



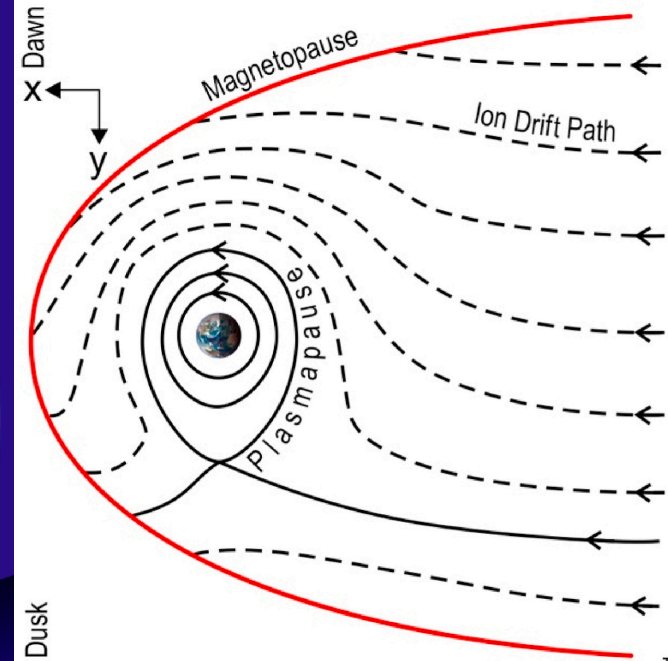
Impacts of ionospheric ions in solar wind - magnetosphere coupling

ESPM-16, 08 September 2021

Toledo-Redondo, S., André, M., Aunai, N., Chappell, C. R. Dargent, J. Fuselier, S. A., Gloer, A., Graham, D. B., Haaland, S., Hesse, M., Kistler, L. M., Lavraud, B., W., Li, Moore, T. E., Tenfjord, P., Vines, S. K.

Toledo-Redondo, S., et al. (2021). Impacts of ionospheric ions on magnetic reconnection and Earth's magnetosphere dynamics. *Reviews of Geophysics*, 59, e2020RG000707.

