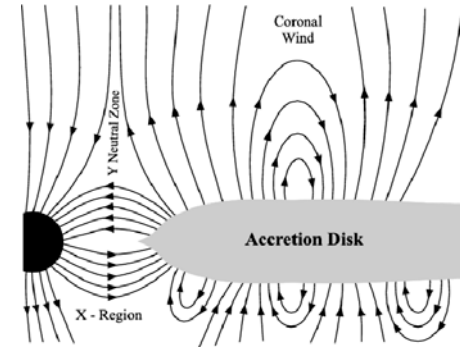
Yokoyama+, ApJL (2001)

Solar corona, CMEs



Kronberg+, ApJ (2004)

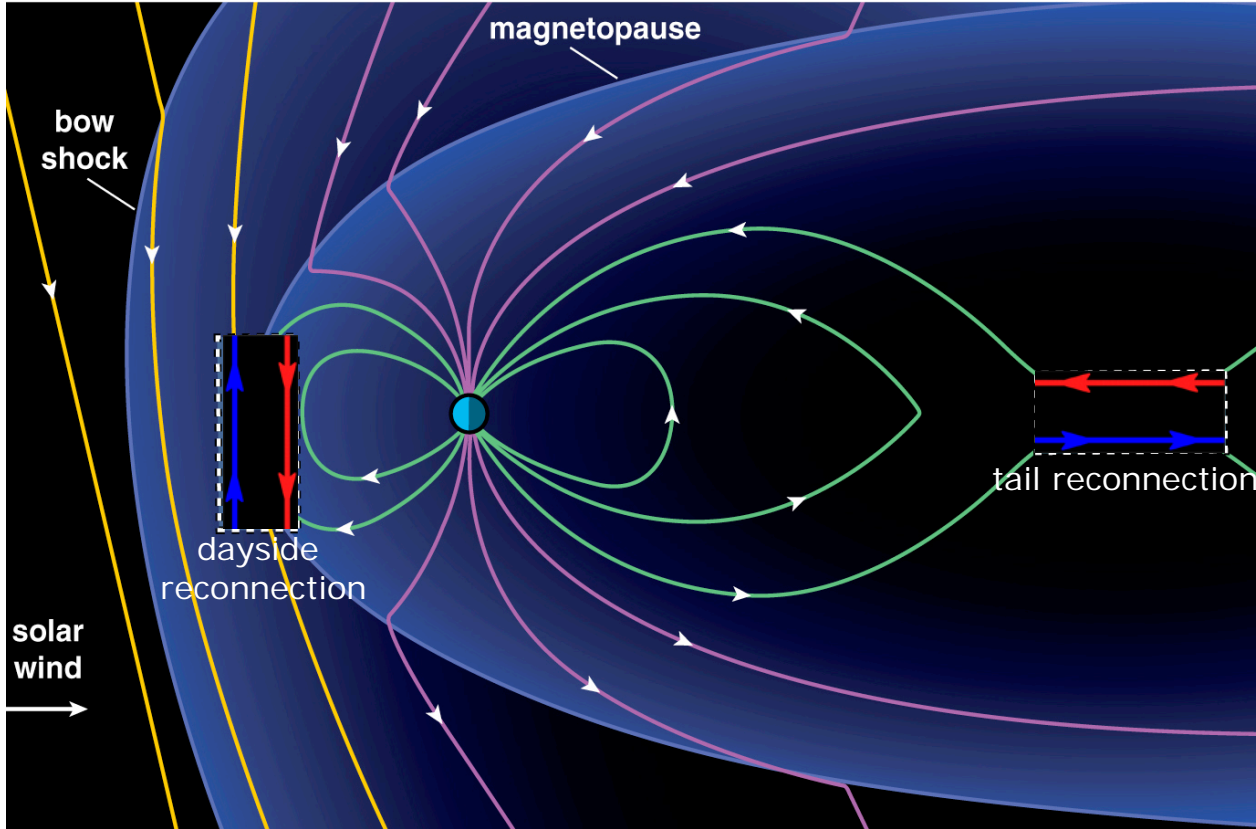
Radio jet in Galaxy lobe



