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A scaling model for plasmoid-dominated turbulent reconnection

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In resistive magnetohydrodynamics (MHD), two magnetic reconnection models have long been discussed: Petschek reconnection model requires some assumptions in the electric resistivity, whereas Sweet--Parker model is too slow to explain reconnection events in the universe. In late- 2000s, it was found that Sweet--Parker reconnection switches to plasmoid-dominated reconnection in larger systems at a high Lundquist number. Plasmoid-dominated reconnection features multiple secondary islands, due to the tearing instability in the reconnecting current sheet. Importantly, the reconnection rate of the plasmoid-dominated reconnection is moderately fast ($R \sim 0.01$), which is insensitive to the Lundquist number. Owing to this, plasmoid-dominated reconnection has been extensively studied over the past decade.

Traditionally, theories on Sweet--Parker and plasmoid-dominated reconnections assume the incompressibility for simplicity. Meanwhile, much less attention has been paid to the compressible fluid effects. In a compressible plasma, the typical Alfvén speed approaches or exceeds the local sound speed, and then various characteristic features appear. In addition, we expect a highly compressible plasma in solar coronal environments. Thus, it is necessary to explore the role of the plasma compressibility in plasmoid-dominated reconnection.

In this contribution, we explore plasmoid-dominated reconnection in compressible parameters, by using a massively-parallel resistive MHD simulations. We find that the reconnection rate increases for compressible parameters, up to $R \sim 0.02$. We propose a simple scaling model for the rate, and we validate our prediction by a series of simulation runs. We will also present an interesting feature on the onset of plasmoid-dominated turbulence.

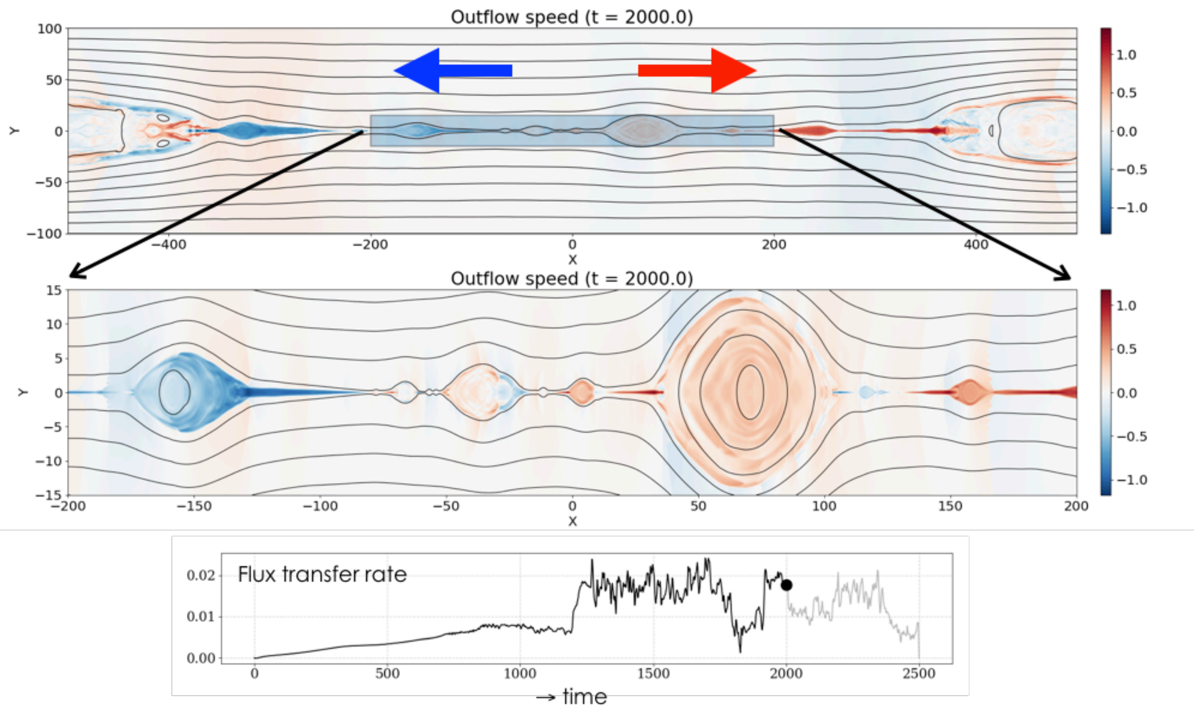

Figure 1. Top) Outflow velocity in the 2-D simulation. It is normalized by a typical Alfvén speed. Bottom) Time evolution of the flux transfer rate (reconnection rate).