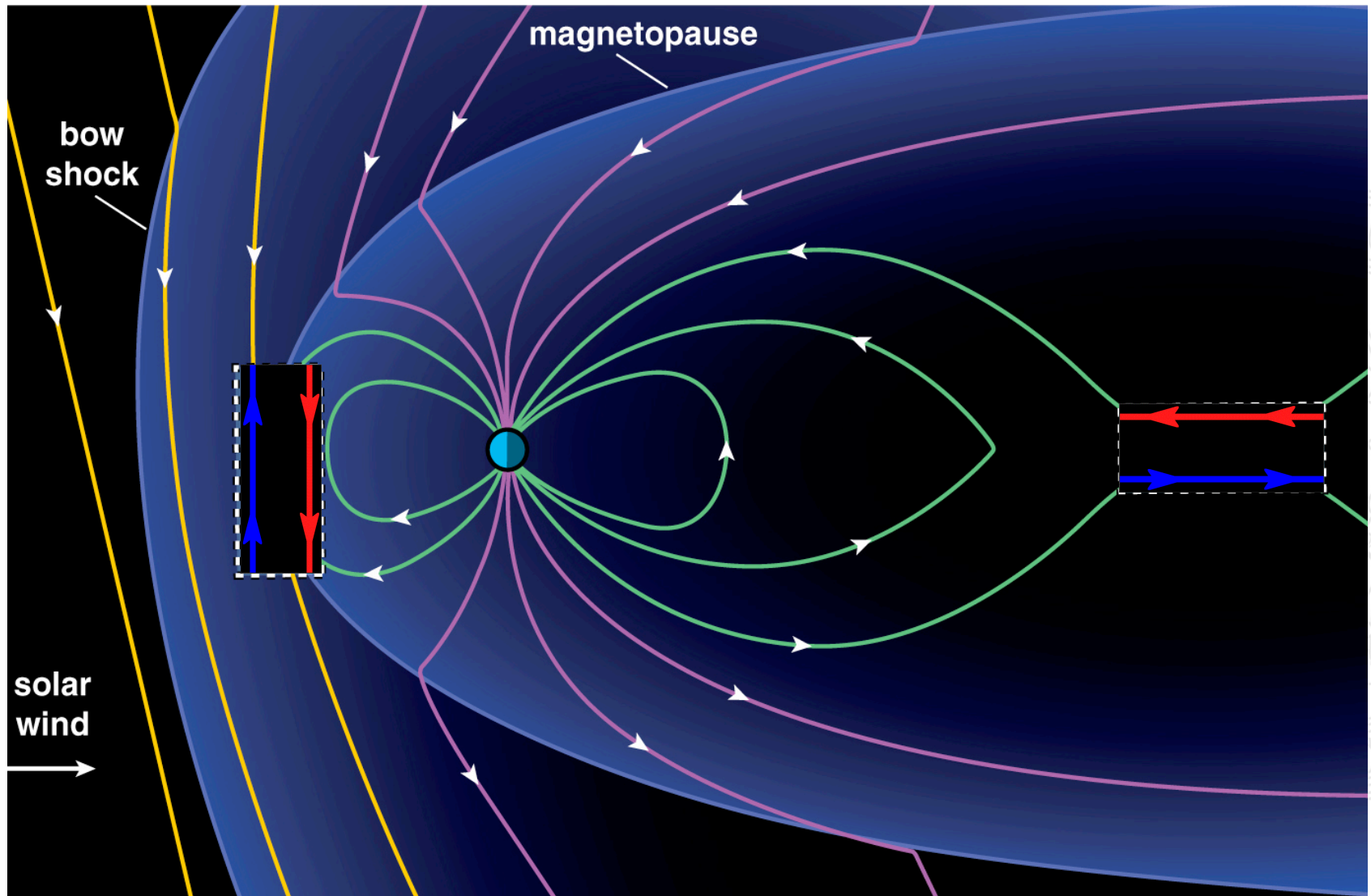
<https://doi.org/10.1029/2020RG000707>



Contribution of the ionosphere is variable and of the same order of magnitude as solar wind)

