
BRIDGING THE DYNAMICS BETWEEN RECONNECTION AND INSTABILITY SCALES

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MOTIVATION & OVERARCHING GOAL

- **Motivation:**

- Non-linear instabilities are ubiquitous.
- Instabilities bring (magnetic) field lines together, leading to magnetic reconnection.
- Turbulent systems have multiple reconnection events, at any given instant.

- **Goal:** Cumulative influence of all reconnection events on global dynamics stay unknown, which we want to address.

In simple, we want to connect the dynamics across scales (small-scale reconnection and large-scale dynamics)

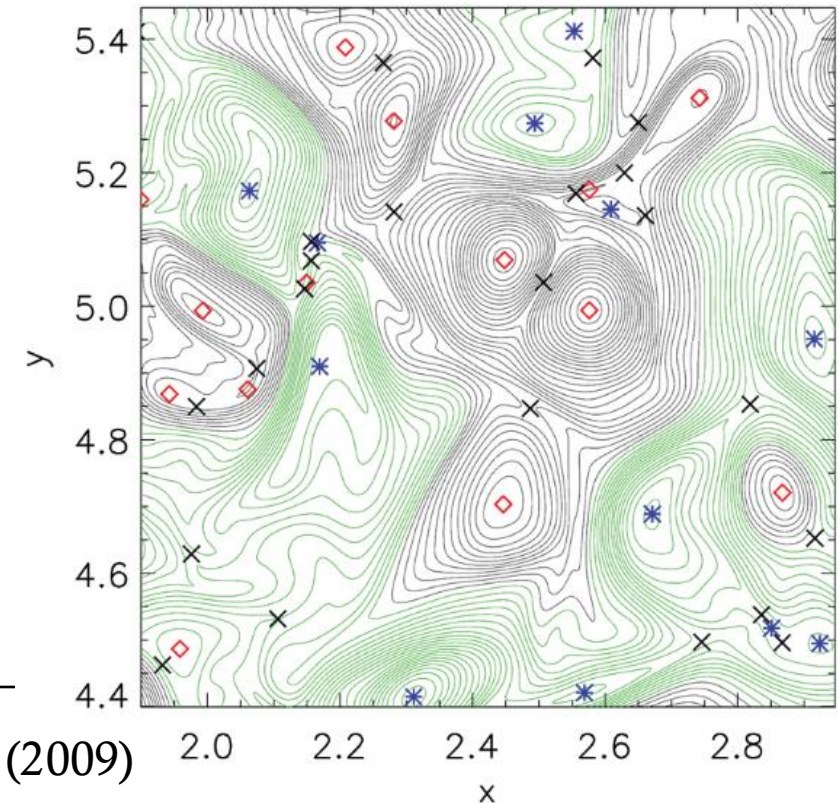
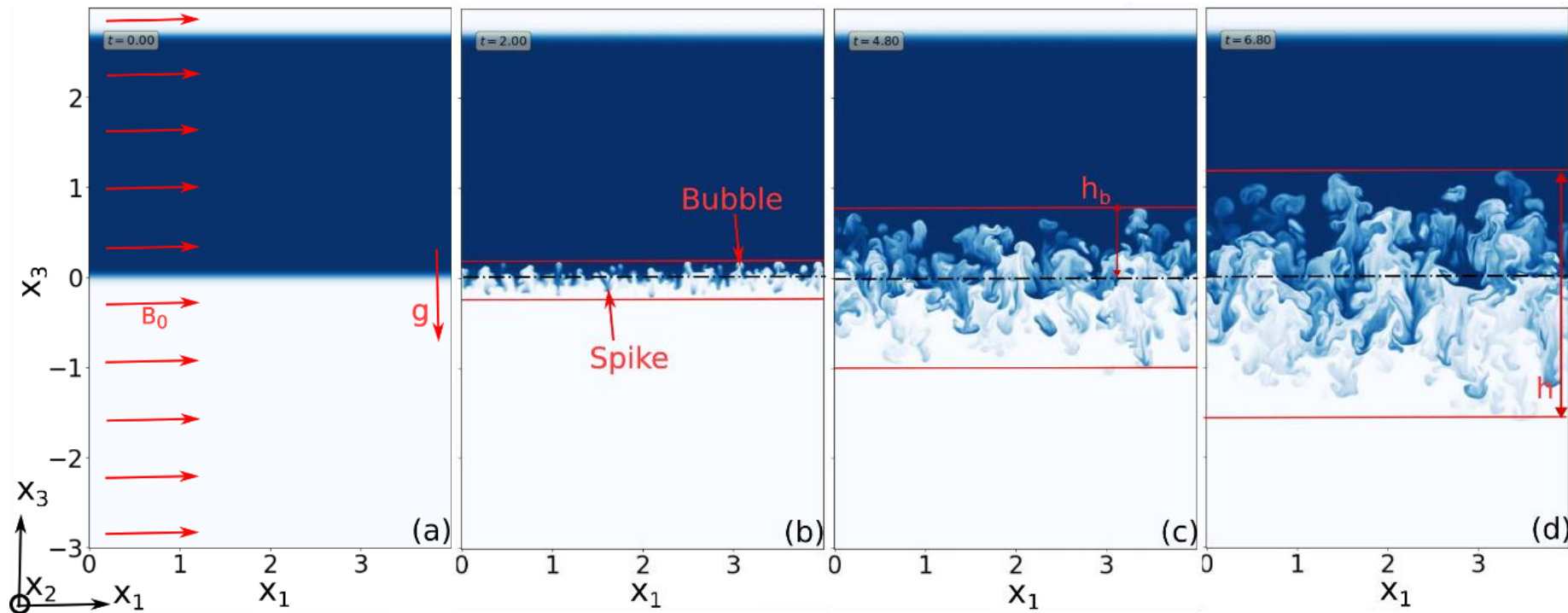


