Time dependent magnetically controlled accretion in YSOs

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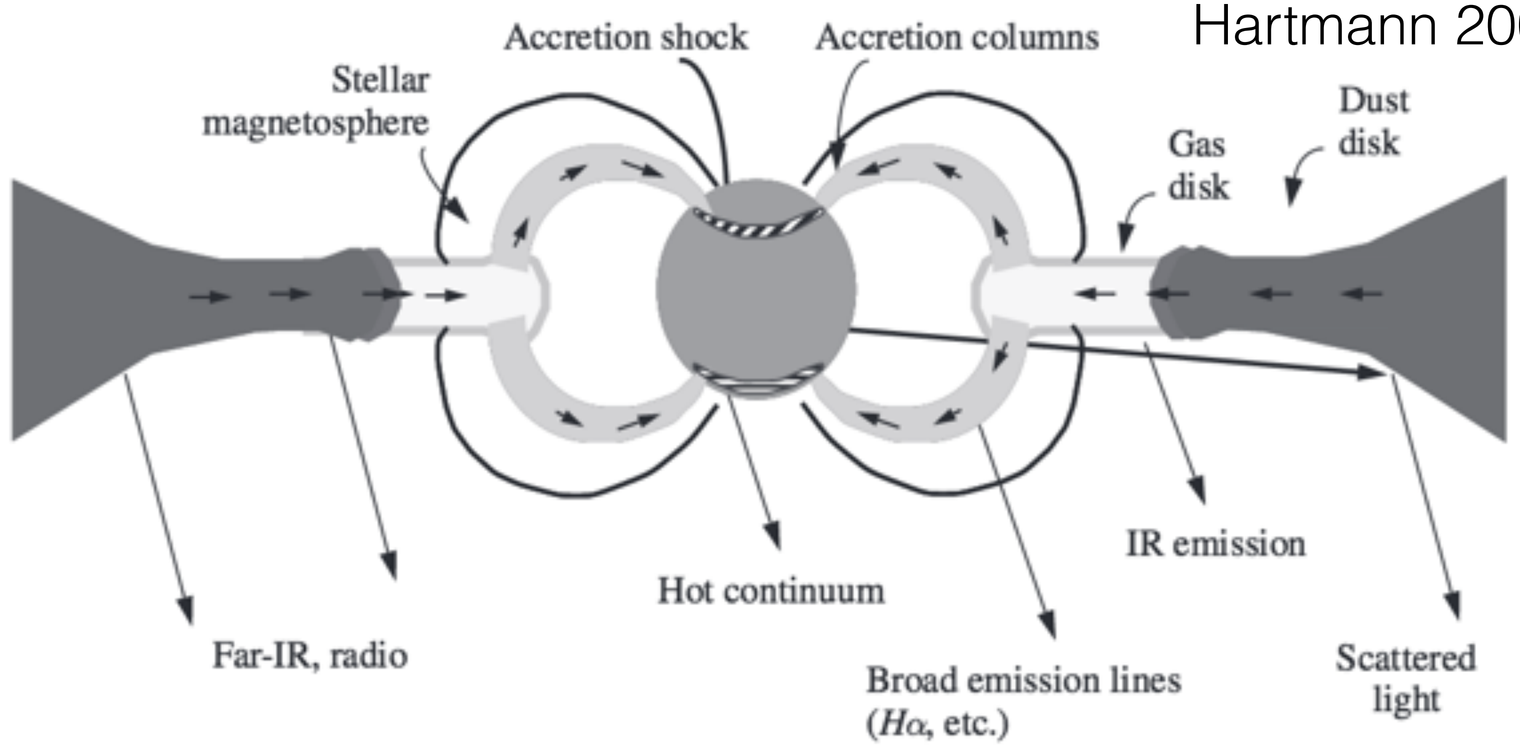
Motivation

