Global 3D MHD Simulations of Dynamo Effects

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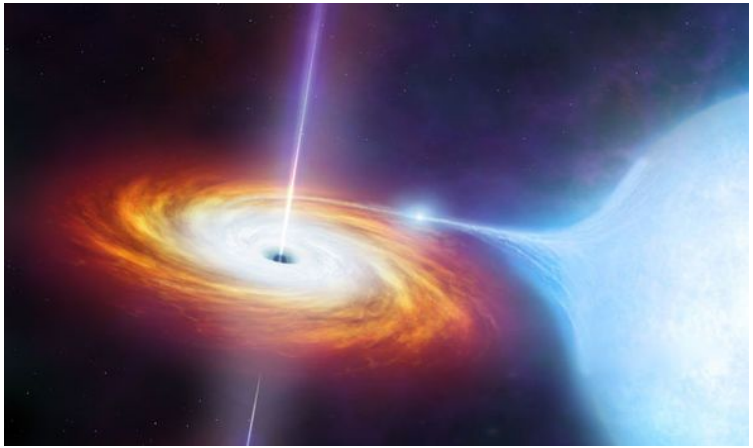
Black Hole Binary State Transitions

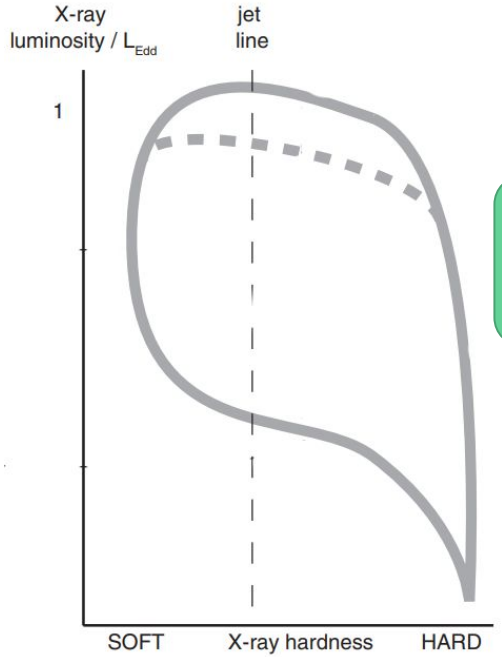
- First discovered: Cygnus X-1
- Usually: X-ray burst, then fade, can observe companion
- Now have > 20 systems[1]