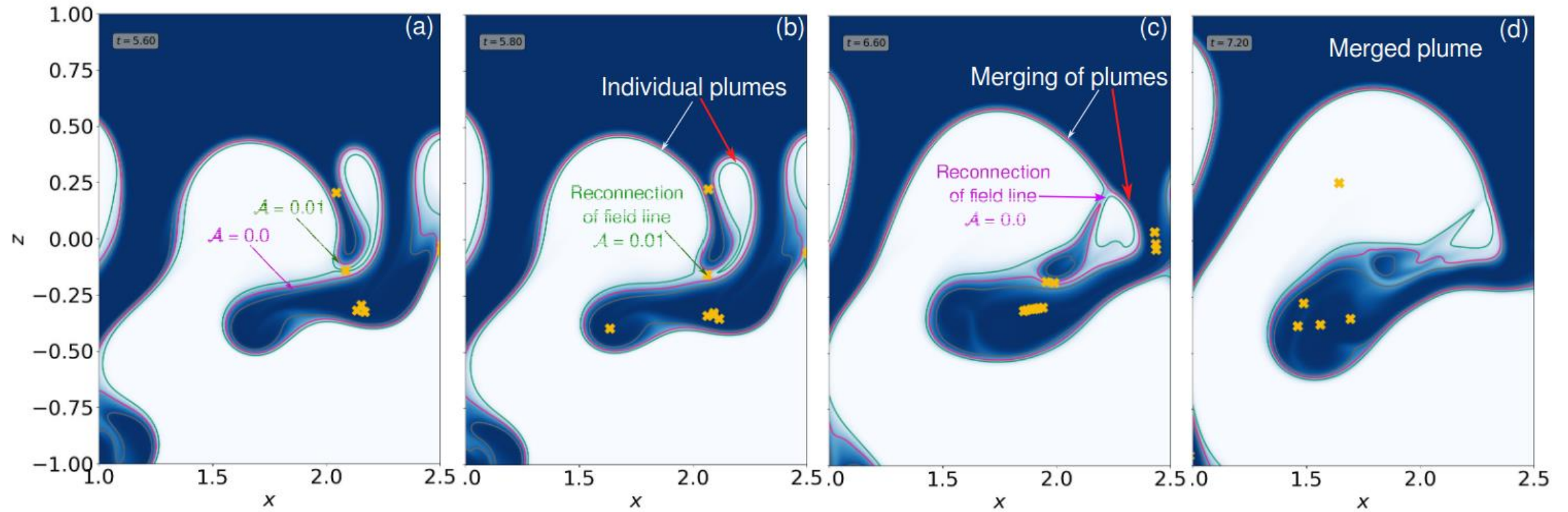
Fig from Servidio et. al. PRL 102, 115003 (2009)

MAGNETIC RAYLEIGH-TAYLOR INSTABILITY

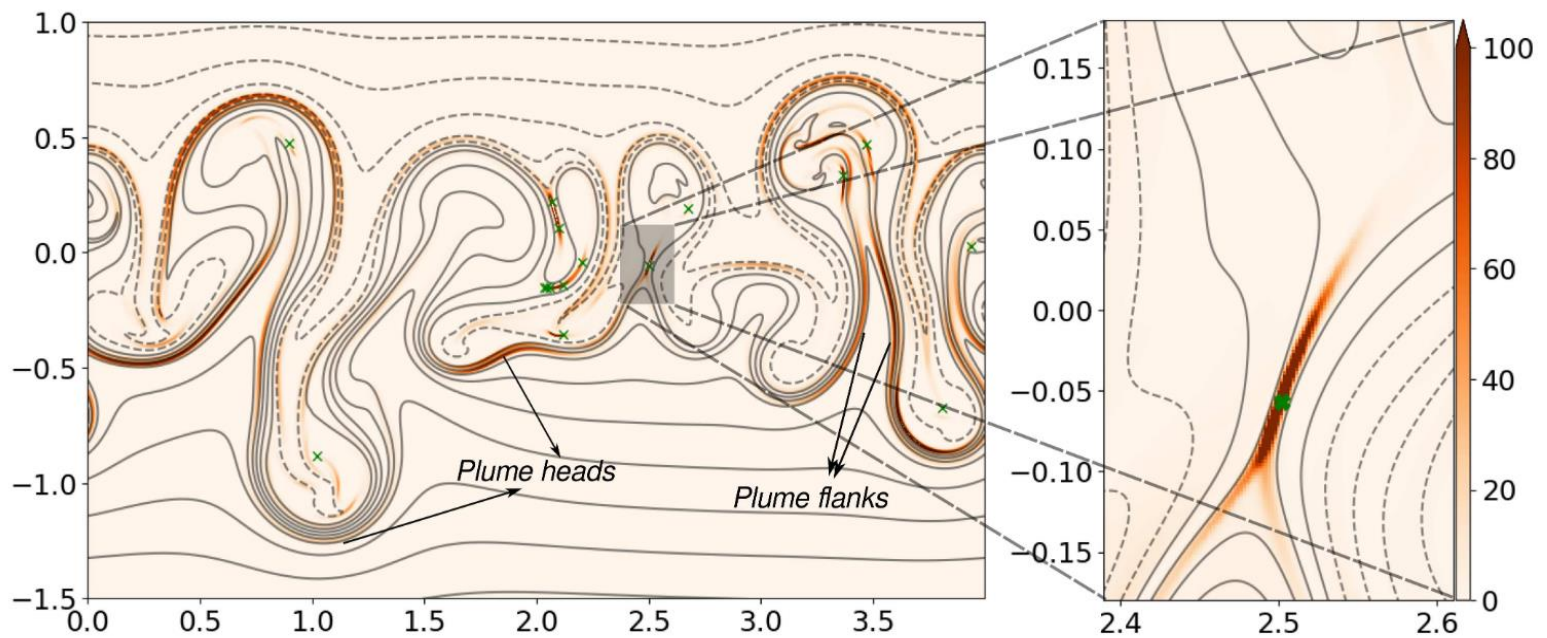
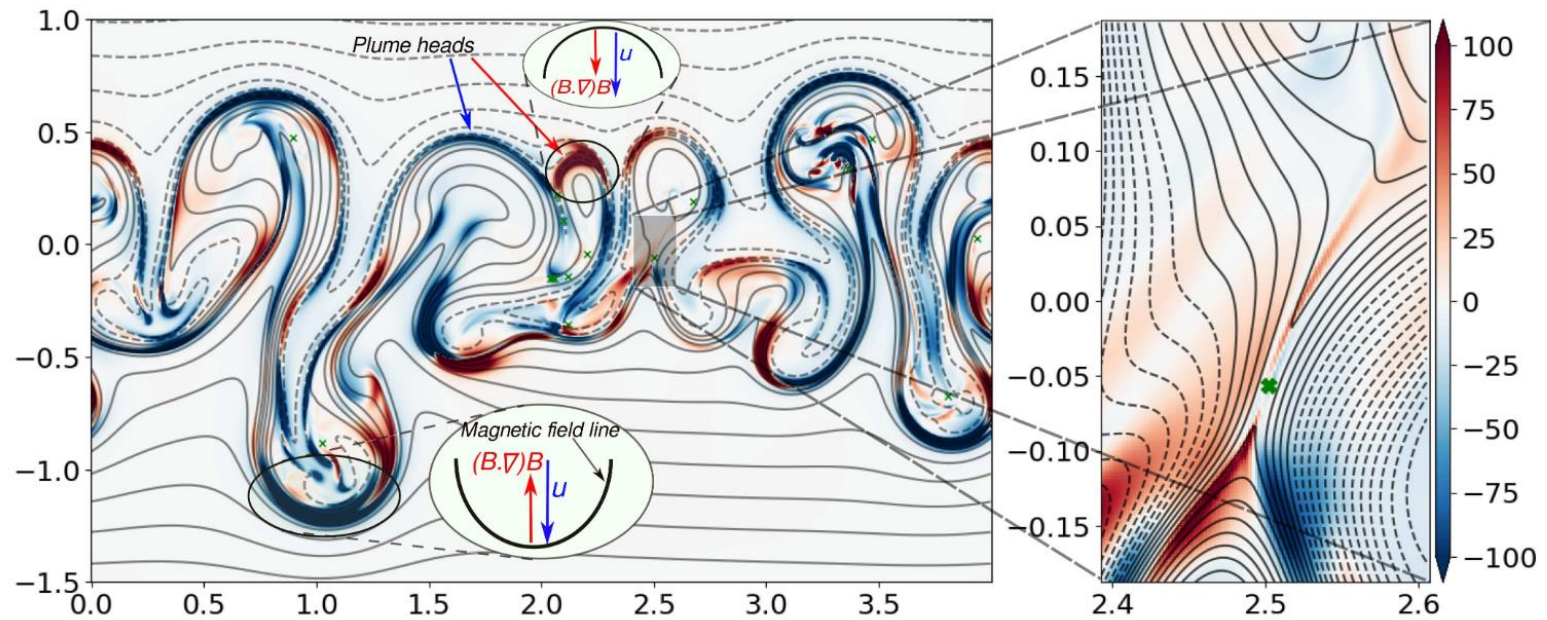
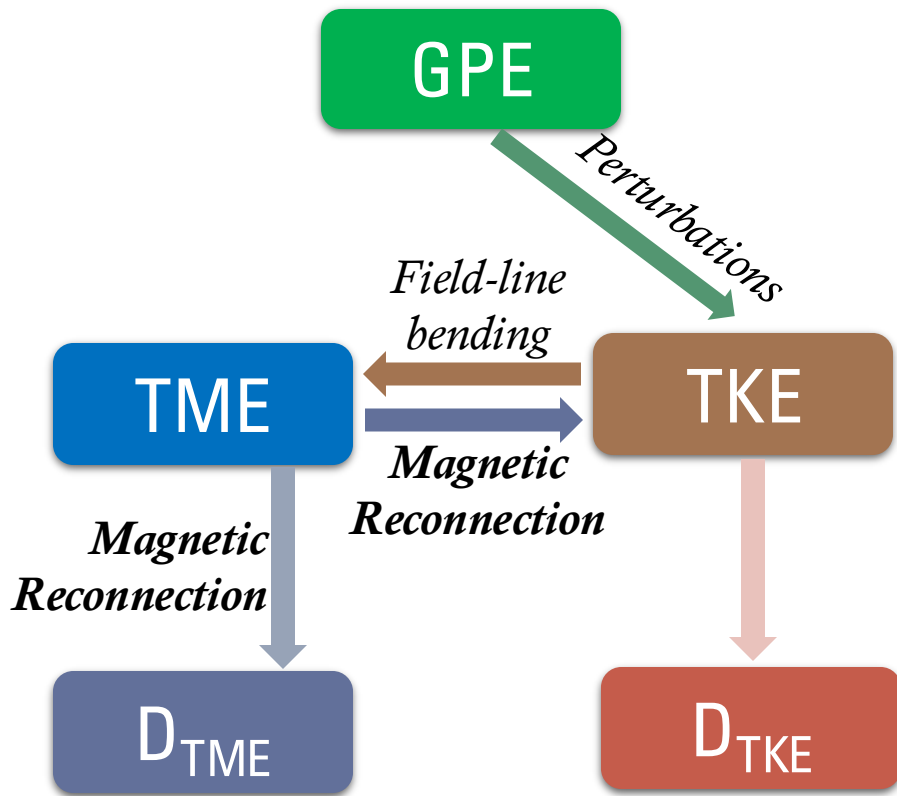
- Configuration: High density plasma superimposed over low density plasma (*Inherently unstable*)
- *Destabilizing force*: Gravity; *Stabilizing force*: Magnetic tension
- In the regime where gravity dominates magnetic tension, interfacial perturbations lead to plasma penetration or mixing ----- magnetic Rayleigh-Taylor instability.