Hartmann 2008

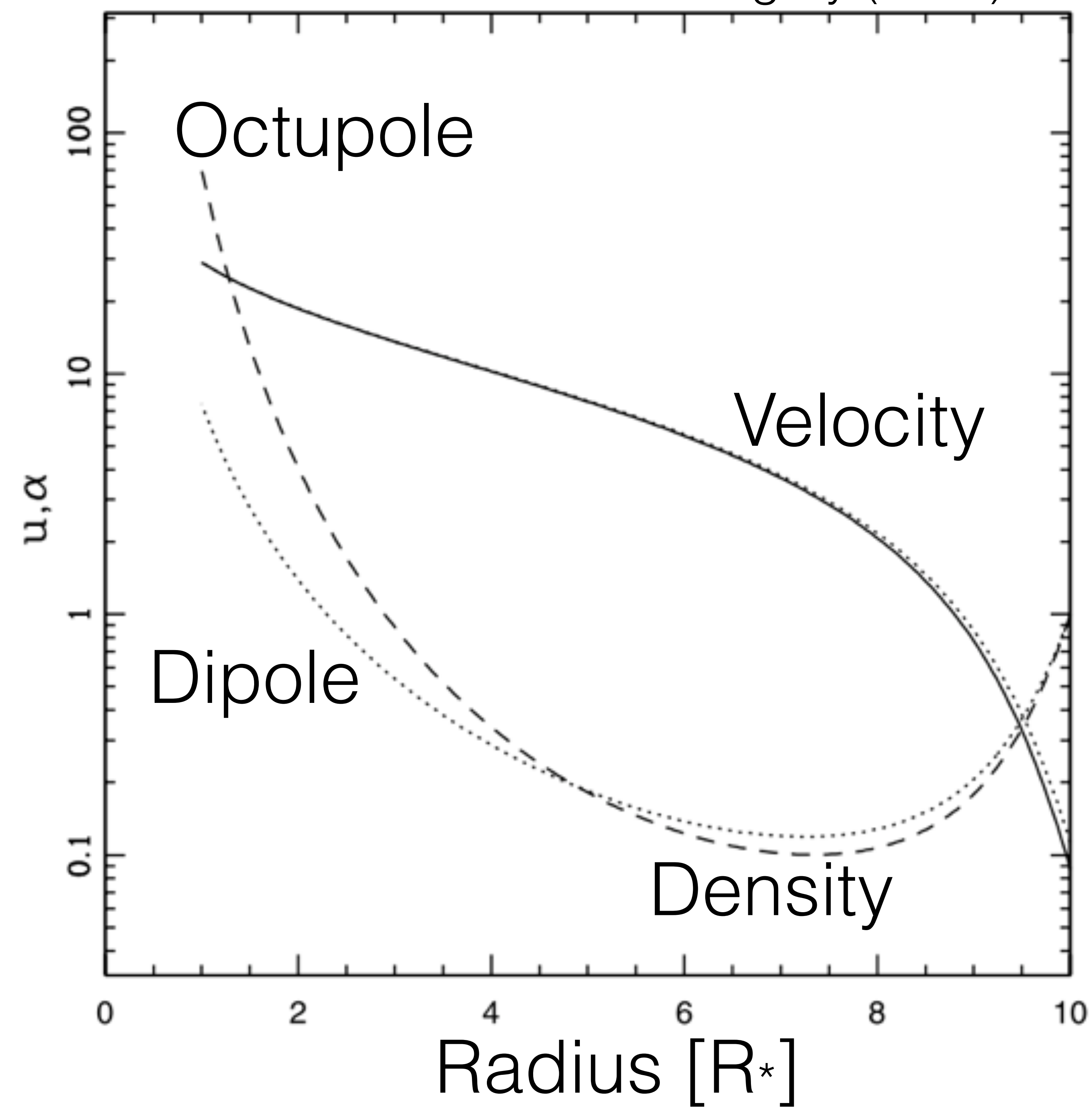


- Observations of YSOs indicate that they have strong magnetic fields.
- Accreting material is funneled onto the star in columns, where the magnetic topology controls there shape.

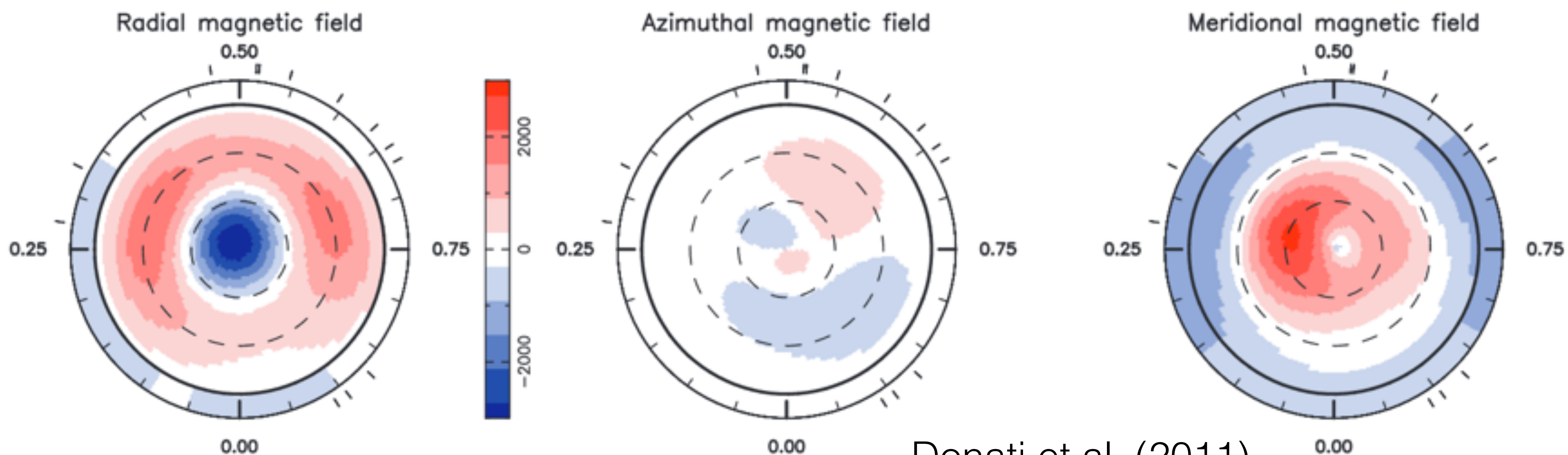
Topology Matters

- Simple steady-state solutions can give flow profile
- Higher order field components, give rise to smaller accretion funnels near star.
- Higher divergence near star gives higher density.
- Different topologies might give rise to different observational signatures for same accretion rate.

Adams & Gregory (2012)