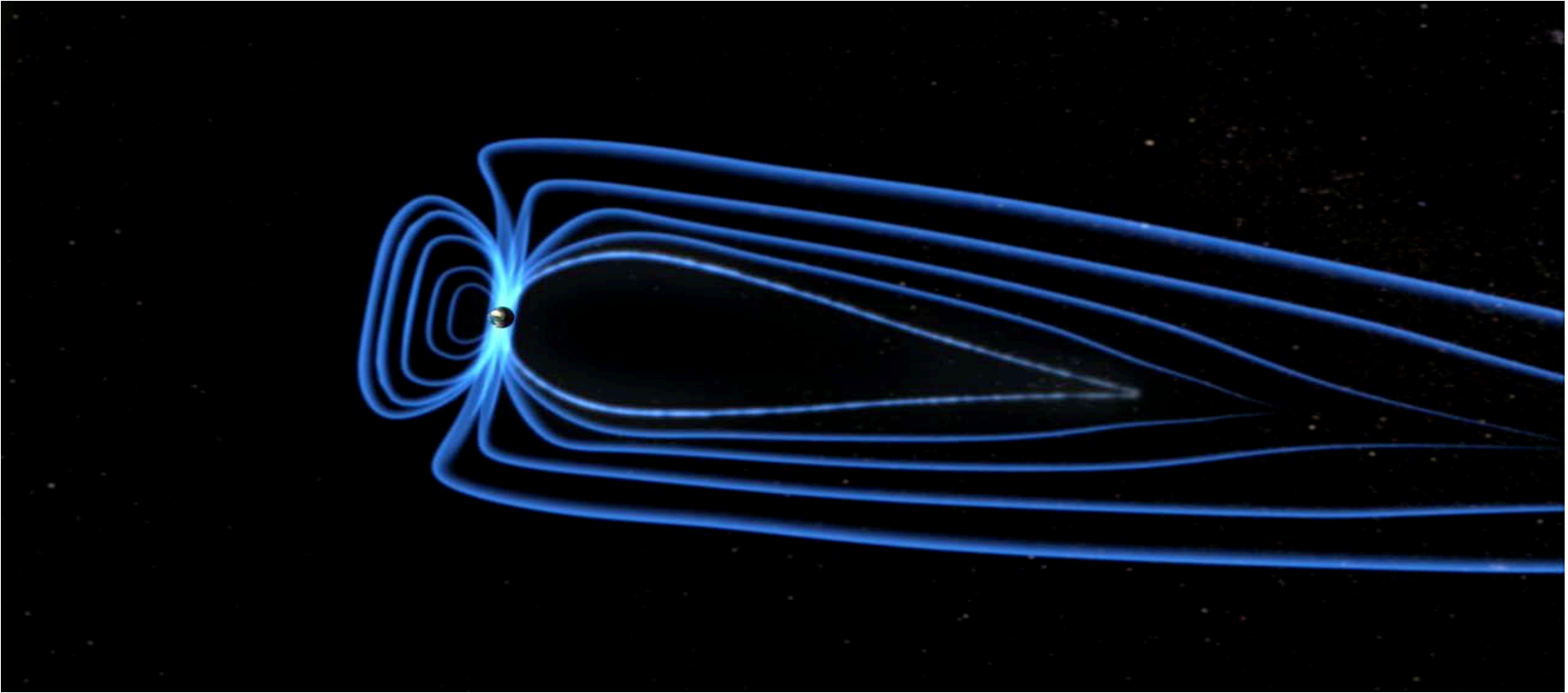
De Gouveia+, A&A (2010)

Accretion disks

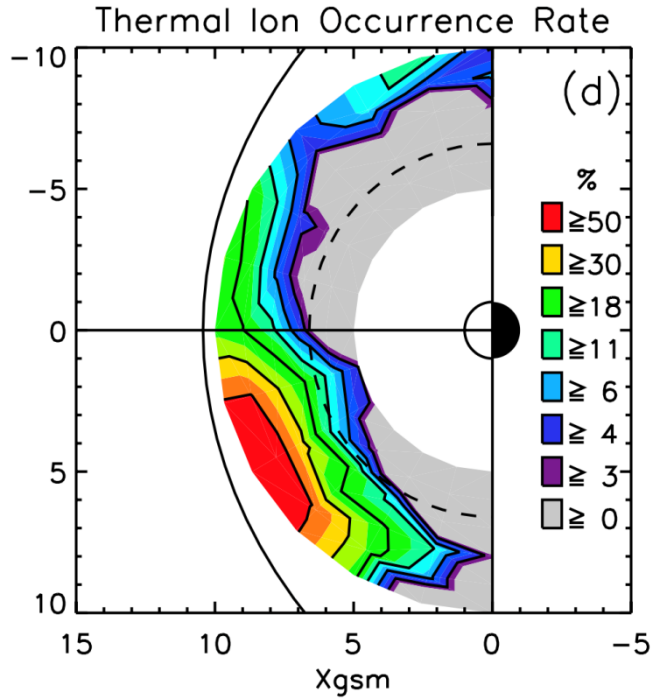
Magnetic reconnection at Earth's magnetosphere