[1]Remillard & McClintock 2006

Transition Hysteresis

Thermal (high/soft) state: Thin disk

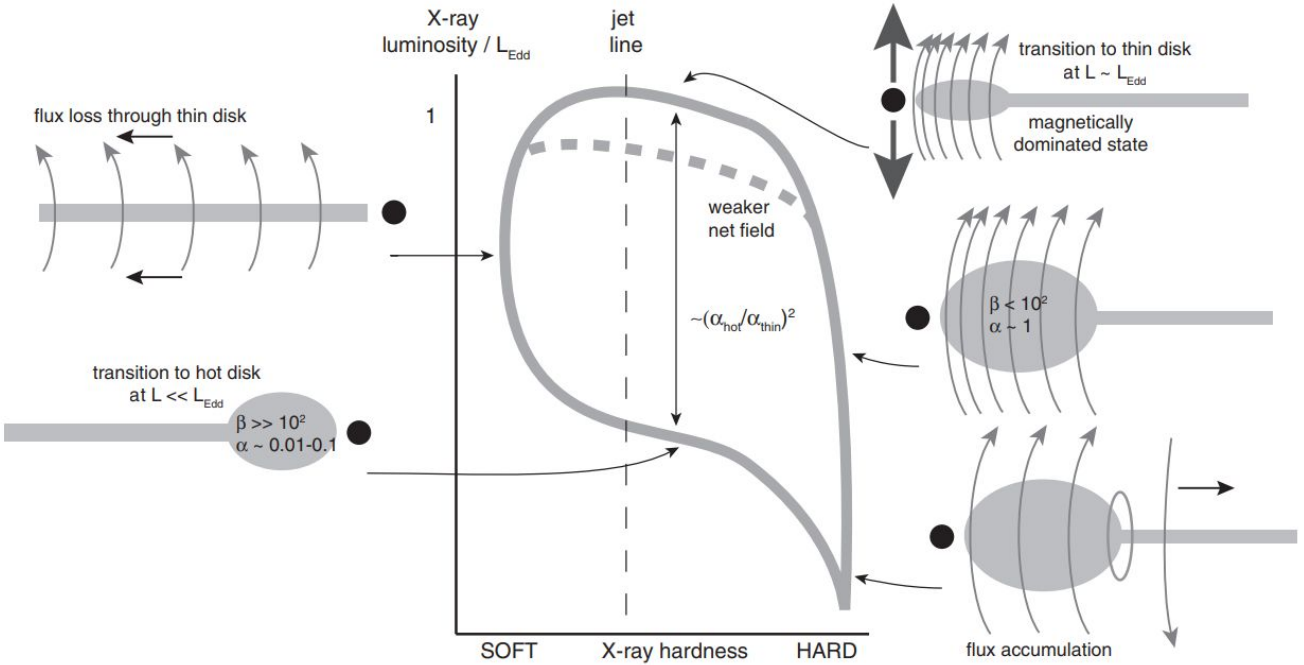


Hard state: Jets, Γ=1.4-2.1

Quiescent state: Dim ($L \approx 10^{30.5}$ erg/s), Γ=1.5-2.1, Thick disk

Model for Hysteresis Mechanism

- Flux accumulates
- Thick-to-thin disk transition
- Flux diffuses out of thin disk
- Thick disk reforms, flux loop develops, footpoints advect/diffuse



Begelman & Armitage 2014, Fig. 1

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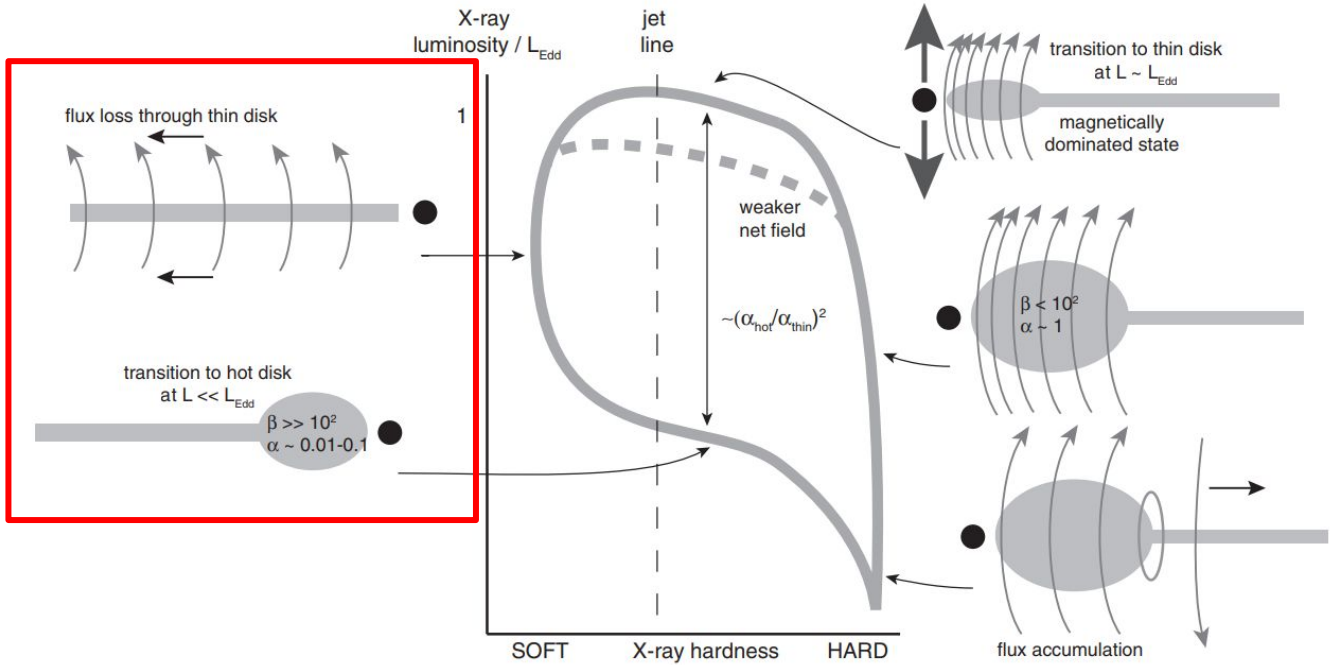