Field Topology

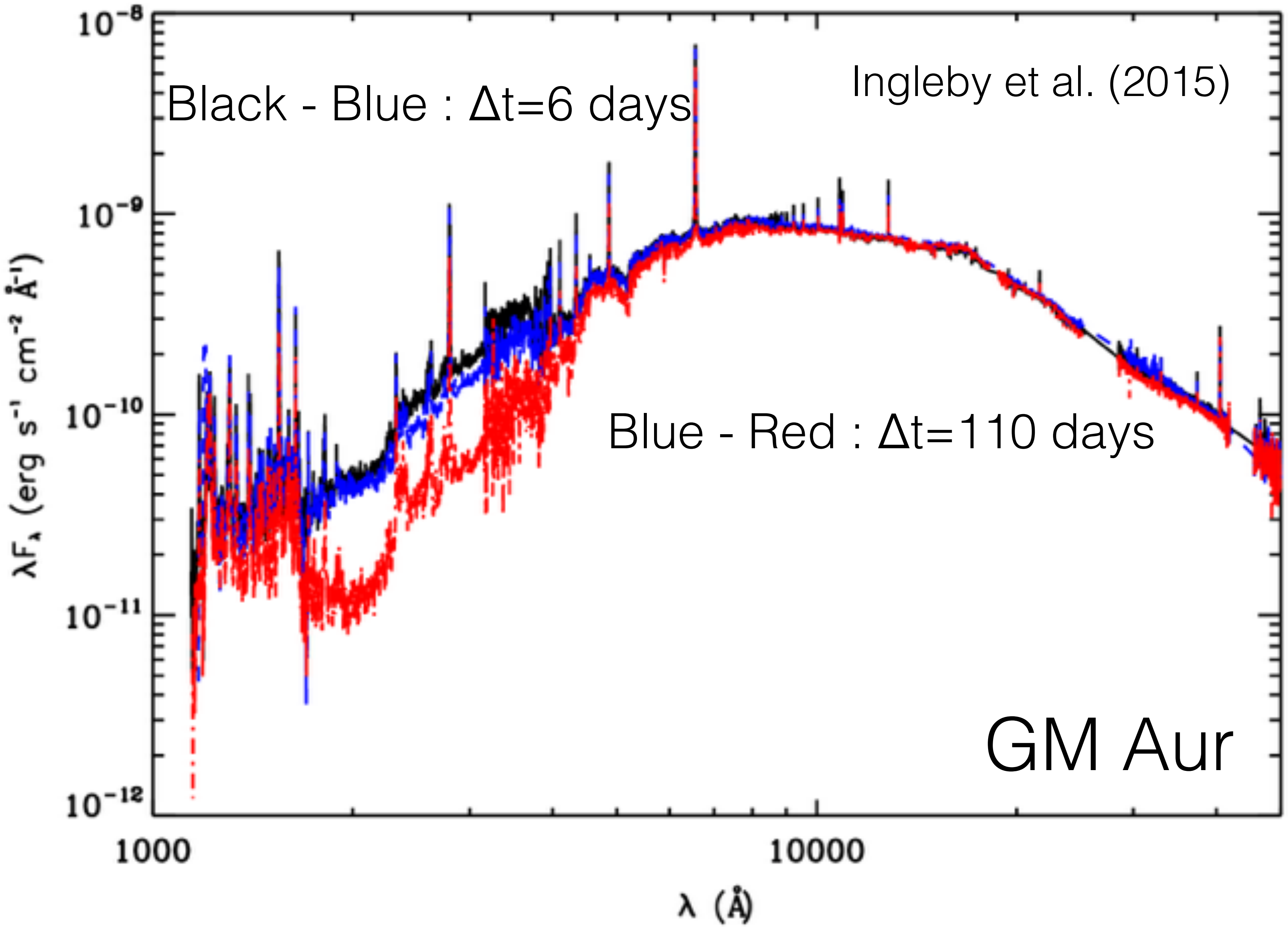


TW Hya

Donati et al. (2011)

- Observations of field structure of young stars shows evidence for strong octuple component in some cases (e.g. Donati et al. 2008, Donati et al. 2011).

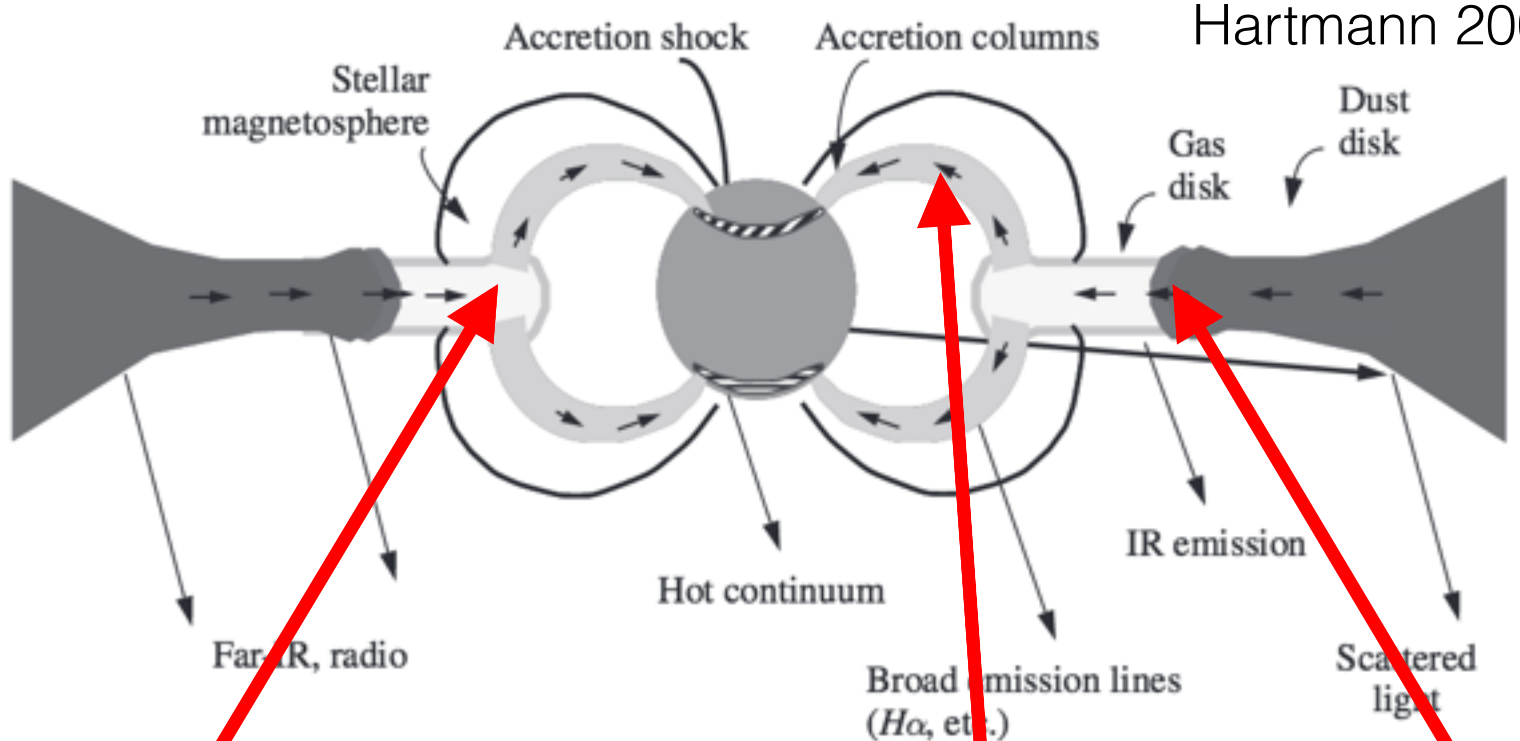
Observations of Variability



- Multiple observations of same objects show evidence for variable accretion with factor of > 2 variability.