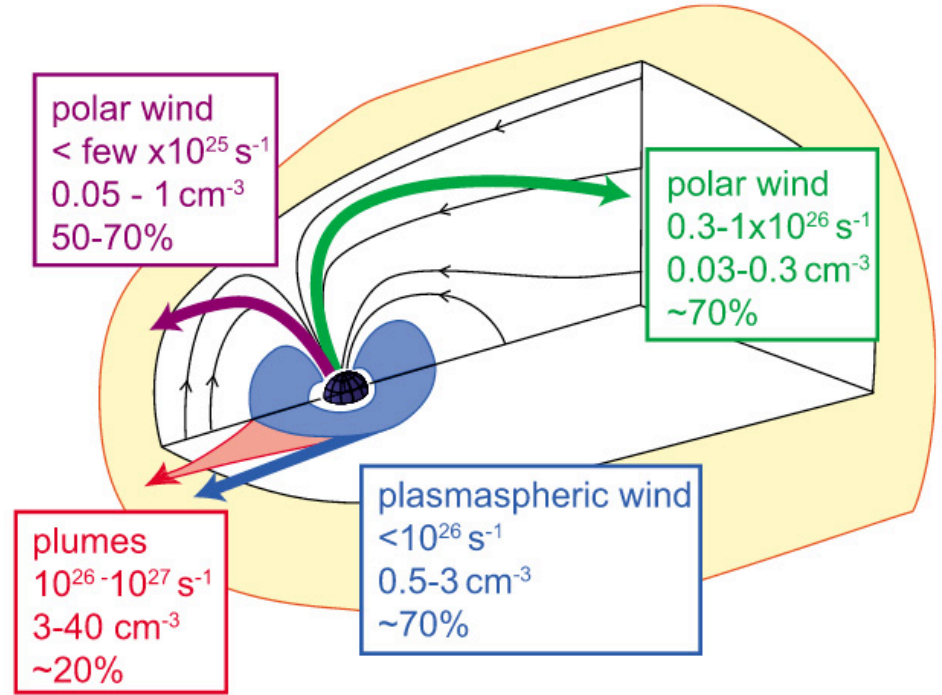
Magnetic reconnection and auroras



Cold ions in the magnetosphere



Chen&Moore, JGR (2006)



Andre+, GRL (2012)

Mass loading

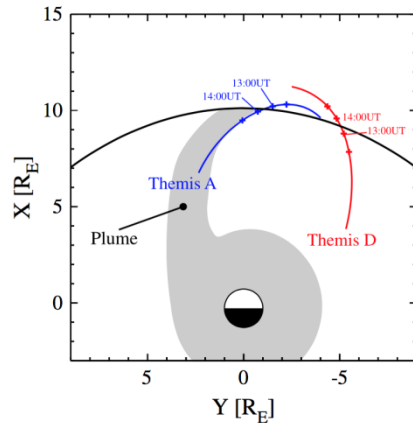
Cold ions of ionospheric origin **mass load** the magnetospheric plasma and **slow down the reconnection rate (outflow velocity)**.

$$v_A^2 = \frac{B^2 / \mu_0}{\rho_m} = \frac{\text{Magnetic tension}}{\text{Mass density}}$$

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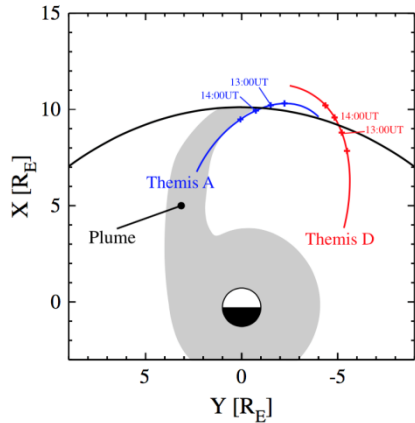