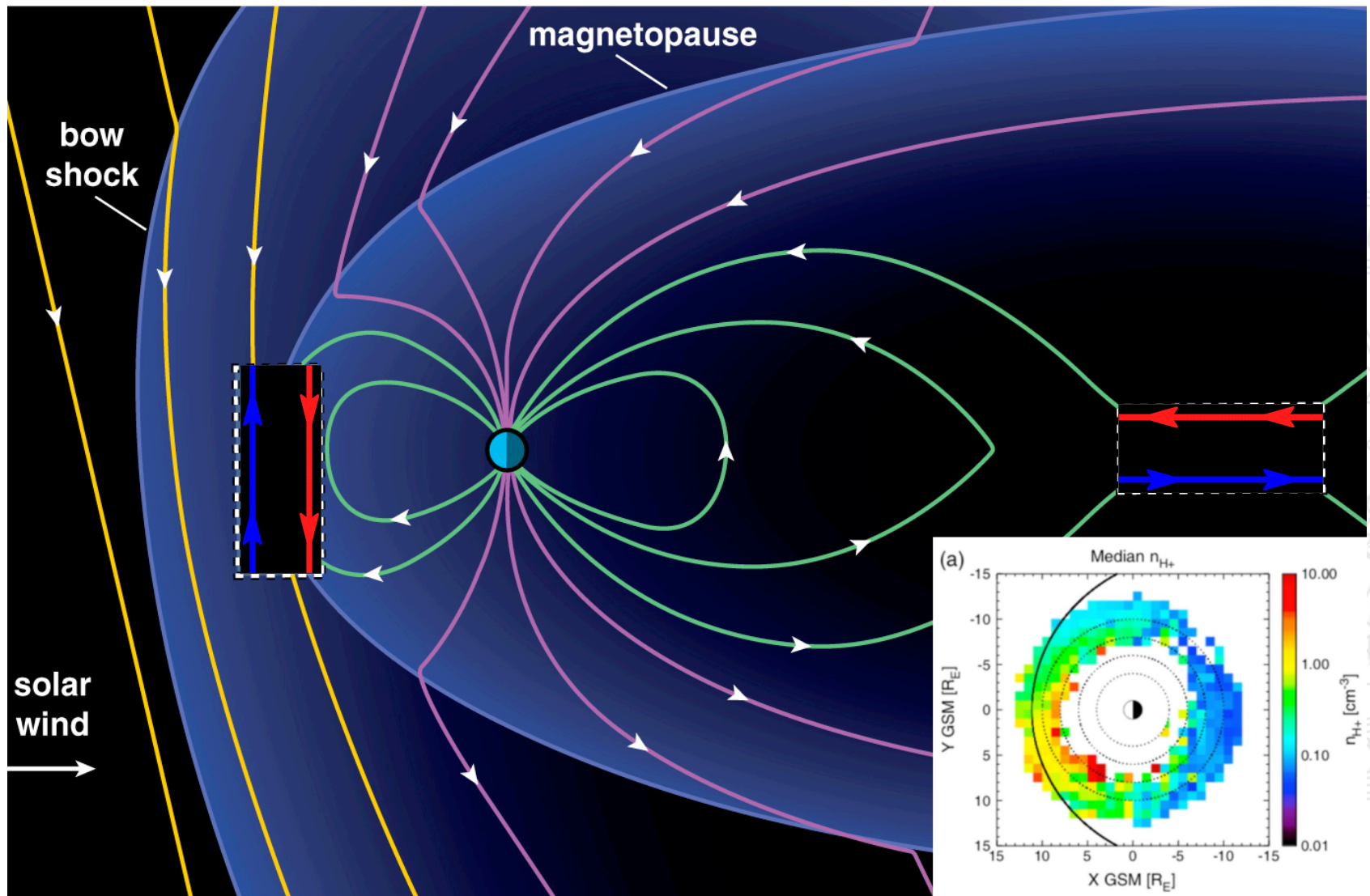
Earth's magnetosphere coupling to the solar wind