Timescales: sources of fast variability

Hartmann 2008



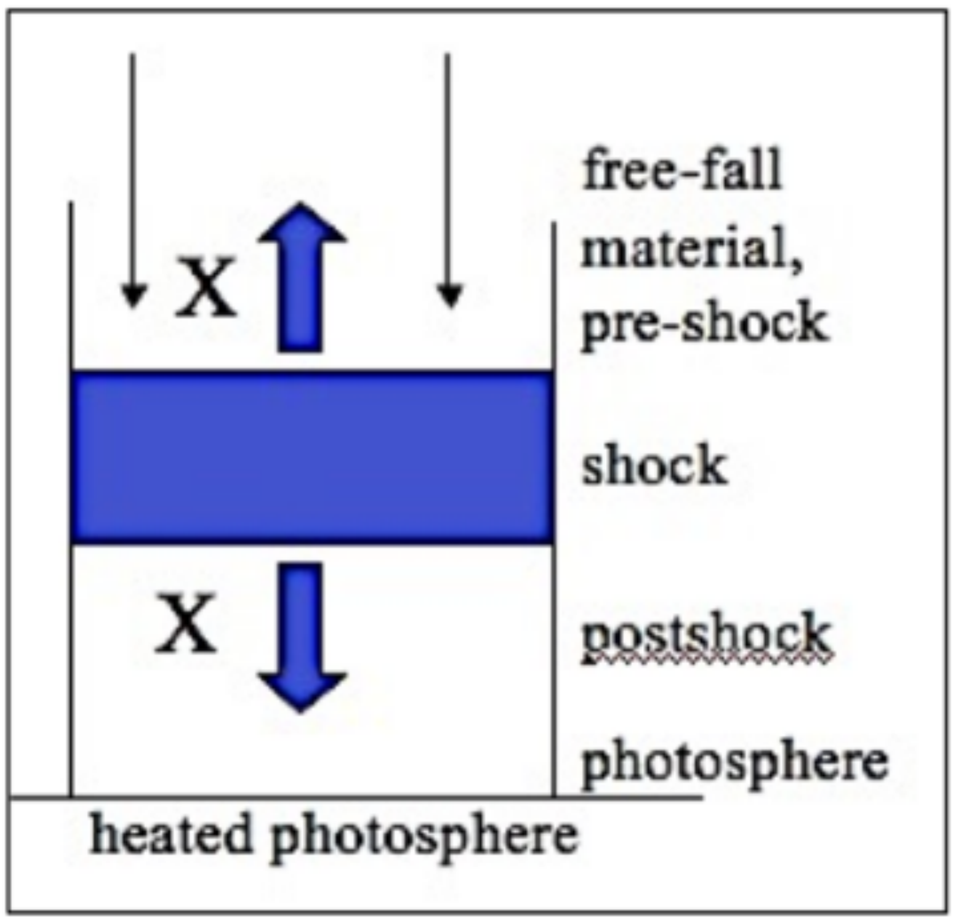
Orbital time ~5 days

Flow crossing time of accretion column ~ 1 days

viscous time in inner disc ~ year

Modelling Solutions

Shock Modelling



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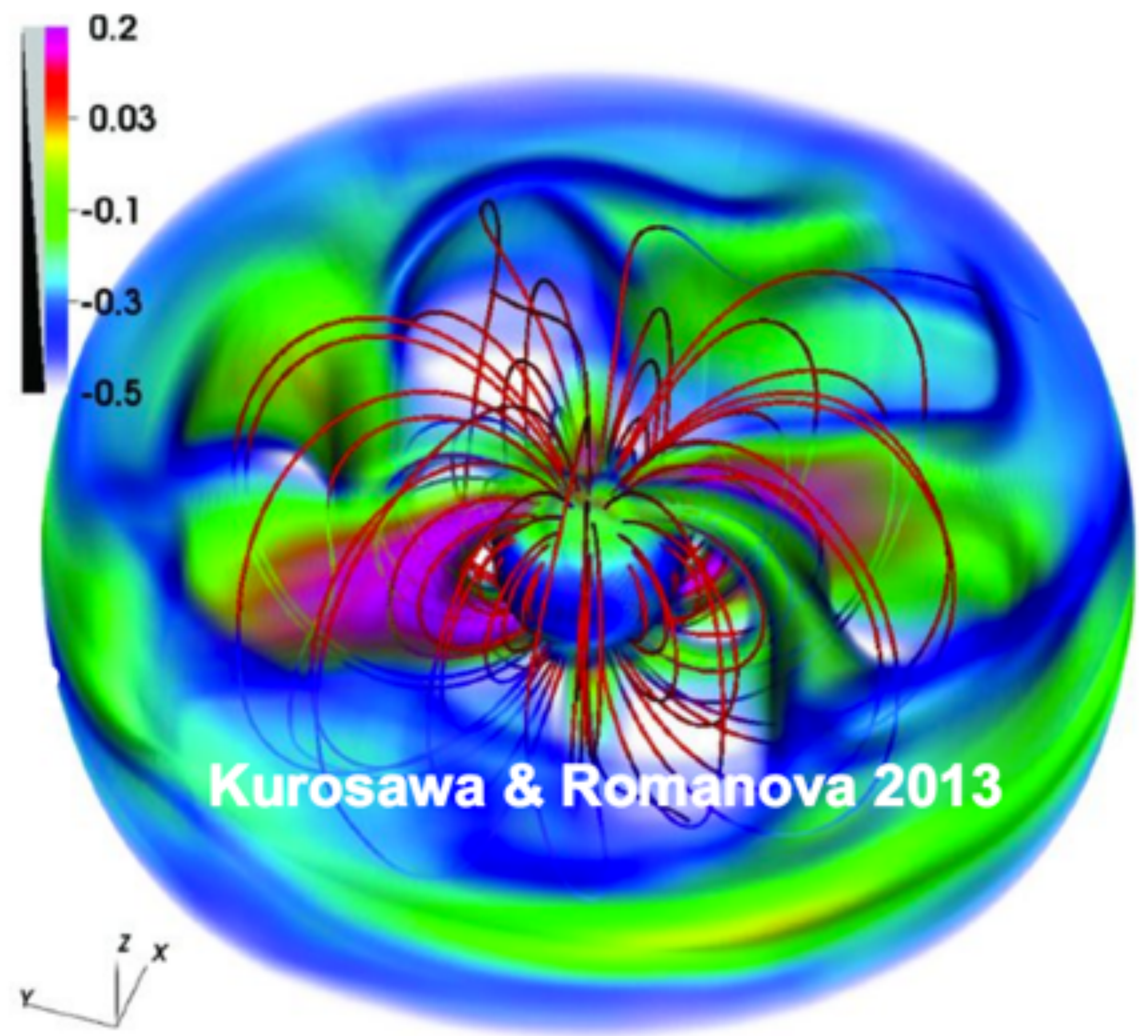
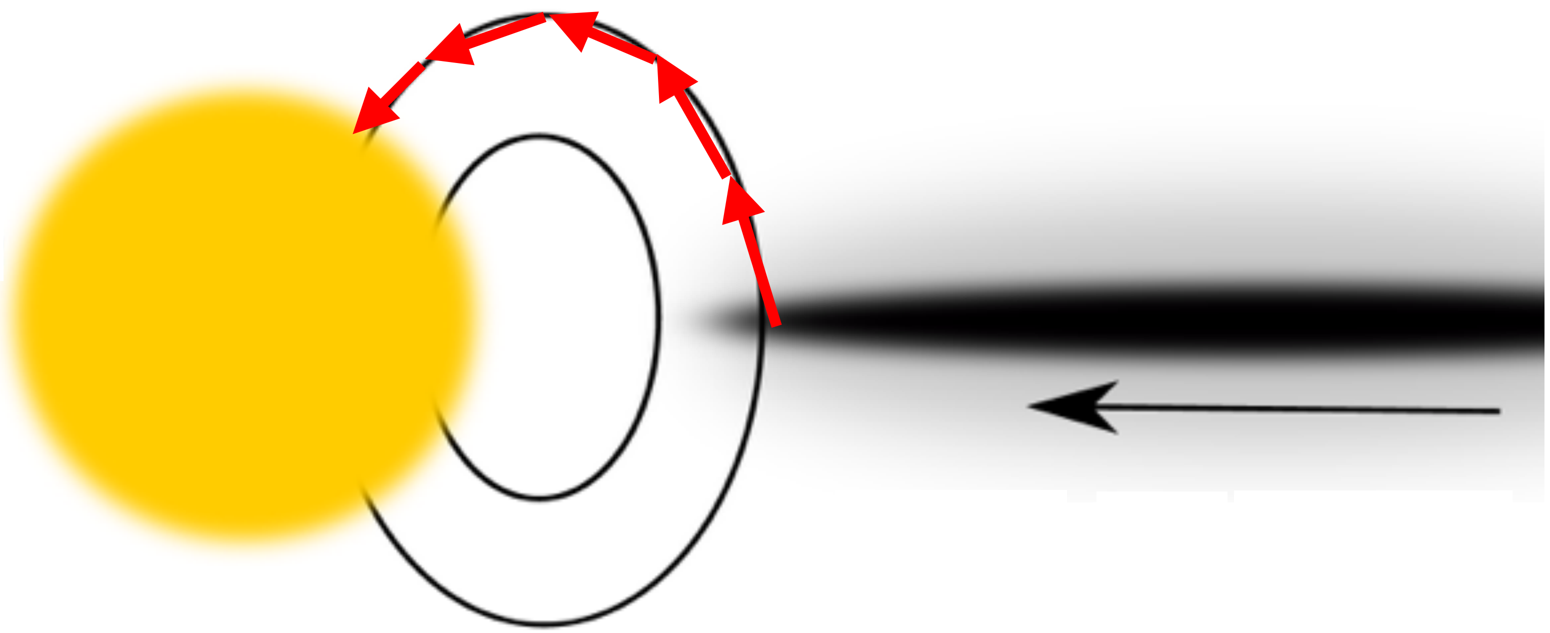
MHD Simulations