RECONNECTION IN INSTABILITIES



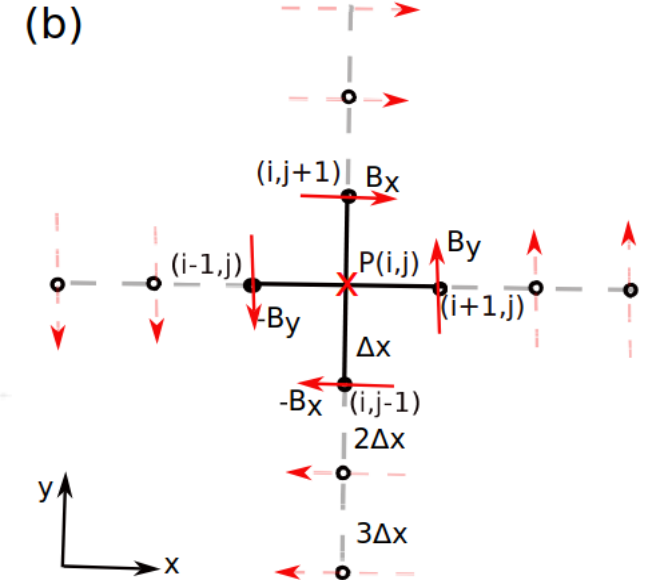
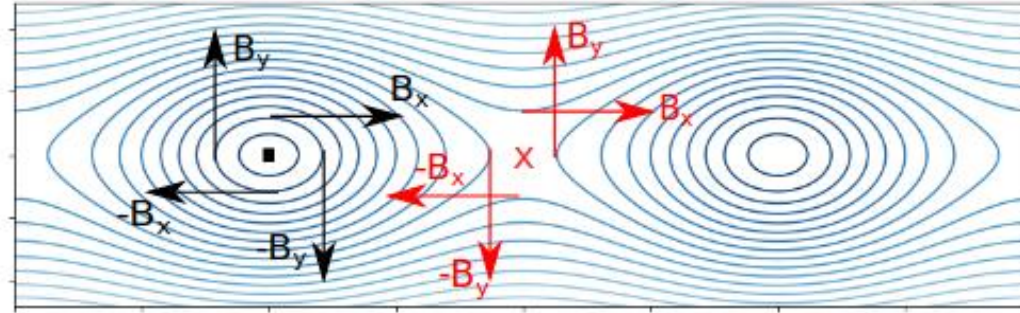
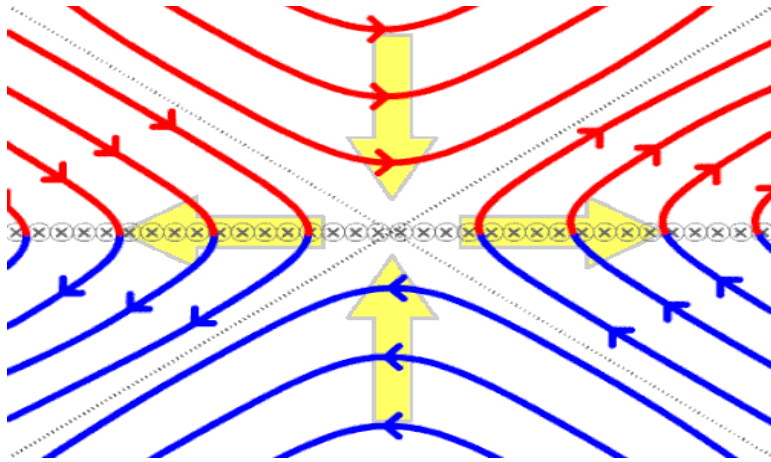
ENERGY FLOW