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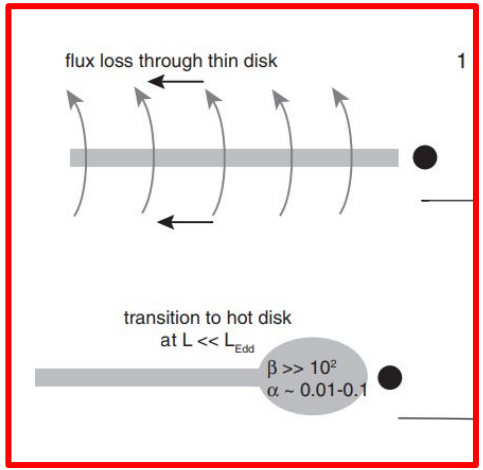
Driving Questions

How does the magnetic field in thin disks behave?



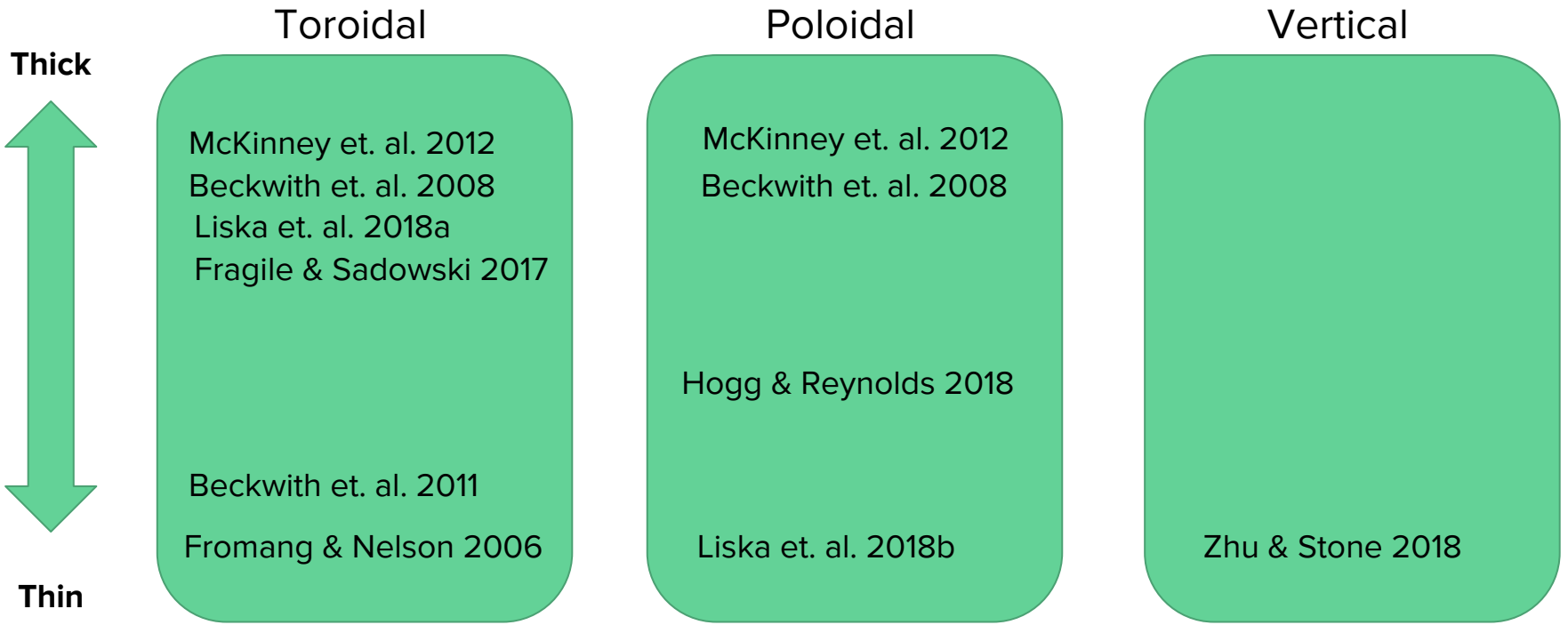
Diffusion/advection

-Conditions
-Lubow, Papaloizou, Pringle 1994
-Guilet & Ogilvie 2012, 2013
-Liska et. al. 2018b

Regeneration

-Dynamo mechanisms
-Global or local?
-Saturation level?
-Generic?
-Lead to transition to thick disk?

