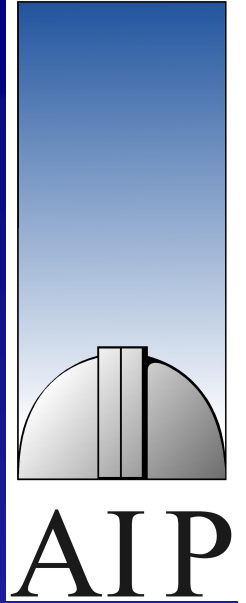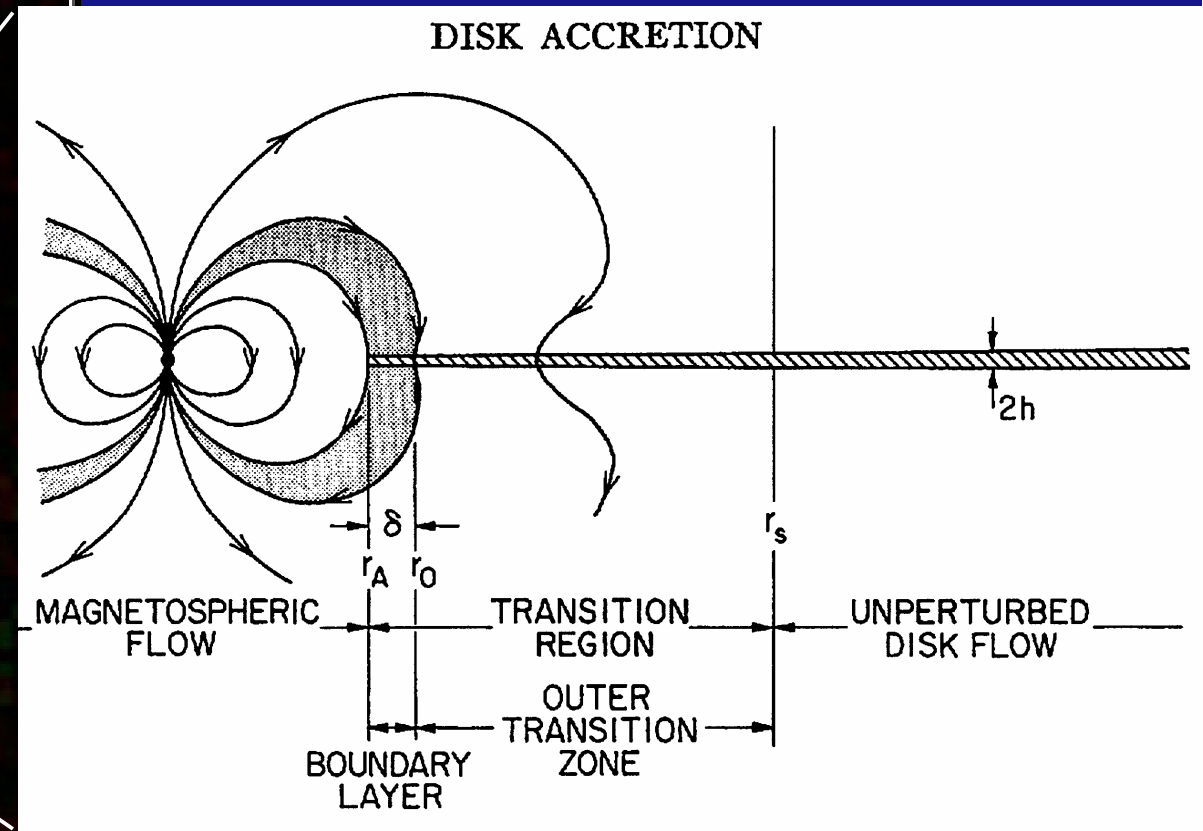