Contours of: (top) $u \cdot (B \cdot \nabla) B$; (bottom) ηj^2

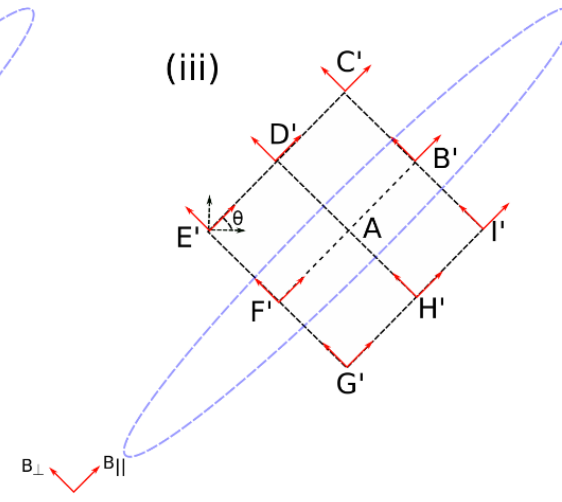
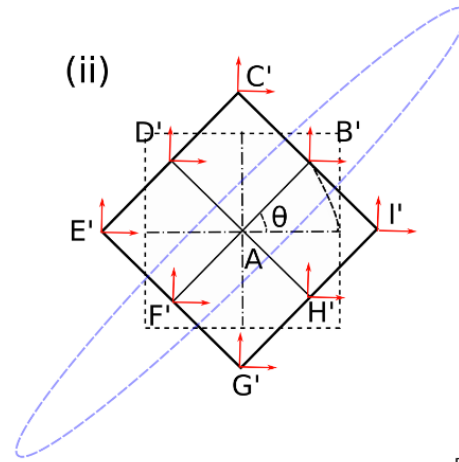
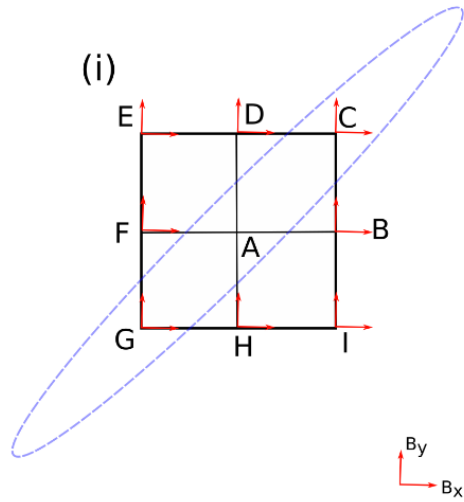
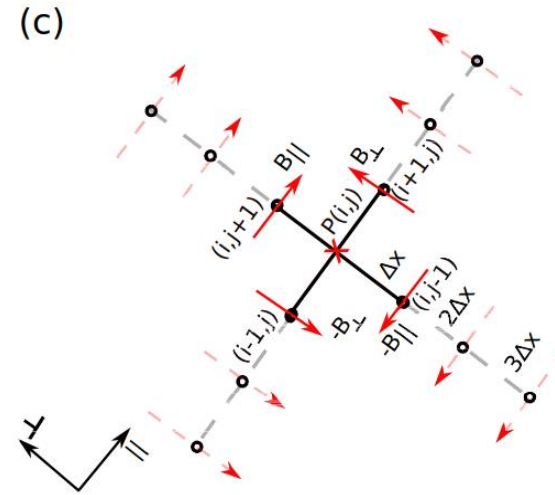
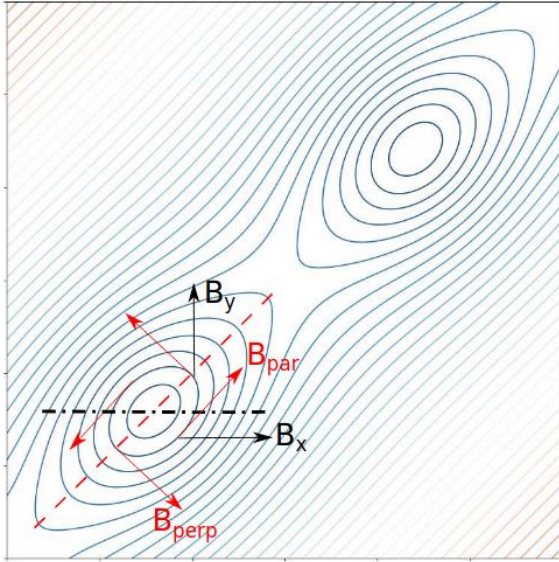
RECONNECTION DETECTION

