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What can limit the effectiveness of magnetic reconnection?

How good is mass-correction for explaining the rate reduction in the presence of cold ions?

Paul Tenfjord, M. Hesse, C. Norgren, S. Spinnangr, H. Kolstø, N. Kwagala

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Mass-loading correction - how good is it?

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Sweet-Parker scaling can be obtained using the laws of conservation of mass, energy, and magnetic flux

$$\oint d\vec{S} \cdot (\rho V) = 0 \quad \left(= \frac{\partial \rho}{\partial t} \right)$$ ***steady-state & incompressibility :*** $$\frac{\rho_{in} V_{in}}{\rho_{out} V_{out}} \rightarrow \quad \frac{V_{in}}{V_{out}} \sim \frac{\delta}{L} \quad , \quad \rho_{in} = \rho_{out}$$

(IDR scales: density in exhaust usually larger than that in the inflow region)

$$\oint d\vec{S} \cdot \left(\frac{\rho v^2}{2} + \frac{\gamma}{\gamma - 1} P + B^2 \right) V = 0$$ ***steady-state & no pressure cont.*** $$V_{out} \sim V_A$$

Ion outflow typically 0.5Va in PIC (thermal and magnetic enthalpy)

$$\oint d\vec{S} \cdot \left(\rho v v + (P + \frac{B^2}{2}) \vec{I} - BB \right) = 0$$ ***Across:*** $P \sim B^2/2$ ***, Along:*** $P \sim \rho v v$

If inflow is cold: Must be heated to preserve pressure balance with outside magnetic field. Requires energy
But this mean lower inflow plasma beta

Alfven speed: $V_A = \frac{B}{\sqrt{\rho}}$ ***(based on upstream values)***

Mass-loading does not depend on temperature because enthalpy (*and* Poynting flux) is neglected

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Rate is generally faster than predicted by mass-loading

$$\frac{V_{in}}{V_A} \sim \frac{\delta}{L} \sim \frac{B_z}{B_x}$$ ***(incompressibility assumed)***

$$E \sim V_{in}B_x \sim V_{out}B_z \sim V_A B_z \sim V_A B_X \frac{\delta}{L} \quad \rightarrow \quad \frac{E}{V_A B_X} \sim \frac{\delta}{L}$$

Alfven speed: $V_A = \frac{B_{in}}{\sqrt{\rho_{in}}}$