Walsh+, GRL (2014)

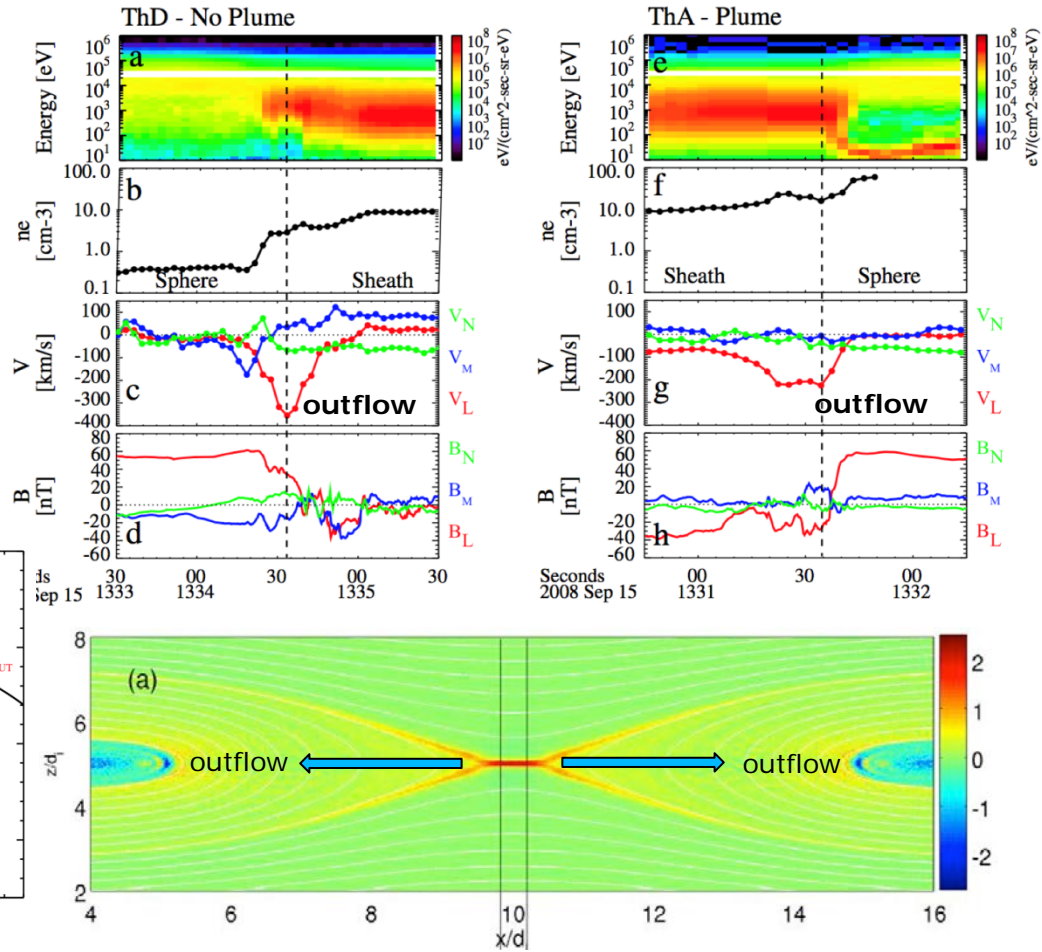
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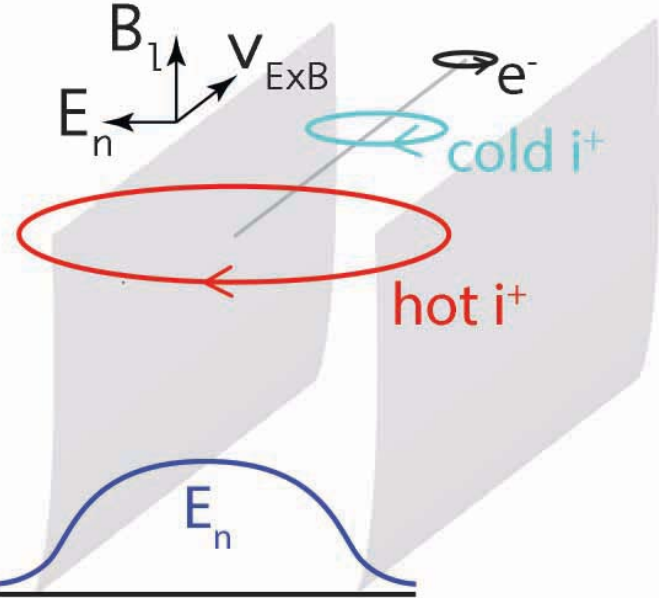