We developed a topology-based reconnection detection algorithm



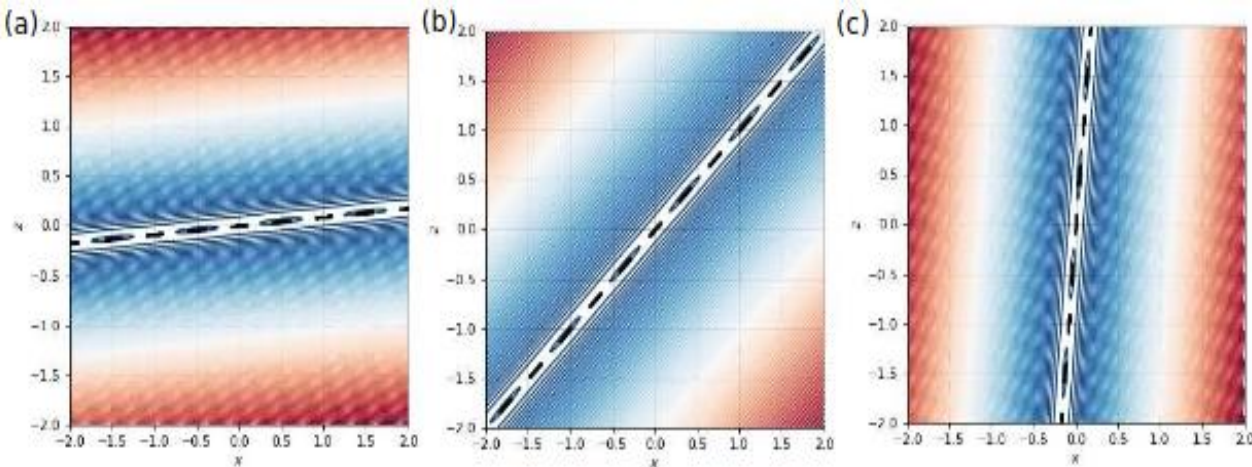
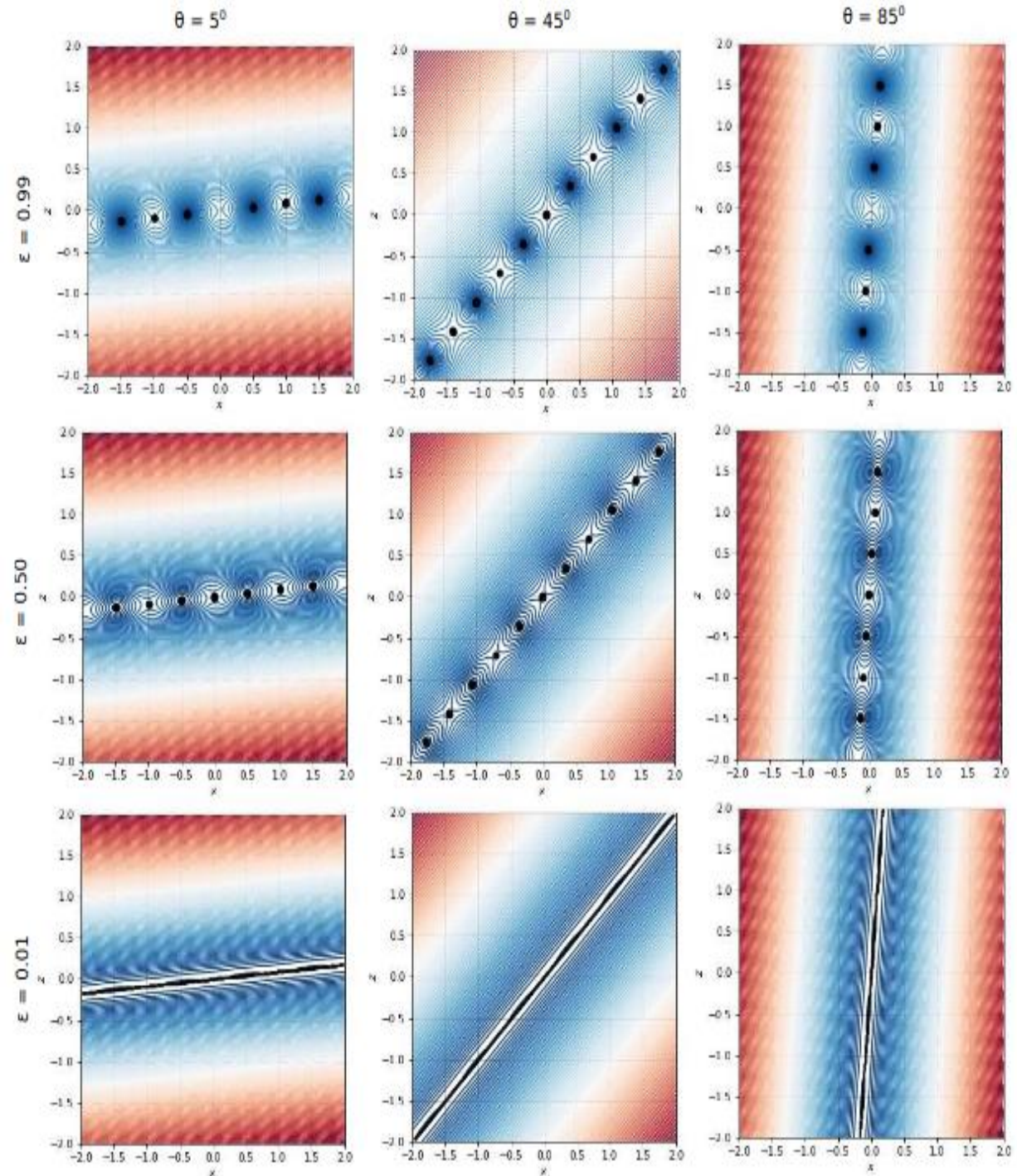
A powerful tool for reconnection and turbulence problems. Welcome you to try this. Please reach out if interested