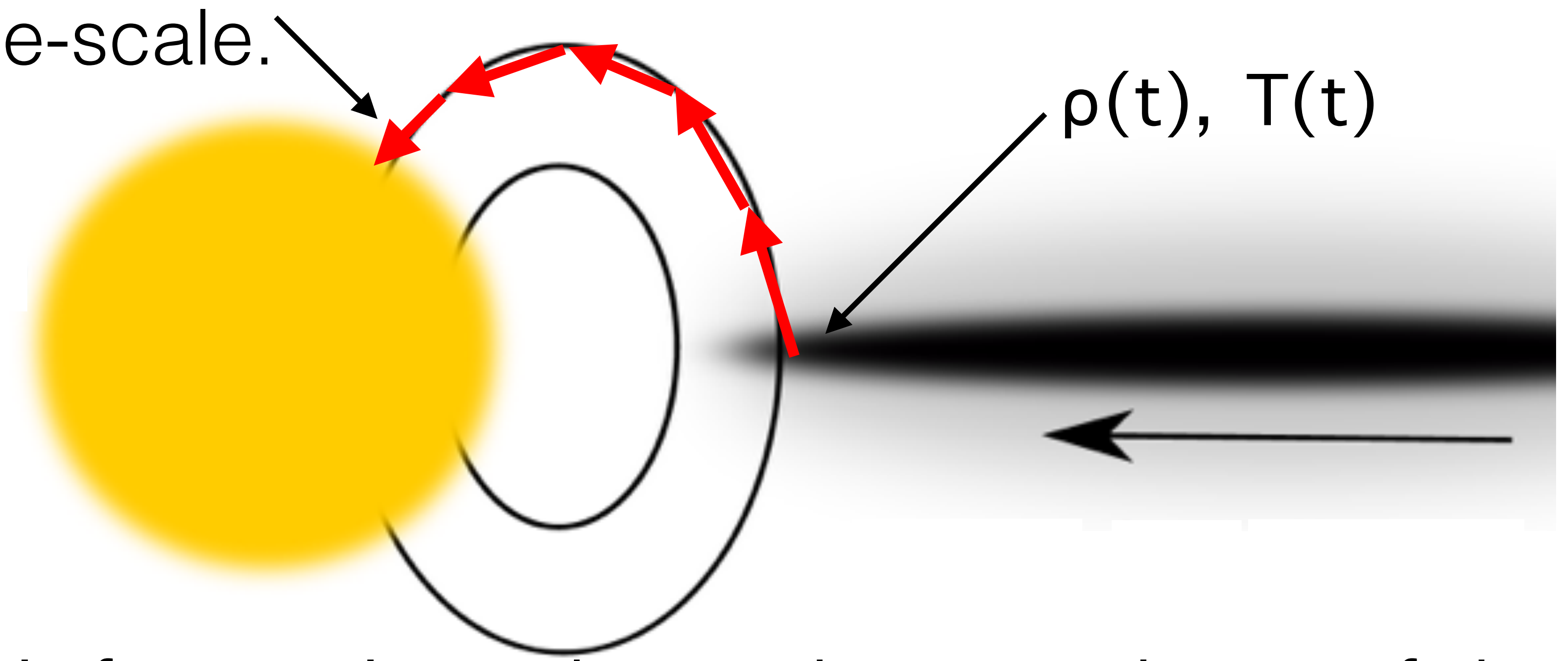


Time dependent flow models that follow the field lines



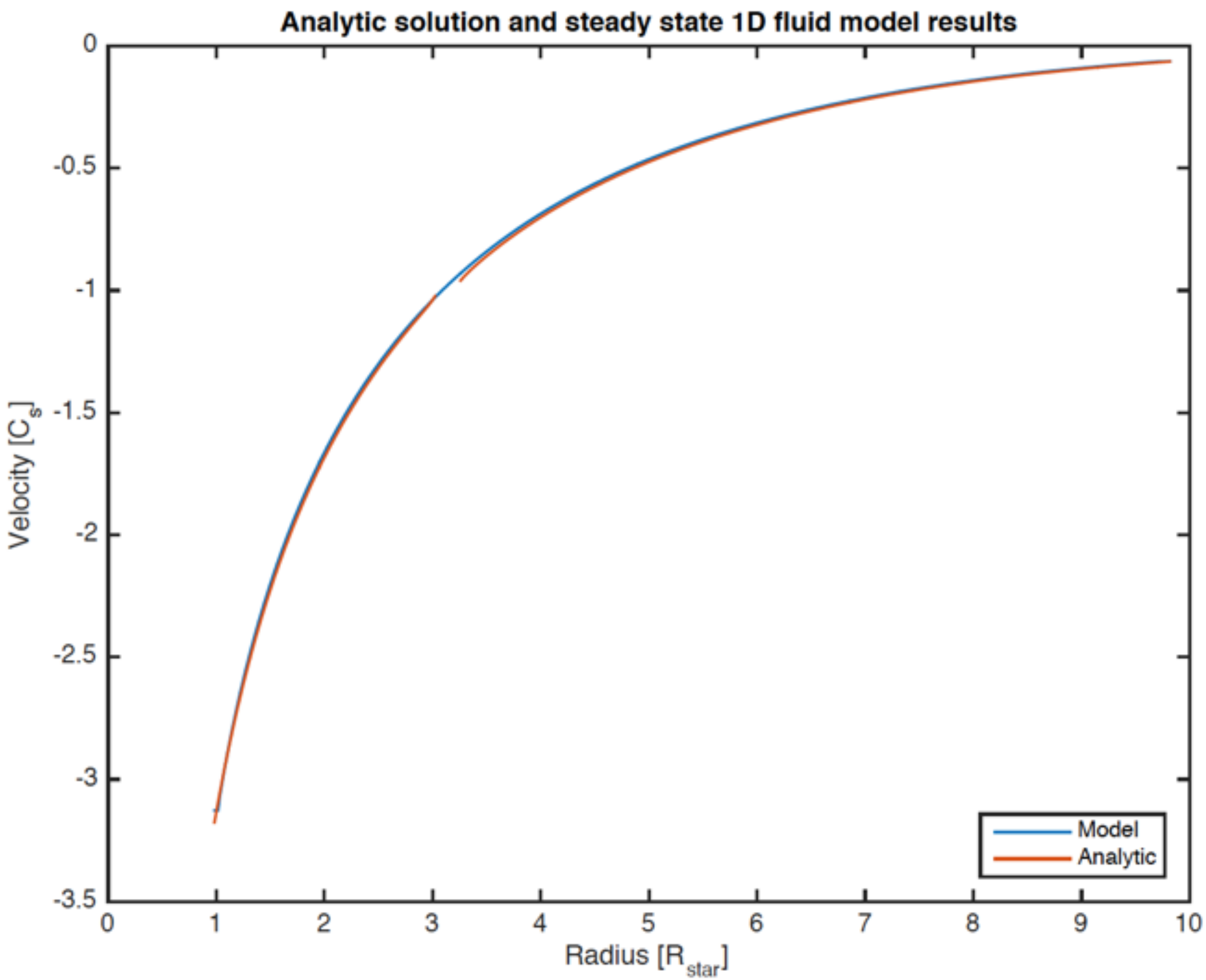
- Work in the strong field limit (the flow doesn't change the field topology).
- Pick a field line that connects disc and star and solve time-dependent problem along field line, with rotation, using a ZEUS like scheme, with full tensor artificial viscosity.
- Steady-state solutions found by Koldoba et al. (2002) - dipole. Adams & Gregory (2012) - generic field.