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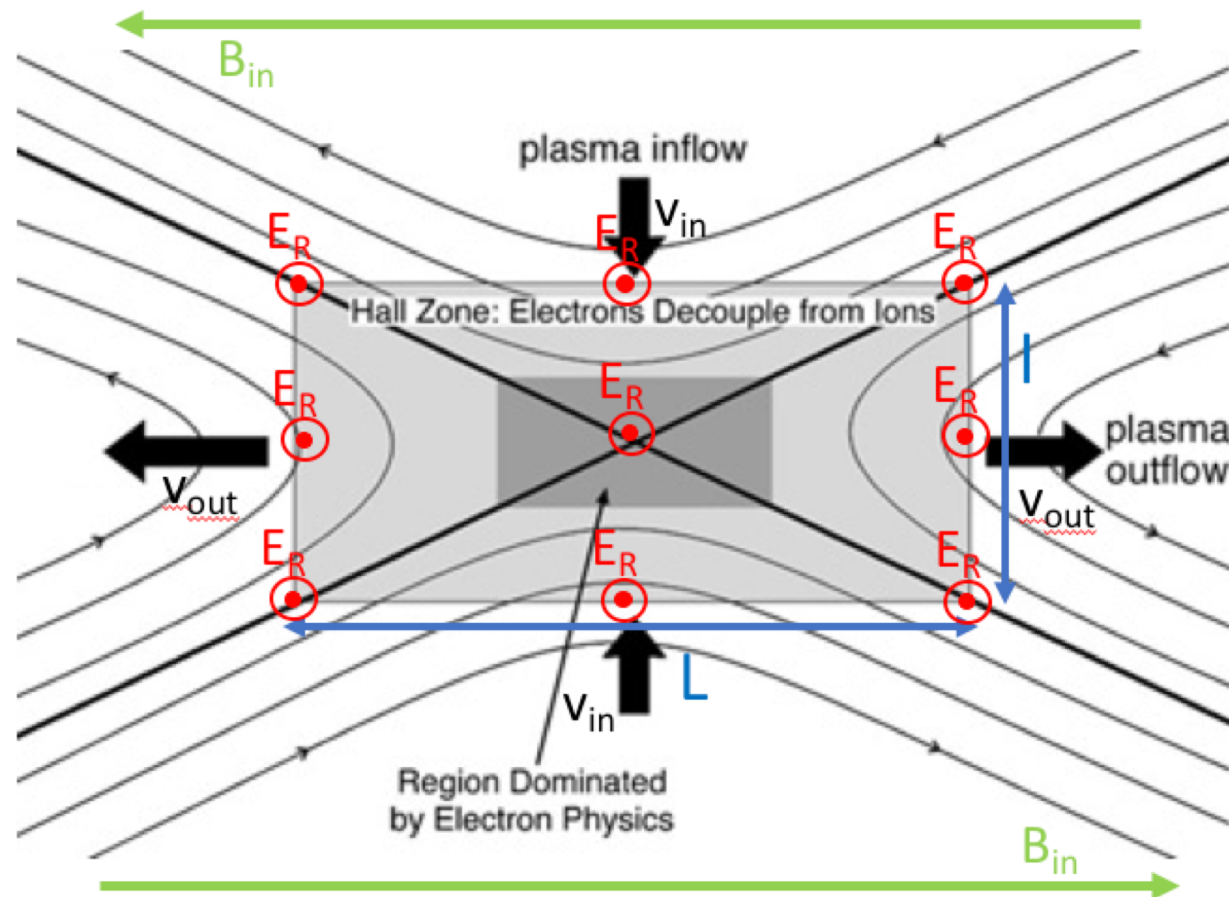


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Mass loading effect on magnetic reconnection