Status of the Large-Scale Dynamo



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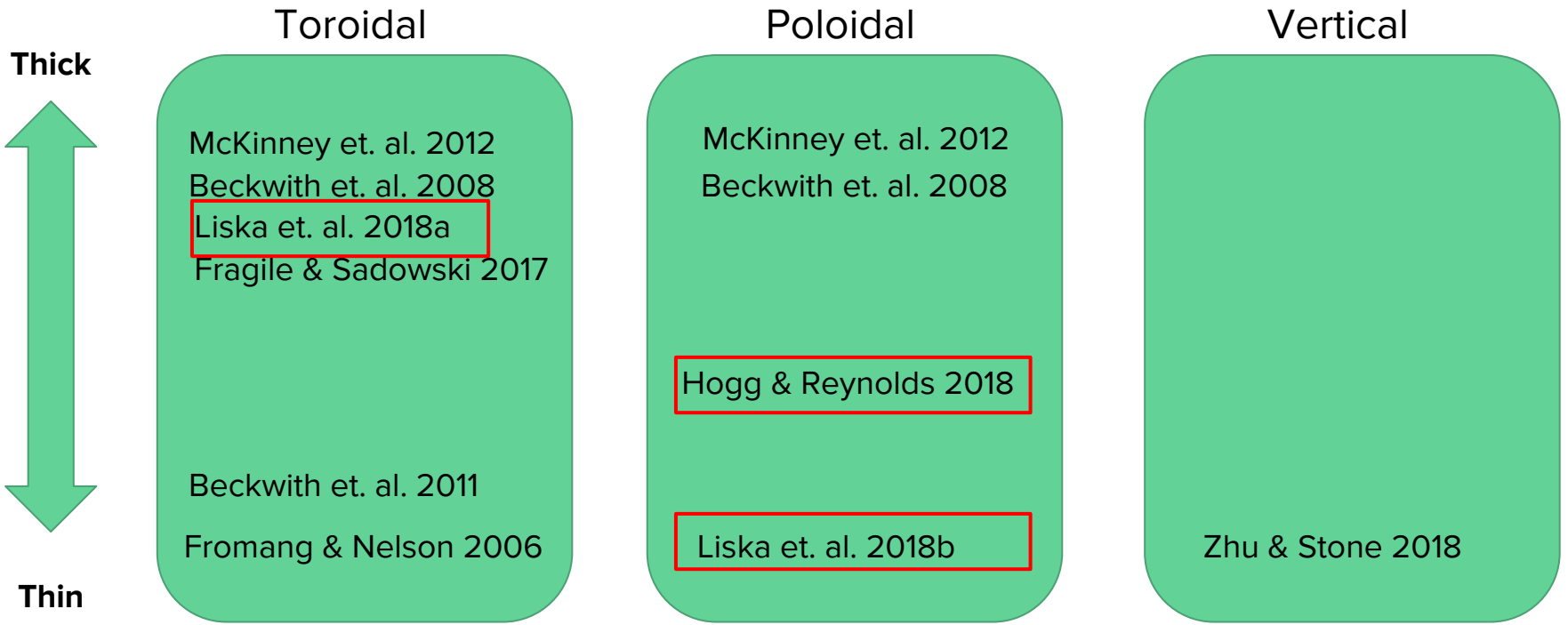