Time dependent flow models that follow the field lines

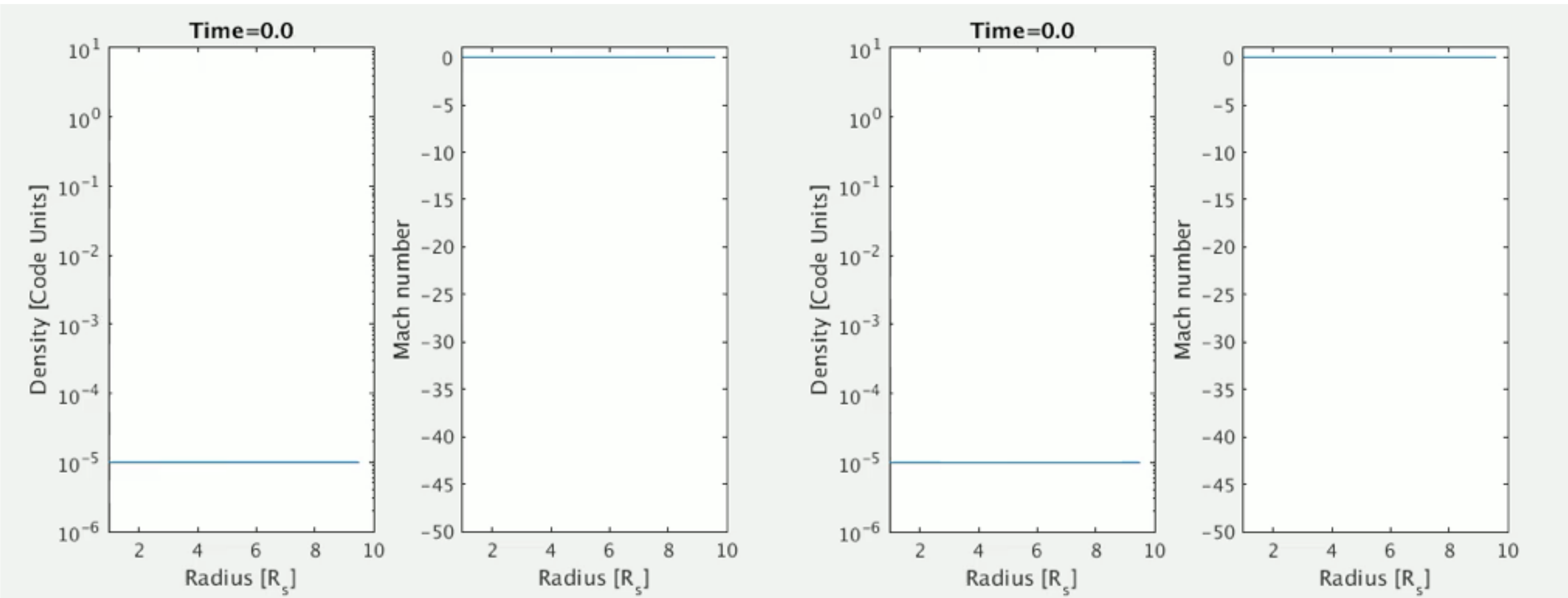


- Encode information about the topology of the field lines in the geometric scale factors (c.f. Adams 2011, Adams & Gregory 2012, Owen & Adams submm.)
- Use polytropic equation of State $P=K\rho^{(1+1/n)}$