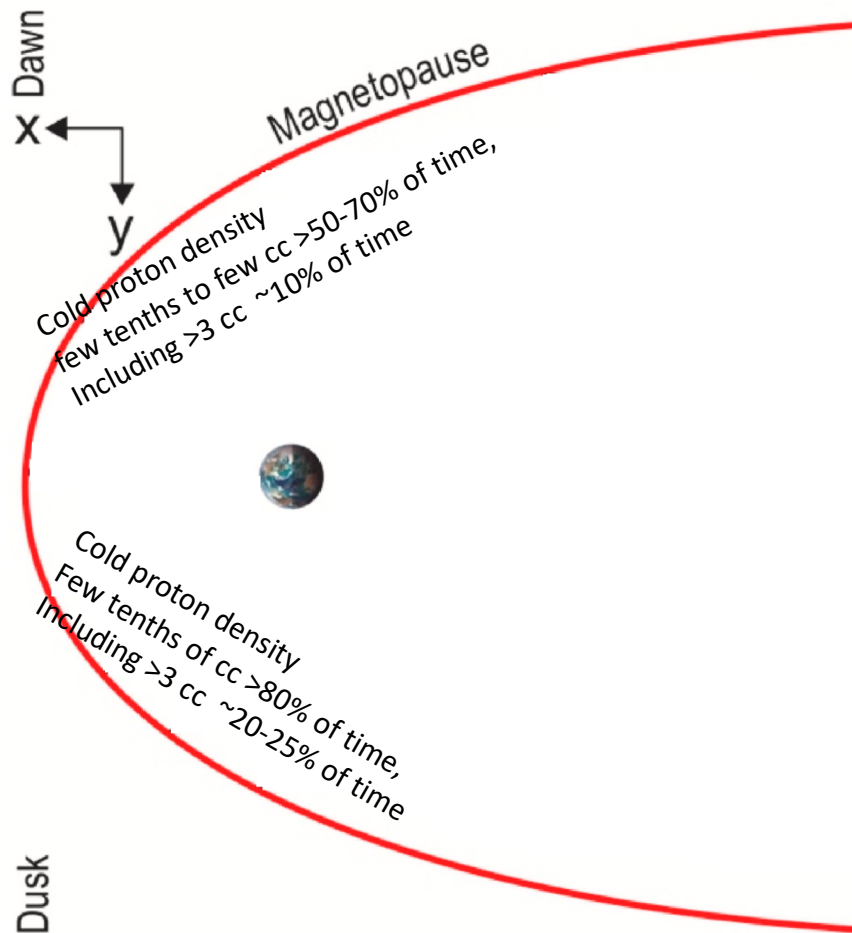


The aspect ratio (I/L) defines the normalized reconnection rate. Experimentally, it is of order of 0.1 [Liu+2016, PRL]

$$E_R \sim B_{in} V_{out} (I/L)$$

$$V_{out} = v_A = B_{out}^2 / (\mu_0 \rho_{out})$$

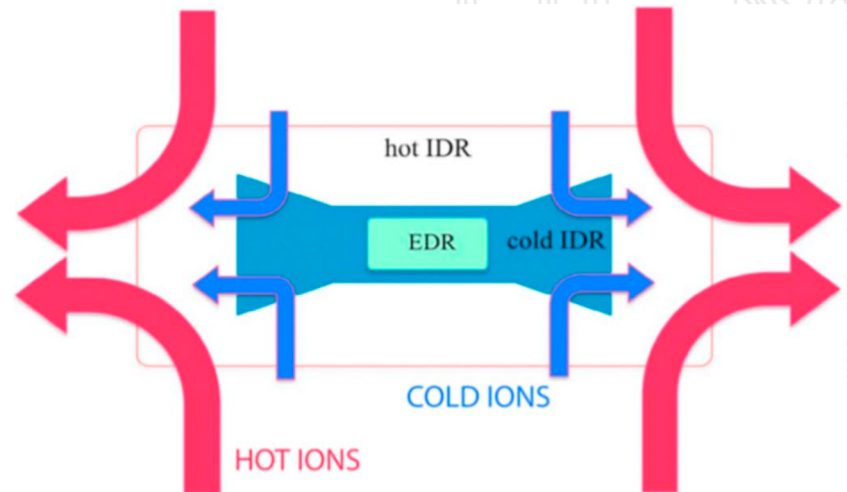
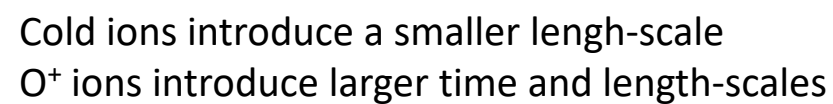
Mass loading effect on magnetic reconnection