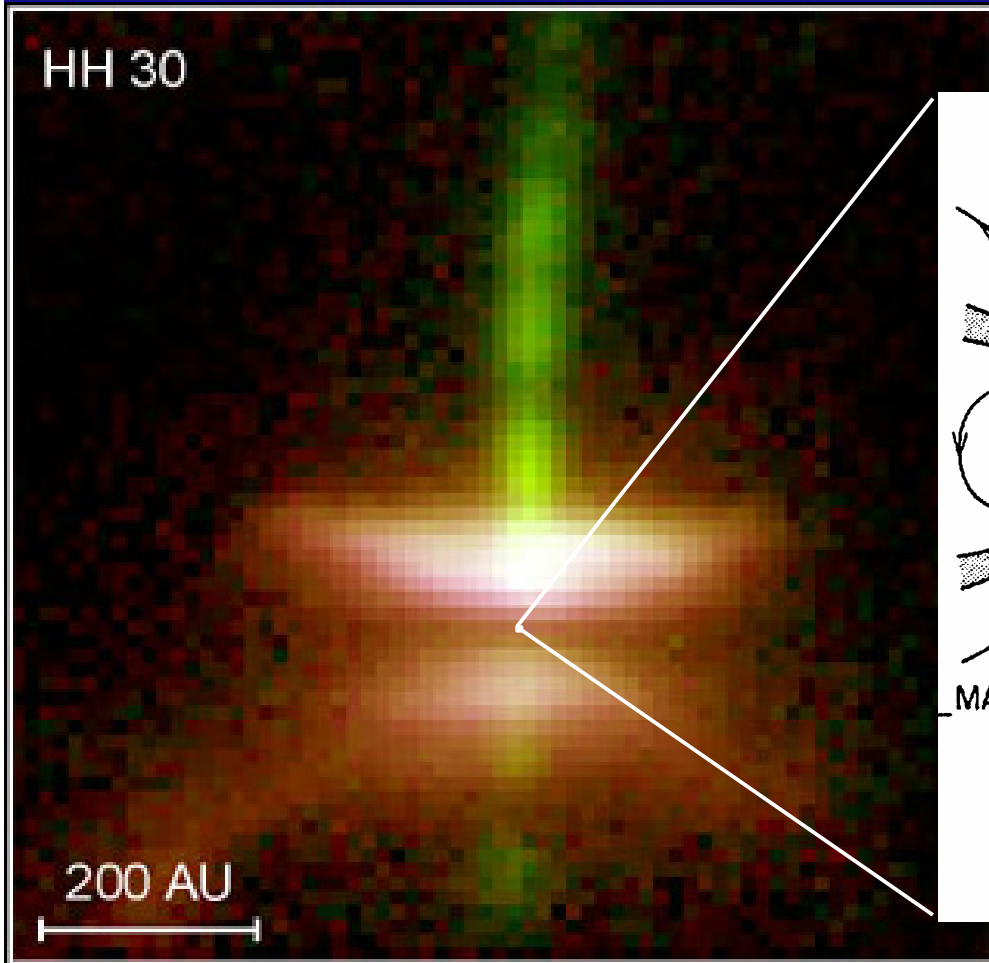# Funnel Flows from Protoplanetary Discs