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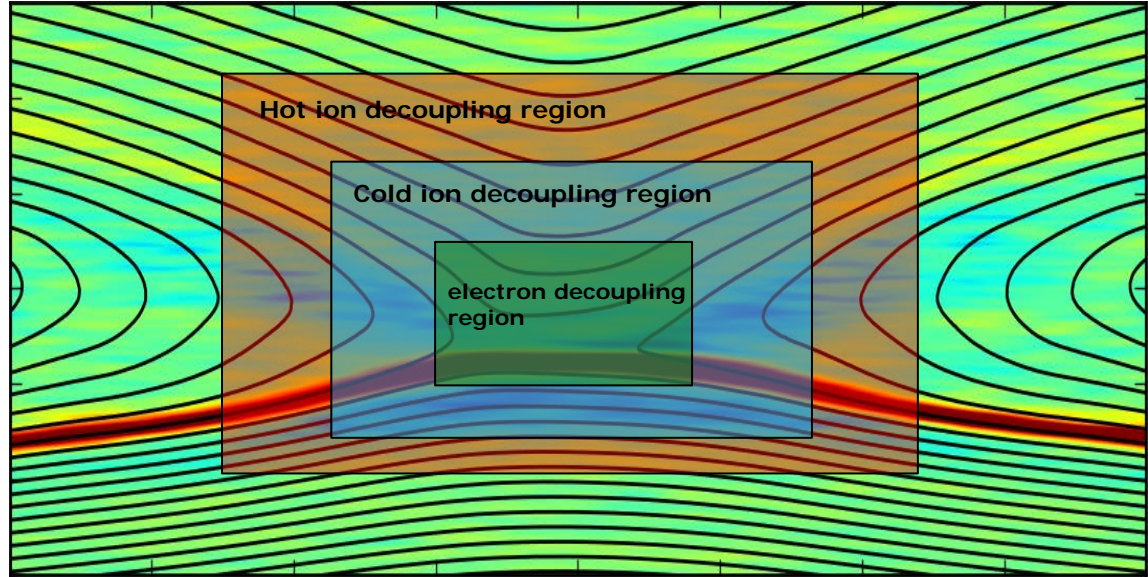
Walsh+, GRL (2014)