RECONNECTION DETECTION



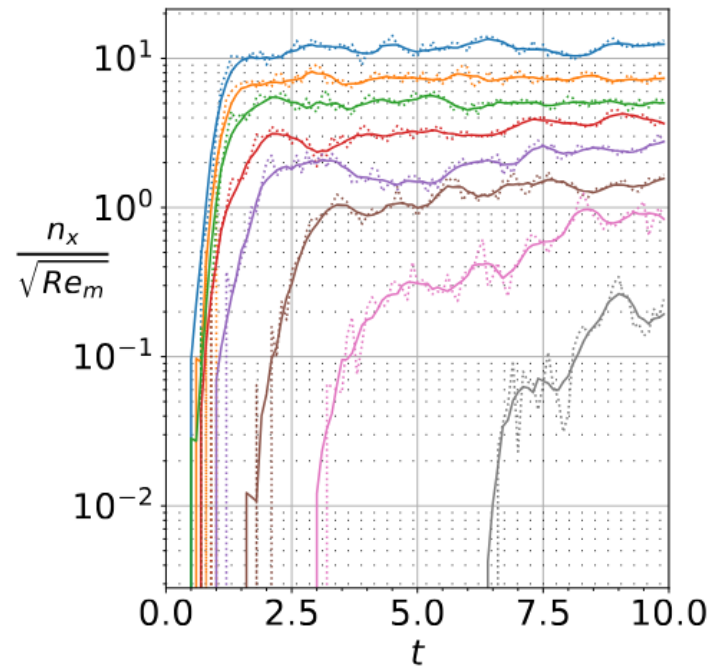
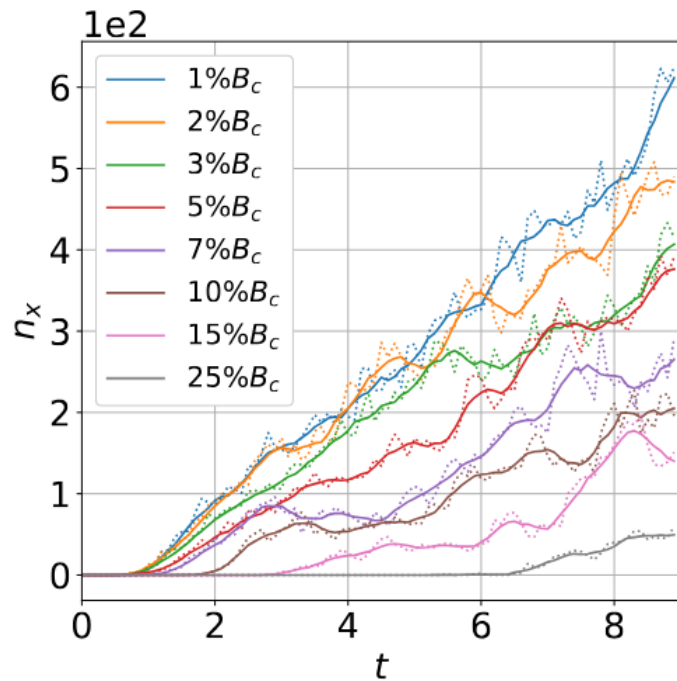
TESTING

- Testing for different plasmoid eccentricities show that when poorly resolved the code results in a chain of points. This can be avoided using higher resolution.
- Due to computational limitations, there always are unresolved plasmoids and hence chain of null points.
- A null point can sometimes appear as a lump of points. This can be fixed by clustering points.



RECONNECTION STATISTICS IN INSTABILITIES & TURBULENCE

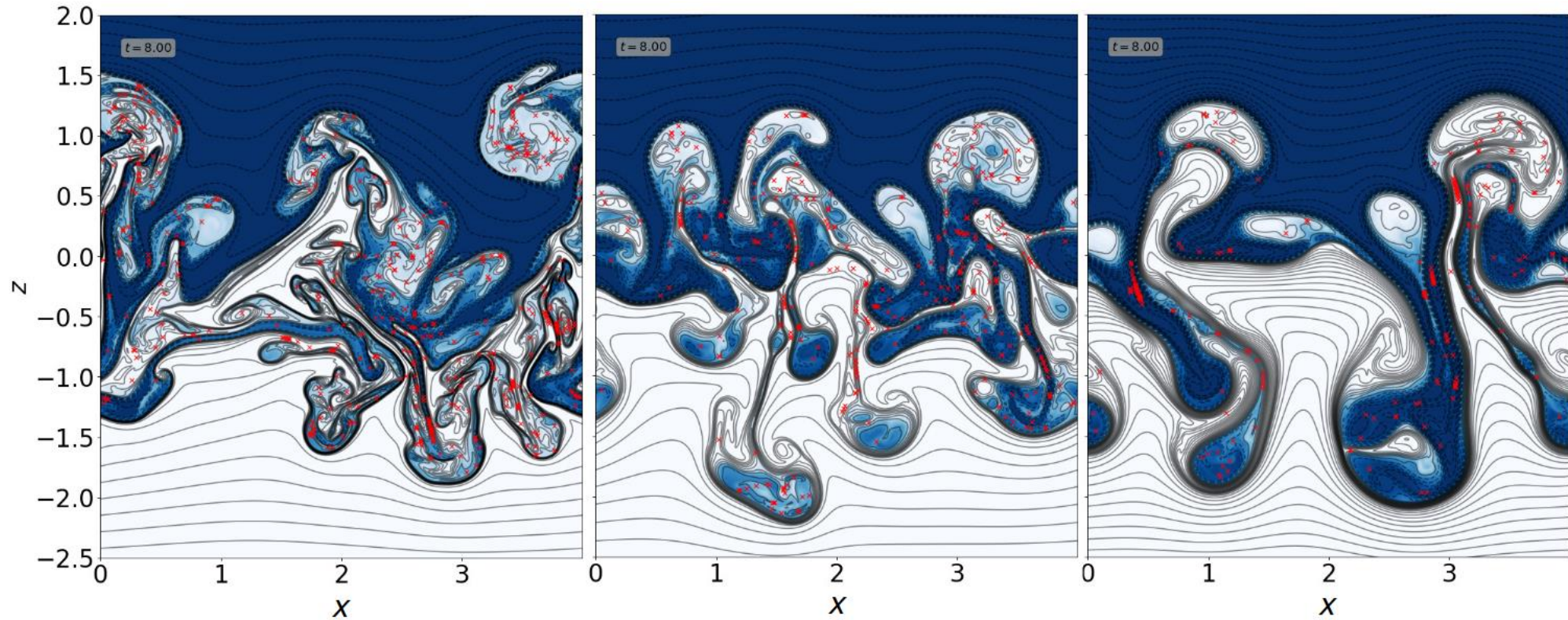
- Has **multiple reconnection events**, (increasing over time)