Isothermal Dipole Test



Octupole versus Dipole

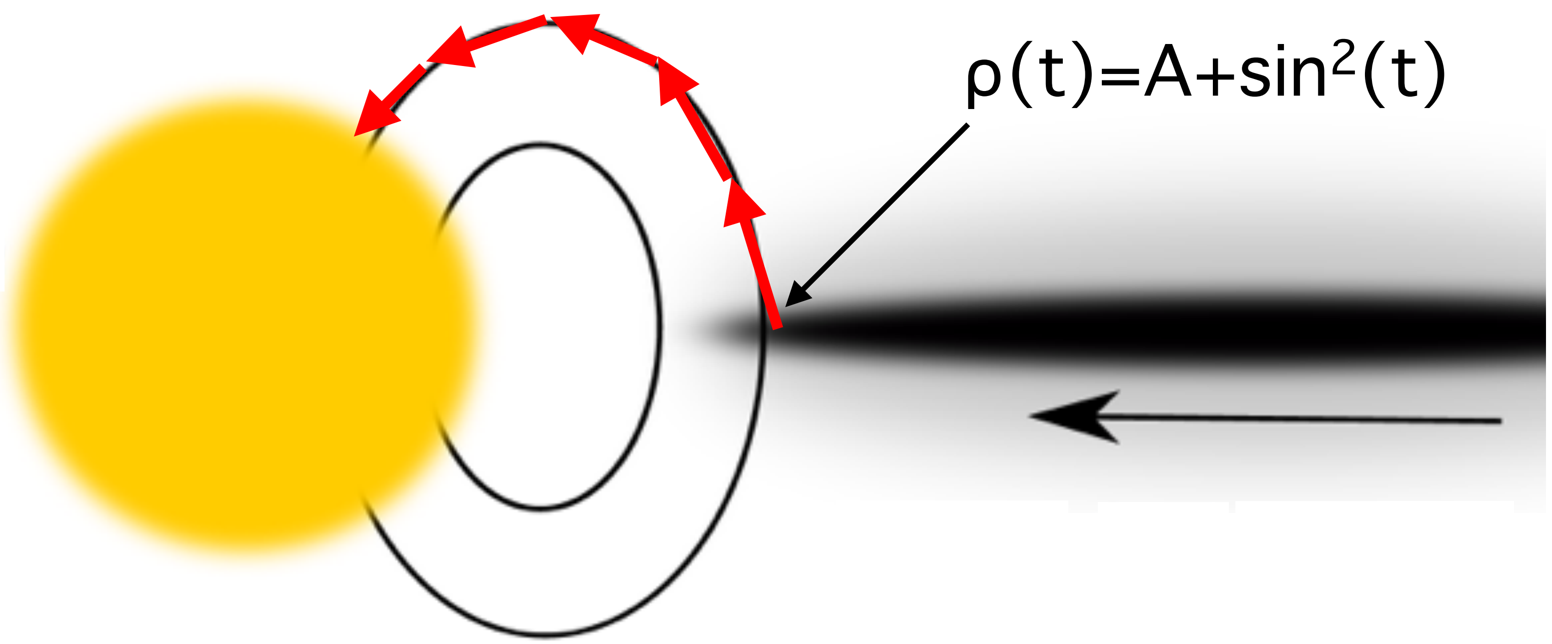


Octuple Ratio=5

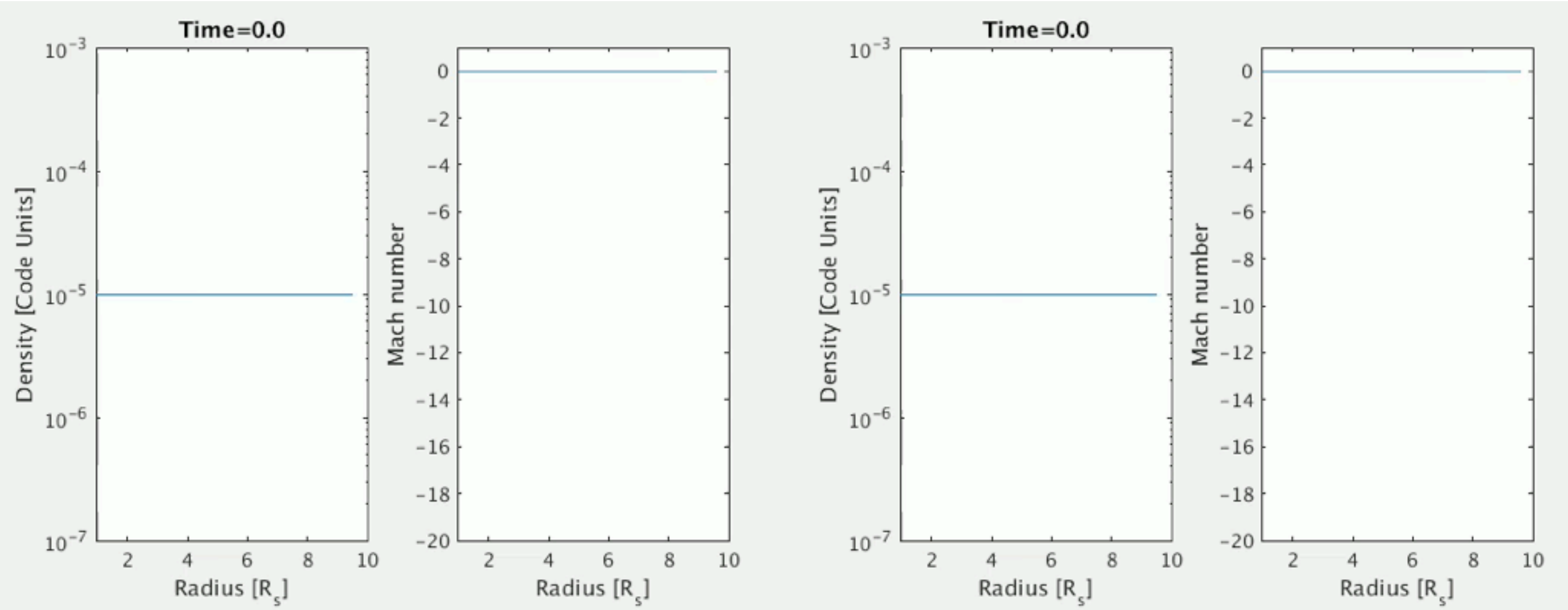
Dipole

Robinson et al. (in prep)

Driven Variability



Driven Variability (2)

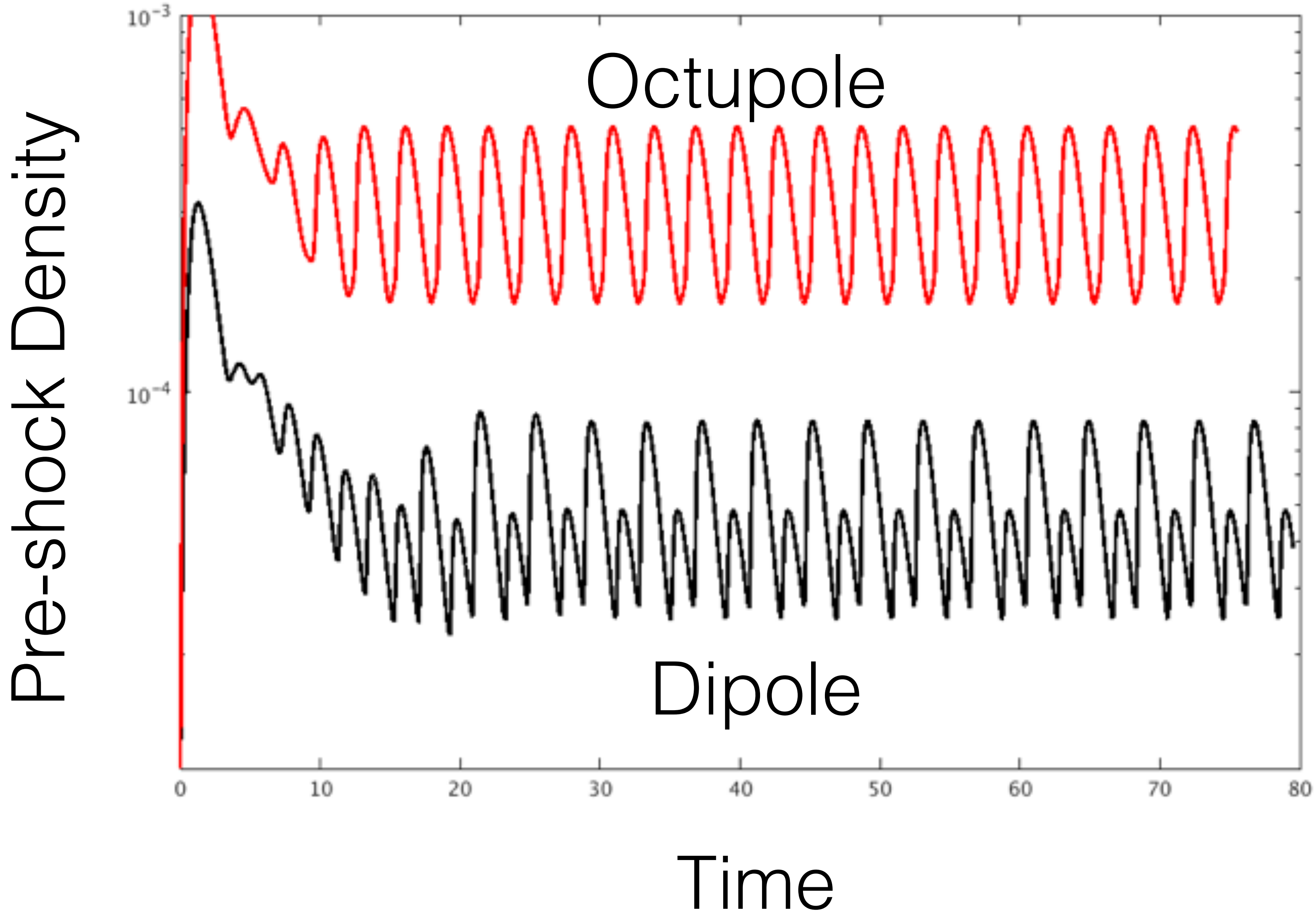


Octuple Ratio=5 Dipole

Robinson et al. (in prep)

Driven Variability (3)

Flow Sinusoidally driven at disc with amplitude of 2



Robinson et al. (in prep)

Conclusions

- Accretion is observed to be time-dependent and magnetically controlled.
- We can use simple time-dependent models to study the flow along the accretion funnel. Results depend on field geometry and thermodynamics. A new tool to study variable accretion.
- Plan to use this tool to study and characterise variability across parameter space. Then compare to observations.
- Getting new accretion rate data on a variety of cadences using the Discovery Channel Telescope.