Cold ions introduce a new length-scale

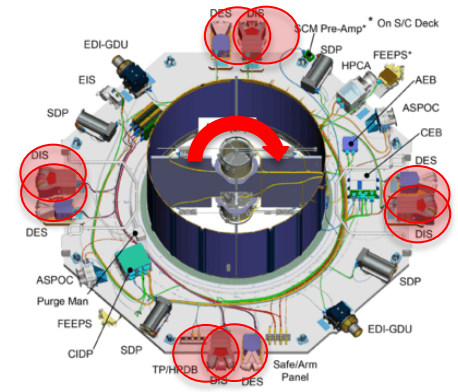
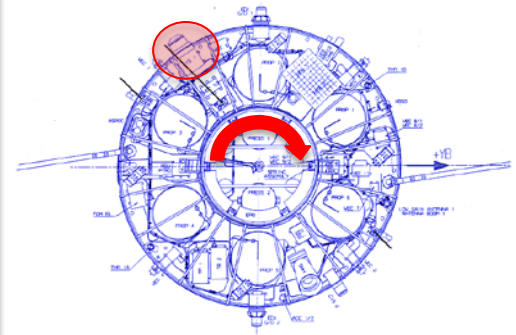
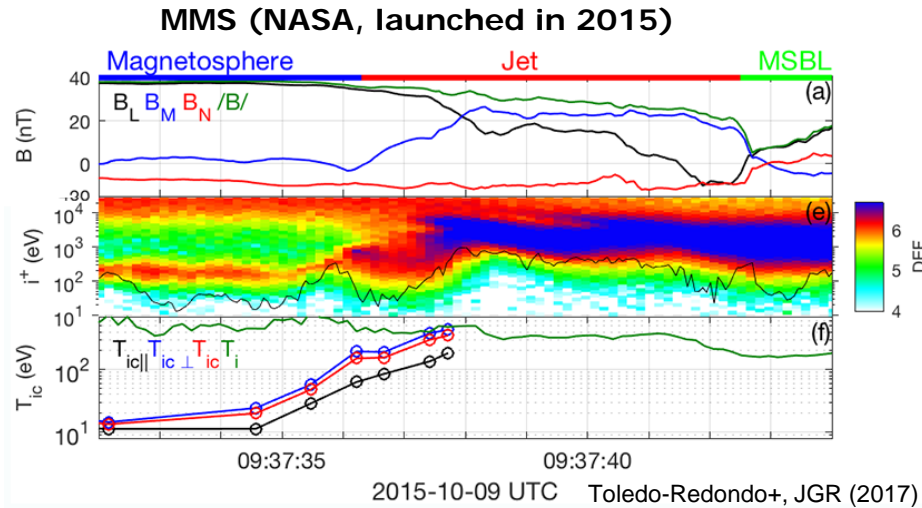
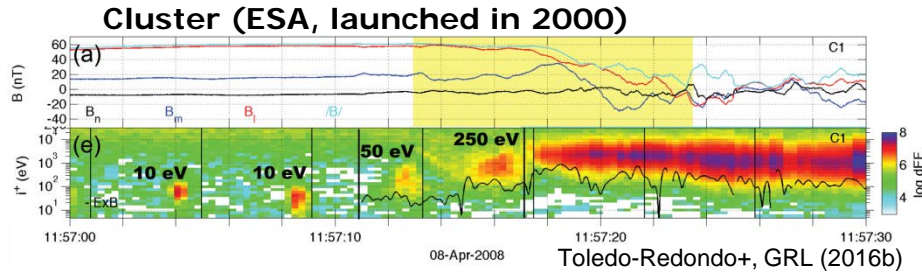
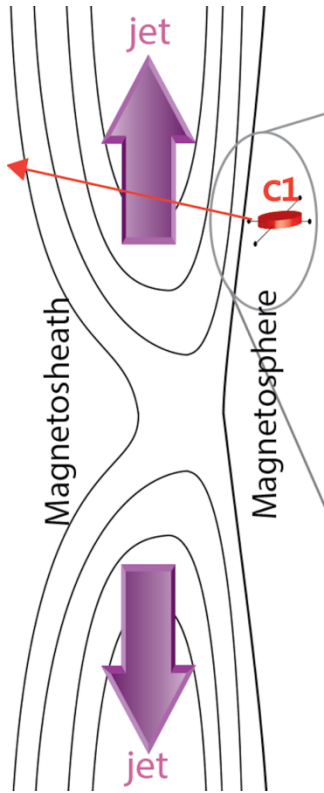


Toledo-Redondo+, GRL (2015)