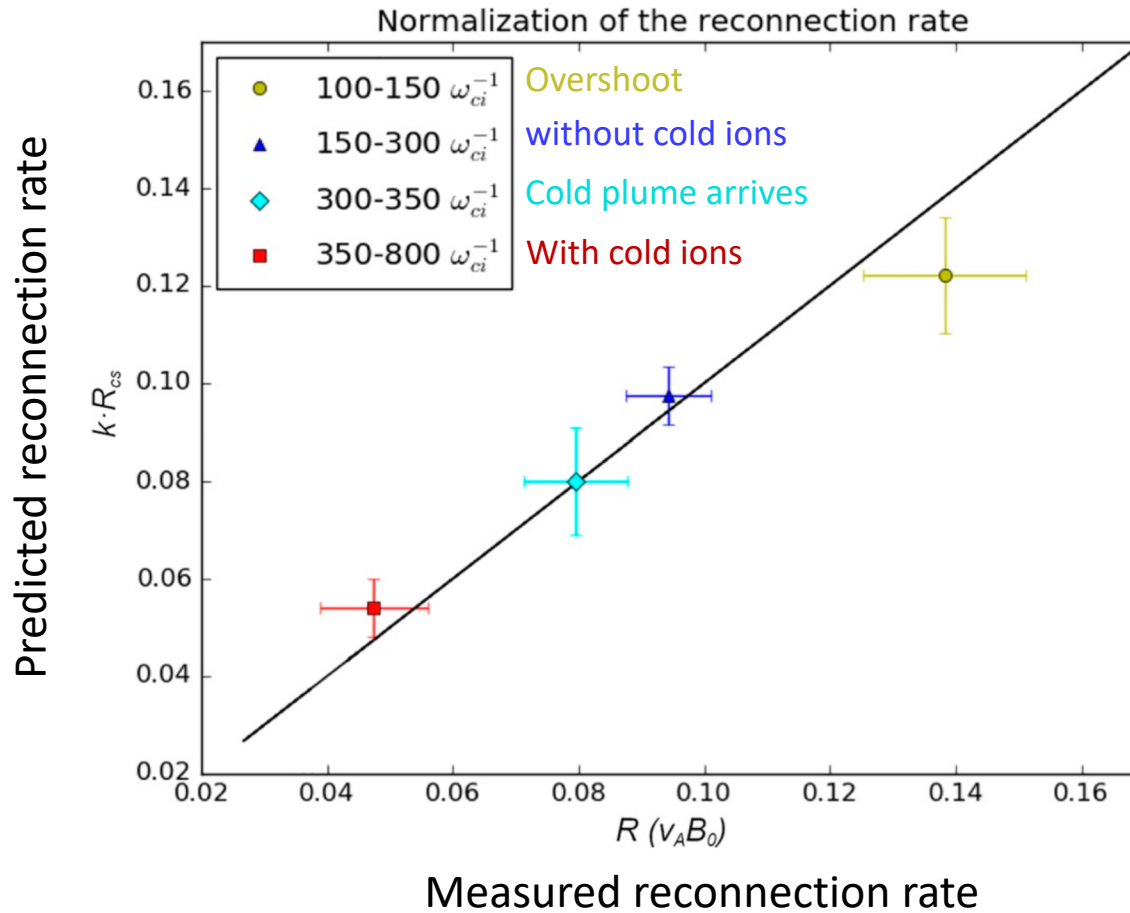
Ionospheric populations increase magnetospheric density near the magnetopause more than a factor 2 most of the time. However, the magnetospheric density is usually 1 order of magnitude than shocked solar wind density.

Reduction in reconnection efficiency by >20% only during <5% of the time (Fuselier et al. 2017, 2019).

During disturbed magnetospheric times (ie increased O⁺), reduction in reconnection efficiency >20% during ~25% of the time.



Conclusions and open questions



Conclusions

- Mass loading of the magnetopause is only significant for magnetic reconnection during magnetospheric disturbed times
- New length-scales are added by cold and heavy ions, which modify the reconnection process at kinetic scales and the energy budget of magnetic reconnection.