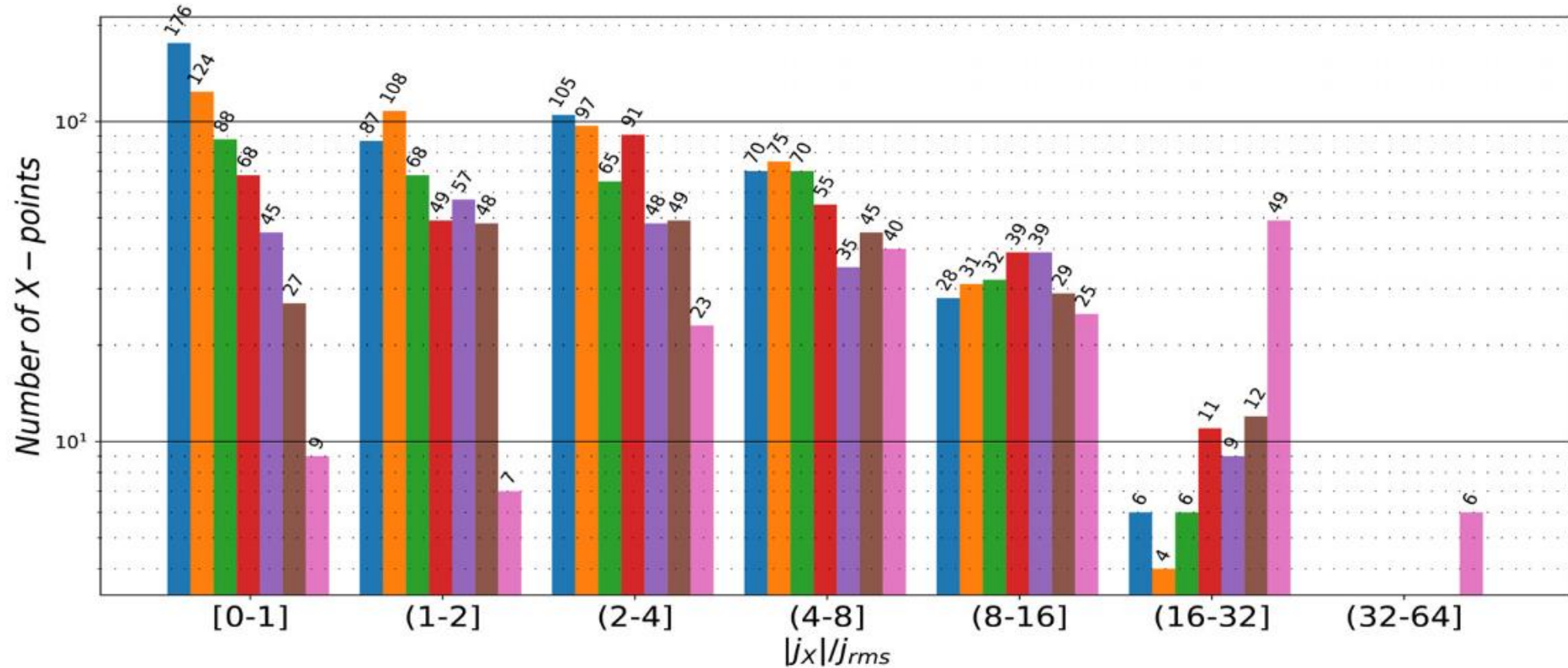
- In MRTI, the number of reconnection events scales with (square root of) magnetic Reynolds number.

EFFECT OF MAGNETIC FIELD STRENGTH

Magnetic field suppresses small scales => Suppresses turbulence => reconnection events decreases



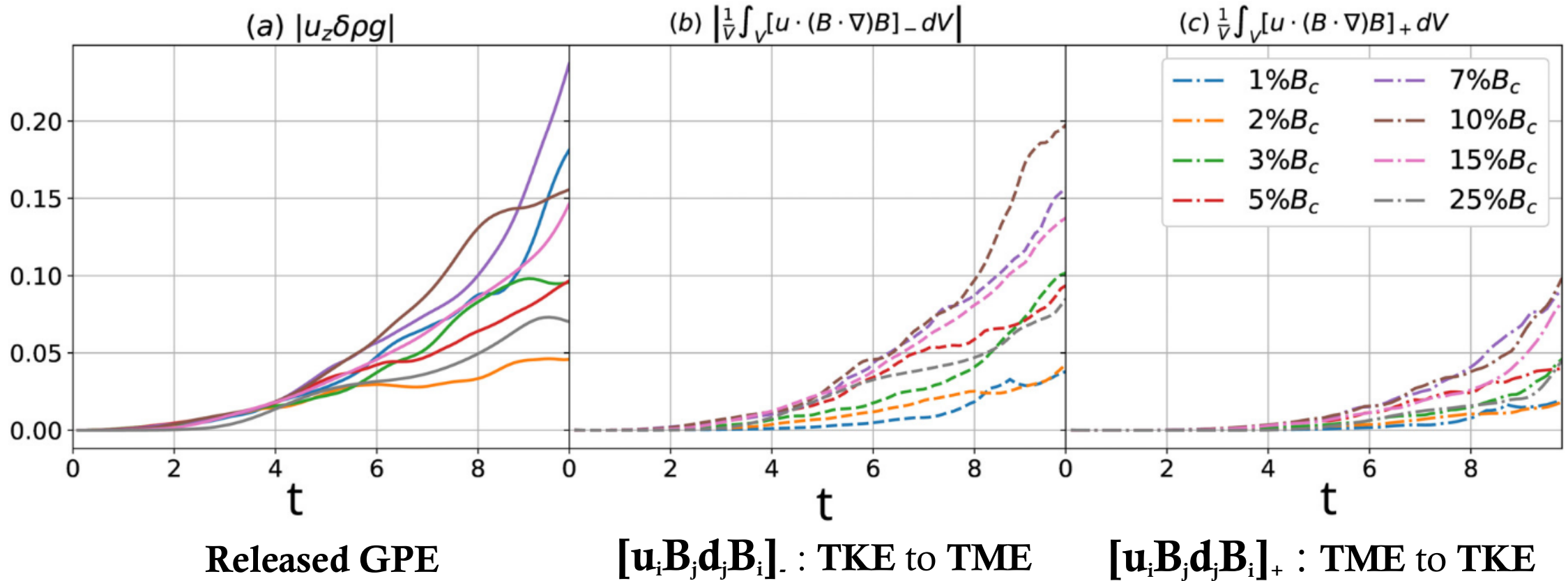
CHARACTERISTICS OF THE RECONNECTION EVENTS



Weak B_0 case: Majority of reconnection is due to weak current sheets.

Strong B_0 case: Majority of reconnection is due to strong current sheets.