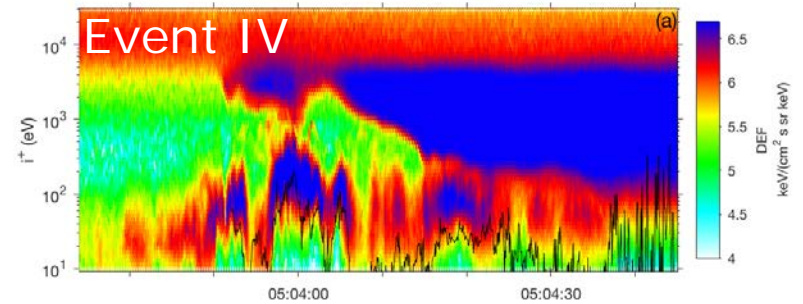
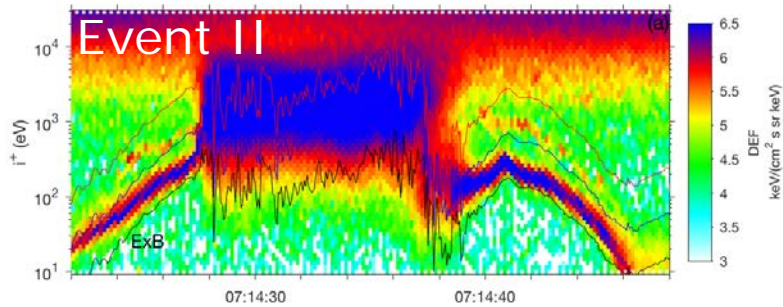
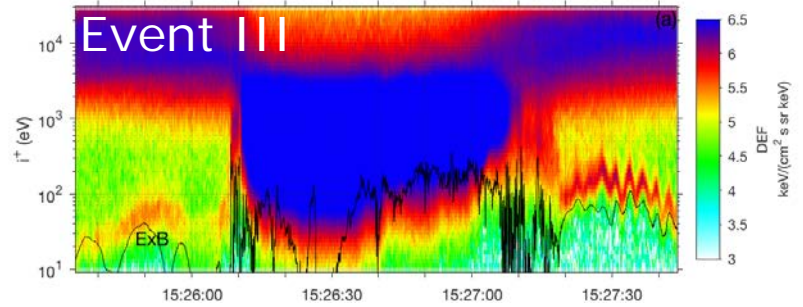
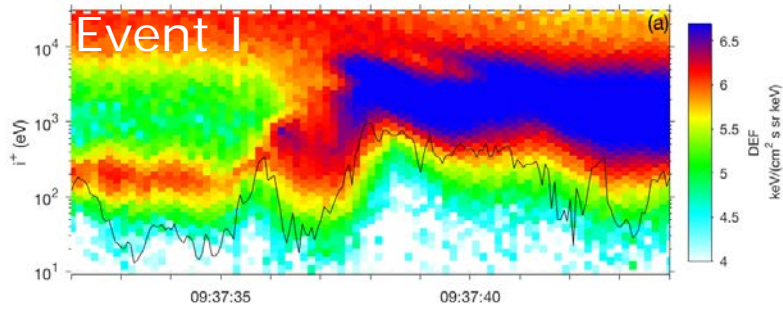


Toledo-Redondo+, GRL (2016)

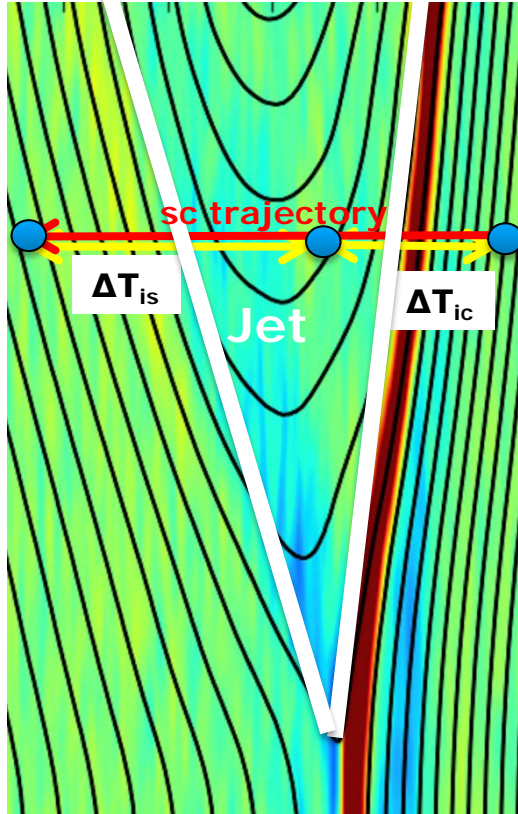
Cold ion heating by reconnection



Cold ion heating by magnetic reconnection



Energy budget of magnetic reconnection



$$\rho_{ic} = \frac{\Delta T_{ic} n_{ic}}{\Delta T_{ic} n_{ic} + \Delta T_{is} n_{is}}$$

Event	ρ_{ic}
I 2015-10-09	20% (H ⁺)
II 2015-10-24 Inb	08% (H ⁺)
III 2015-10-10	20% (H ⁺) 07% (He ⁺)
IV 2015-10-24 Out	No cold ion heating

- Cold ions **mass load** the magnetosphere and **reduce the reconnection rate**.
- In addition, they introduce **new microphysics** owing to their small gyroradii and can facilitate, for instance, the **generation of plasmoids**.
- Based on Cluster and MMS observations, reconnection can spend **20%** or more of the heating **energy** into **heating the cold ions**, when present.

Thanks for your attention