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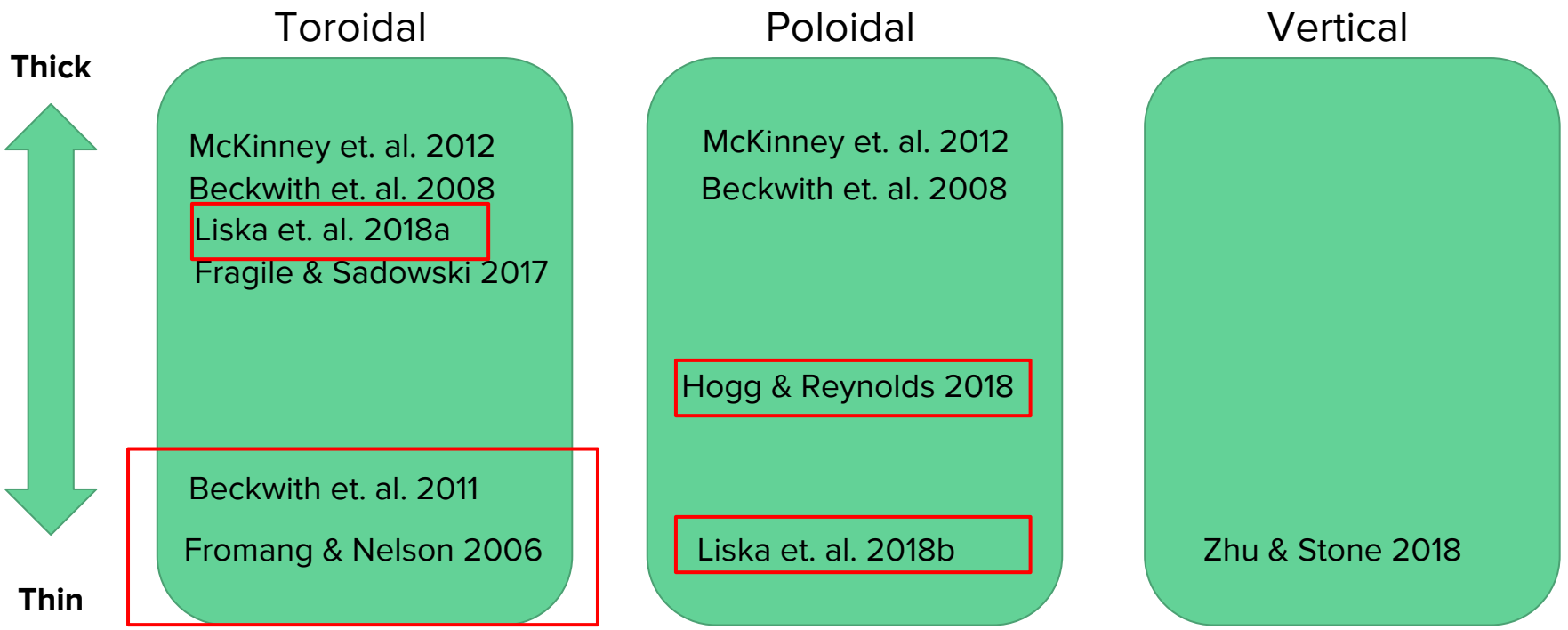
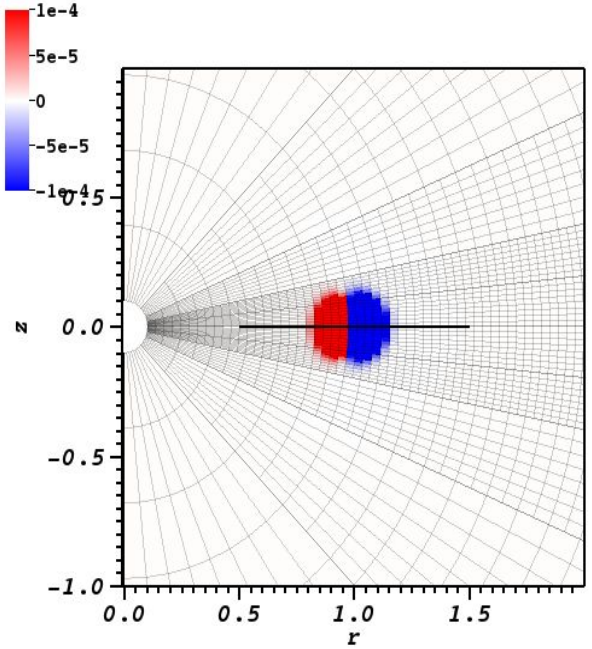
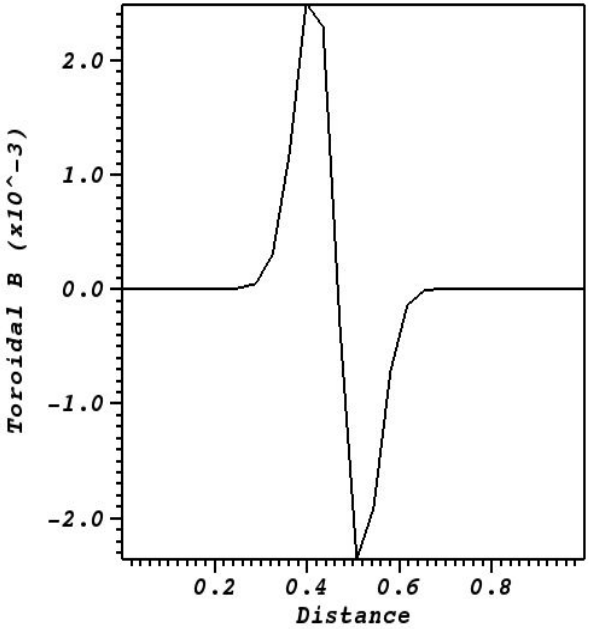