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Star-Disk Interaction

HH 30

200 AU

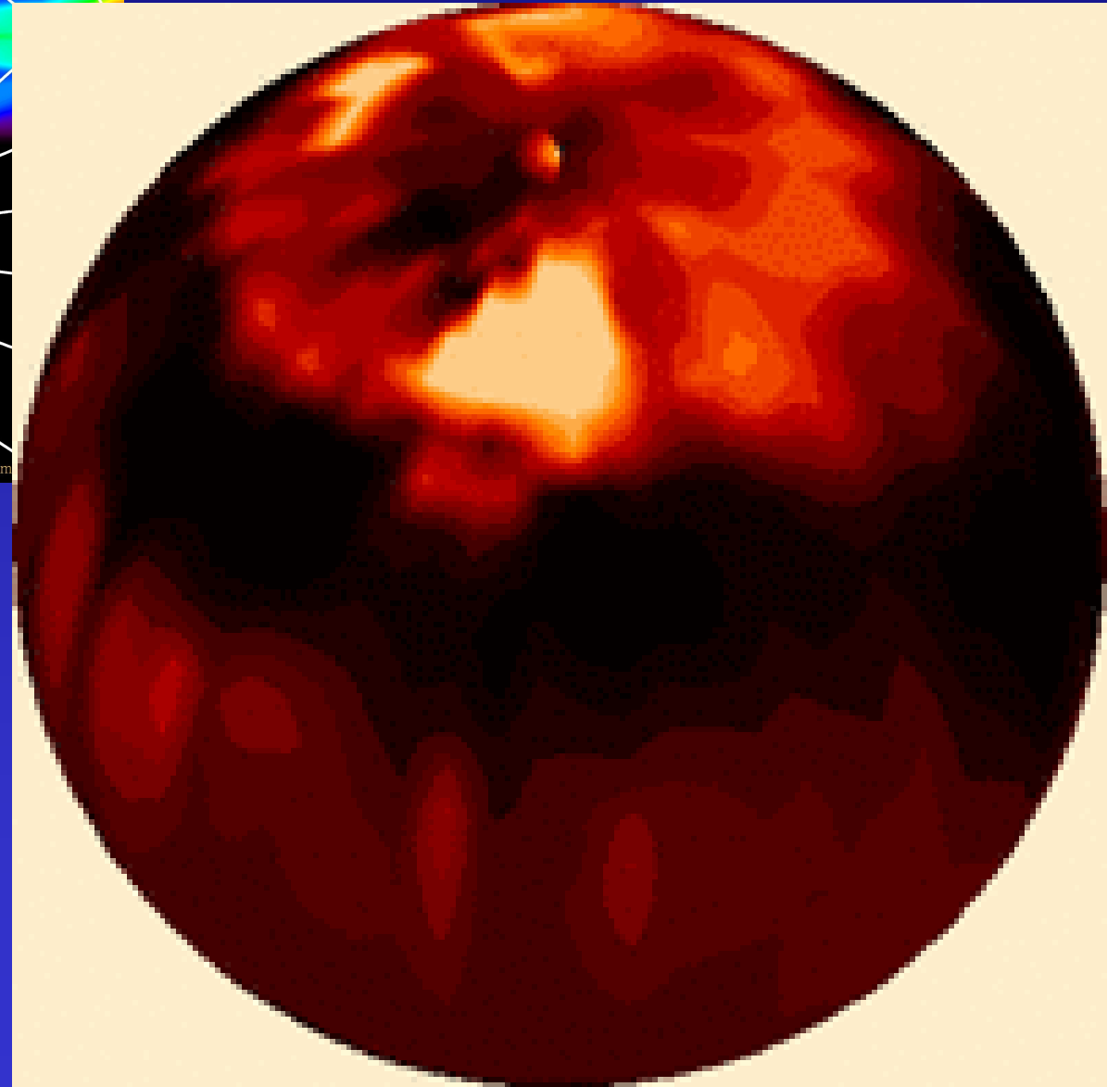Picture: Ch. Burrows (STScI)

DISK ACCRETION

2h

δ

r_A r_0

r_s

MAGNETOSPHERIC
FLOW

TRANSITION
REGION

UNPERTURBED
DISK FLOW

OUTER
TRANSITION
ZONE

BOUNDARY
LAYER

Ghosh & Lamb 1979

MN Lupi

MN Lupi

log(density)
-14.0   -13.0   -12.0   -11.0   -10.0   -9.0

K. Strassm

Strassmeier et al. 2005

Disk Evolution: Equations

Mass conservation:
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho u) = 0$$

Momentum conservation:
$$\rho \left[\frac{\partial u}{\partial t} + (u \cdot \nabla) u \right] = -\nabla p + f + \nabla \cdot V$$

Temperature:
$$c_V \rho \left[\frac{\partial T}{\partial t} + (u \cdot \nabla) T \right] = -p \nabla \cdot u + \Phi_{visc} + \Phi_{mag}$$