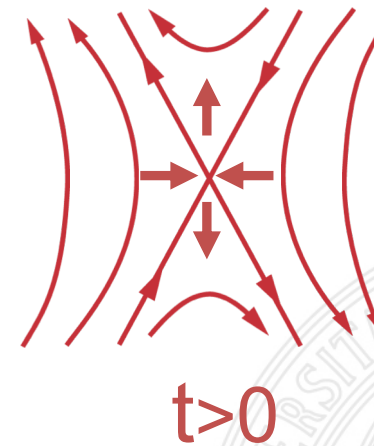
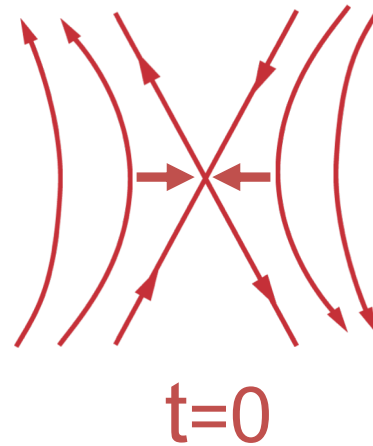
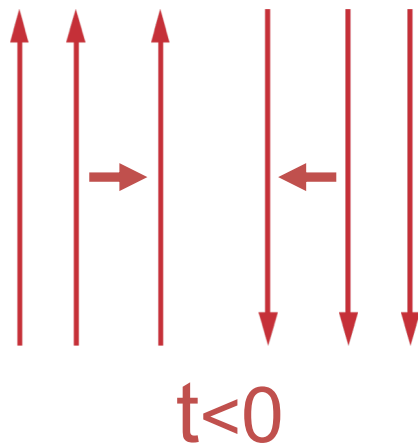
Some open questions

- Relative contribution of the two magnetospheric plasma sources (ionosphere and solar wind)
- Microphysics of multiple ions, how they affect MHD scales of reconnection?
- Energy budget. Which fraction of reconnection energy goes into cold and heavy ions?



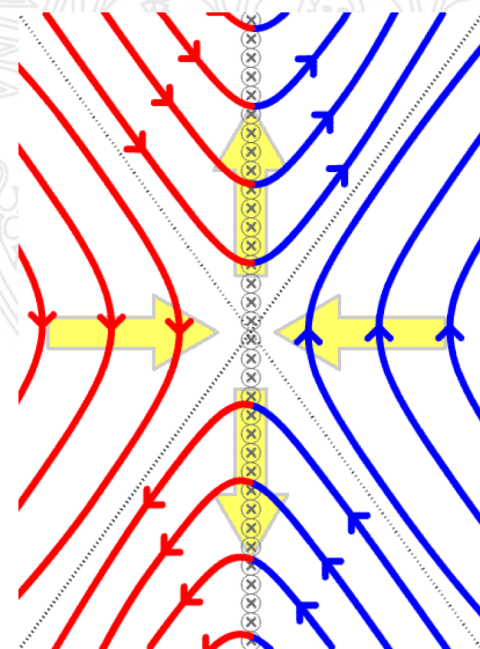
THANK YOU

Magnetic reconnection



Magnetic reconnection in plasmas changes the **topology** of the magnetic fields, relaxing them and **converting the energy** into the kinetic particle energy.

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



Relative contribution of the two magnetospheric plasma sources (ionosphere and solar wind)

Local versus global coupling of the solar wind magnetosphere

Microphysics of multiple ions, how they affect MHD scales of reconnection?

Energy budget. Which fraction of reconnection energy goes into cold and heavy ions?

Table 4

Summary of Open Questions in the Role of Ionospheric Ions and Magnetic Reconnection in the Magnetosphere

Global magnetospheric dynamics	What is the relative contribution of solar wind versus ionospheric-originating H^+ to the magnetosphere?
	How is the plasma sheet formed?
	Does the variable magnetospheric density affect the global coupling with the solar wind efficiency?
Kinetic physics of magnetic reconnection	How do the microphysics introduced by multiple ion populations change reconnection at MHD scales?
	Does the WPC alter the suppression of magnetic reconnection?
	Which portion of the reconnection energy is taken by cold and heavy ions?
	What are the effects of cold electrons in magnetic reconnection?
	How ionospheric ions in the plasma sheet condition the onset of magnetic reconnection?

Abbreviation: WPC, warm plasma cloak.