Set-up

- Global, ideal MHD, pseudo-Newtonian potential
- H/R = 0.05, hydrostatic equilibrium
- Two toroidal flux tubes: zero net flux, $<\beta_{min}>=10^3$





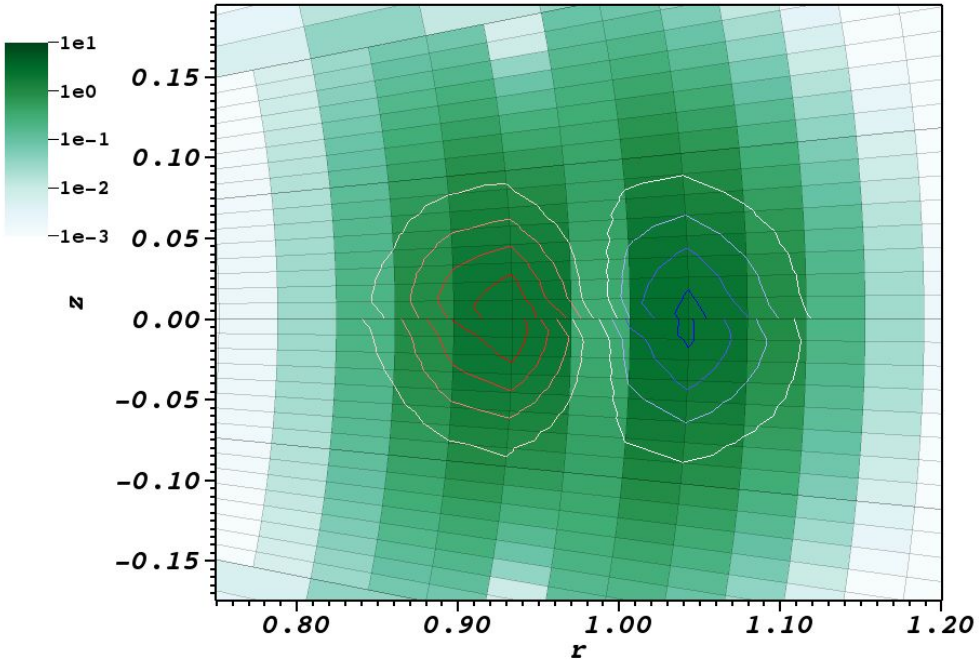
Next Steps

- Ensure the MRI is resolved: both toroidal and poloidal! Necessary condition:

$$Q_\theta, Q_\phi \gtrsim 10$$

May push to stronger magnetic fields

- Run, run at different resolutions, analyze



Summary

- Under what conditions is poloidal flux generated from toroidal flux?
- Is the dynamo process global or local? Compare to local simulations

Questions?