Magnetic field:
$$\frac{\partial B}{\partial t} = \nabla \times \left[u \times B - \eta_t \nabla \times B \right]$$
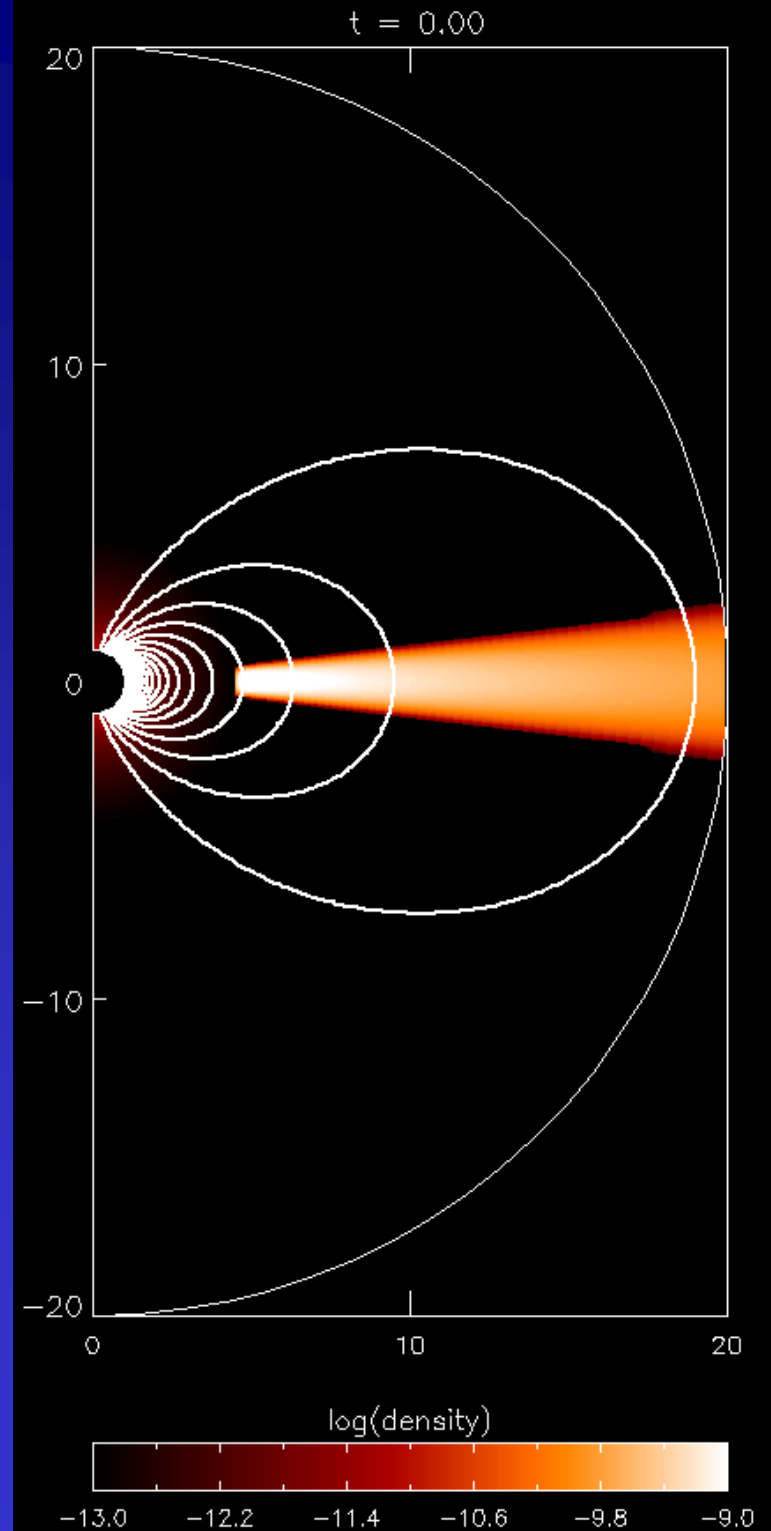
Forces:
$$f = \rho \nabla \frac{GM}{r} + \frac{1}{4\pi} \nabla \times B \times B$$