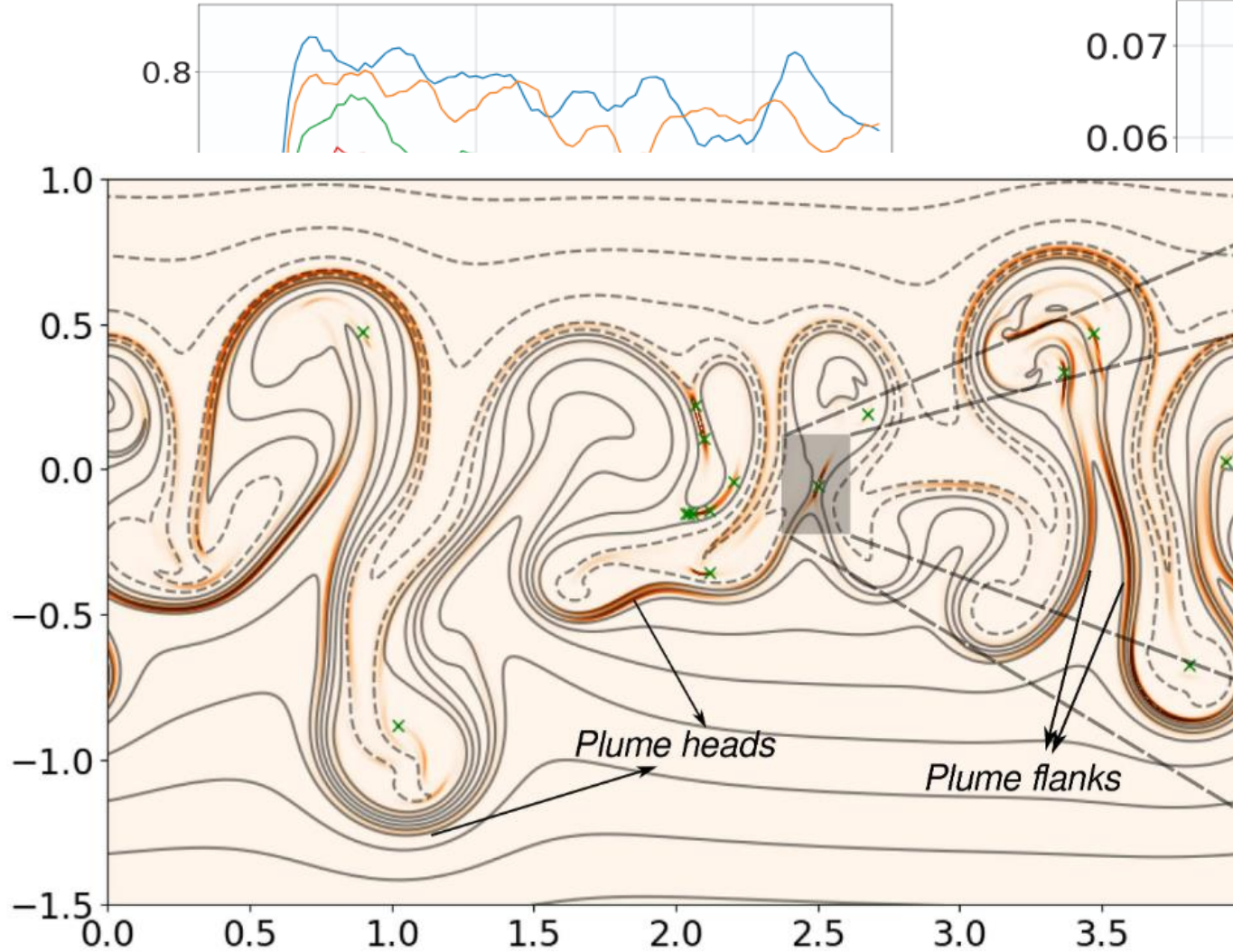
GLOBAL ENERGY FLOW



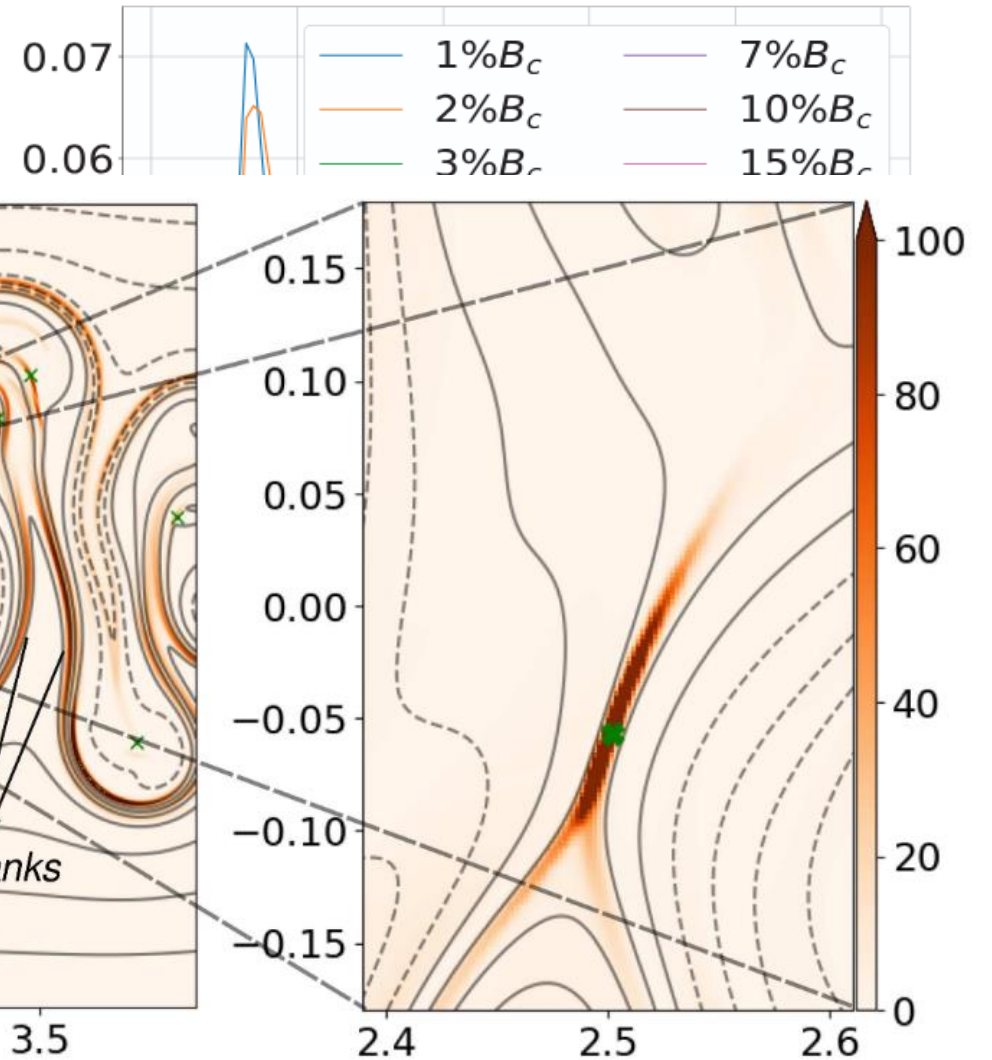
- Most of released GPE is used to bend magnetic field lines (TME).
- Almost half of this TME is converted (back) to TKE due to reconnection.

CUMMULATIVE EFFECT OF RECONNECTION ON ENERGY DYNAMICS

TME to TKE



TME Dissipation



CONCLUSION

- Goal is to understand the cumulative influence of reconnection on large-scale dynamics.
 - **Reconnection detection algorithm was developed.**
 - Number of reconnection points increase with time (proportional to magnetic Reynolds number).
 - Reconnection contributes **significantly to energy transfer** from TME to TKE **in weak field** case. This reduces with increasing field strength.
 - **Reconnection contributes marginally to TME dissipation in MRTI.**
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THANK YOU

LET'S DISCUSS YOUR QUERIES AND COMMENTS



Paper?



SCAN ME

Feel free to reach out: kalluri@ipgp.fr