Dissipation:
$$\Phi_{visc} = (V \cdot \nabla) u \qquad \Phi_{mag} = 4\pi \eta_t j^2$$

Model setup I

- T Tauri star + accretion disc + magnetic field

- Star:

  - Mass: $M = M_{Sun}$

  - Radius: $R = 3R_{Sun}$

  - Rotation period: $P = 0.1P_K$

  - Corotation radius: $R_\Omega = 4.6R_{Star}$

  - Magnetic field: axisymmetric dipole

$$B_0 = 5kG$$
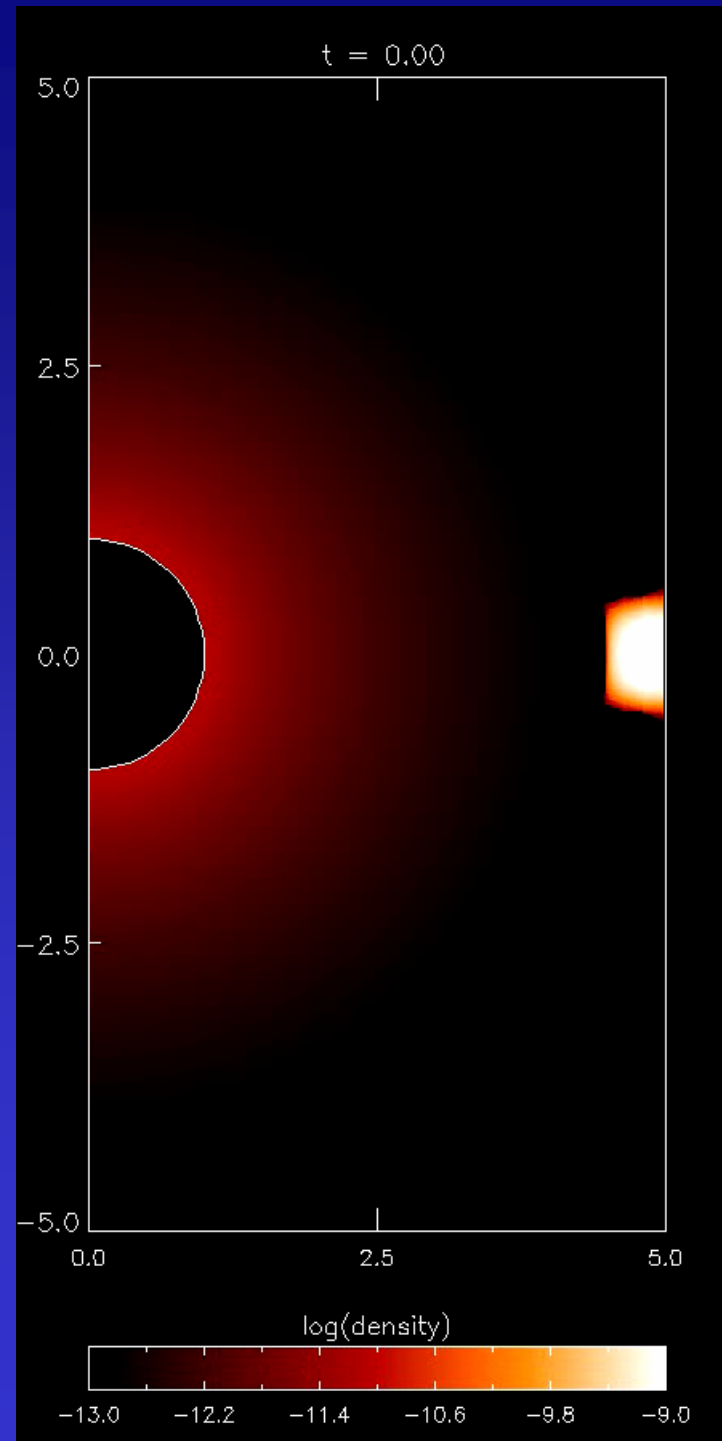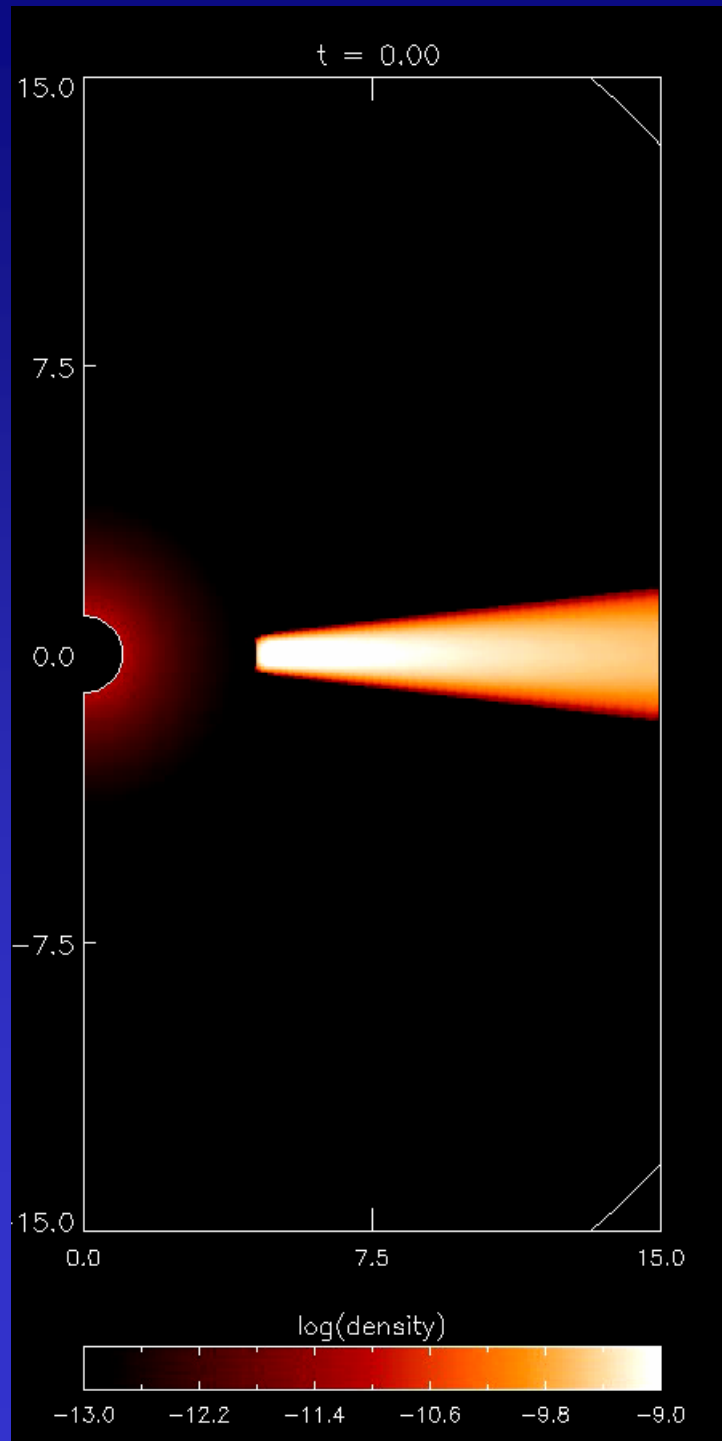
Model setup II

- Disc:

  - Mass accretion rate: $\dot{M} = 10^{-8} M_{Sun} / yr$

  - Turbulence viscosity: $\alpha_{SS} = 0.01$

  - Magnetic diffusion: $Pm = 1$

  - No dynamo

  - No primordial field

  - EOS: ideal gas

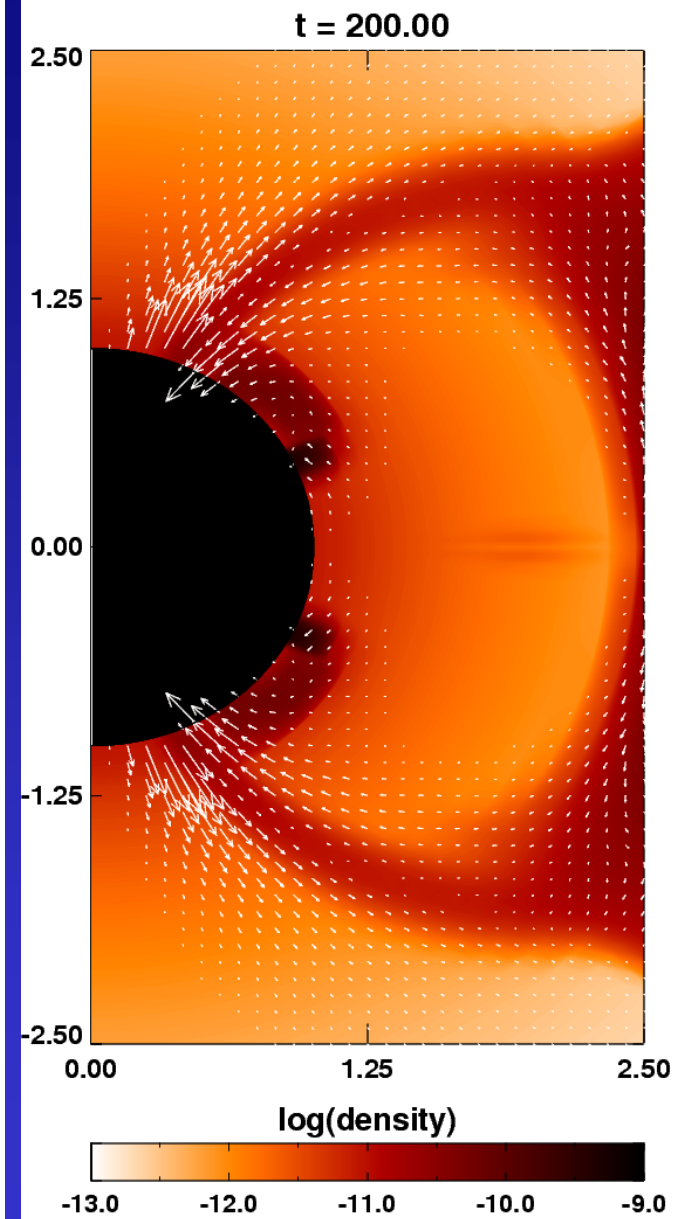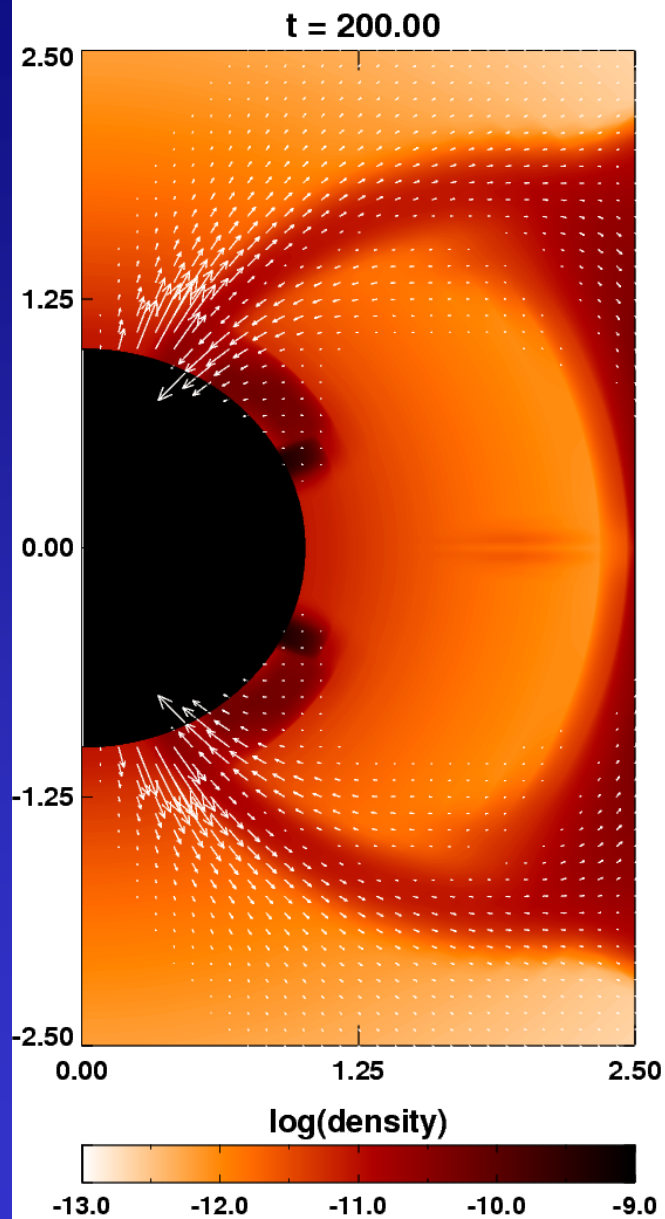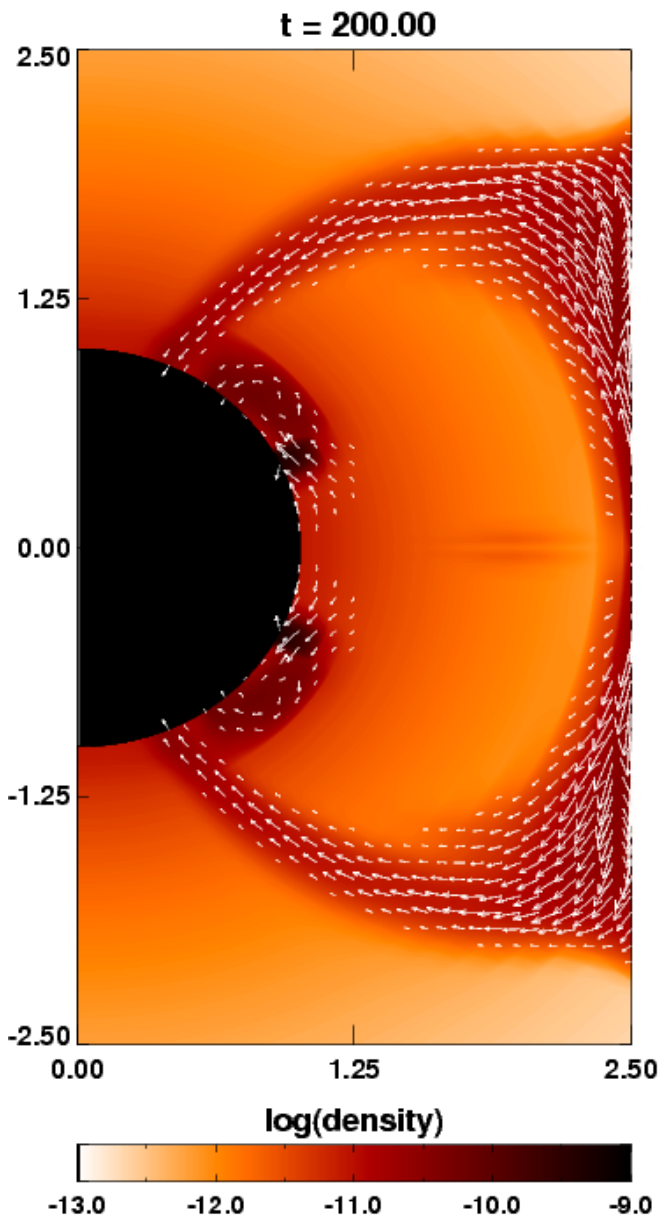- Halo:

  - Density $\rho = \rho_o r^{-n}$

  - Low resistivity

Funnel Flow: Simulation

Funnel Flow: Torques

accretion   magnetic   total