Resistive MHD simulations of protostellar jet launching

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Outline

- Introduction
- Model
- Initial and boundary conditions
- Results
- Summary

Introduction

- Protostellar jet launching problem
- Disk as a a boundary
- Disk included in the simulations
- Resistive vs. other dissipative processes

Model

- Disk included in computational box
- Interaction of stellar magnetosphere & disk
- Stellar surface "included"

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

$$\rho \left[\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla) \mathbf{u} \right] + \nabla p - \rho \nabla \left(\frac{GM}{\sqrt{r^2 + z^2}} \right) - \frac{\mathbf{j} \times \mathbf{B}}{c} = 0$$

$$\frac{\partial \mathbf{B}}{\partial t} - \nabla \times \left(\mathbf{u} \times \mathbf{B} - \frac{c\mathbf{j}}{\sigma} \right) = 0$$

$$\rho \left[\frac{\partial e}{\partial t} + (\mathbf{u} \cdot \nabla) e \right] + p(\nabla \cdot \mathbf{u}) - \frac{\mathbf{j}^2}{\sigma} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

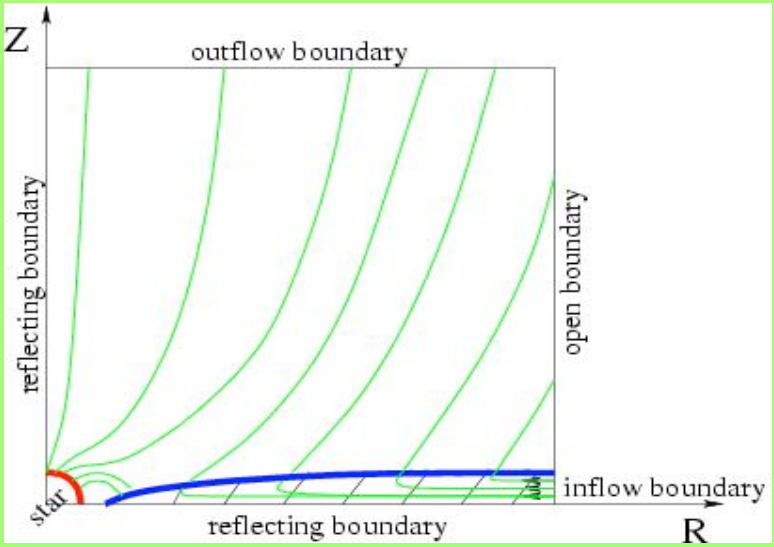
$$\frac{4\pi}{c} \mathbf{j} = \nabla \times \mathbf{B}$$

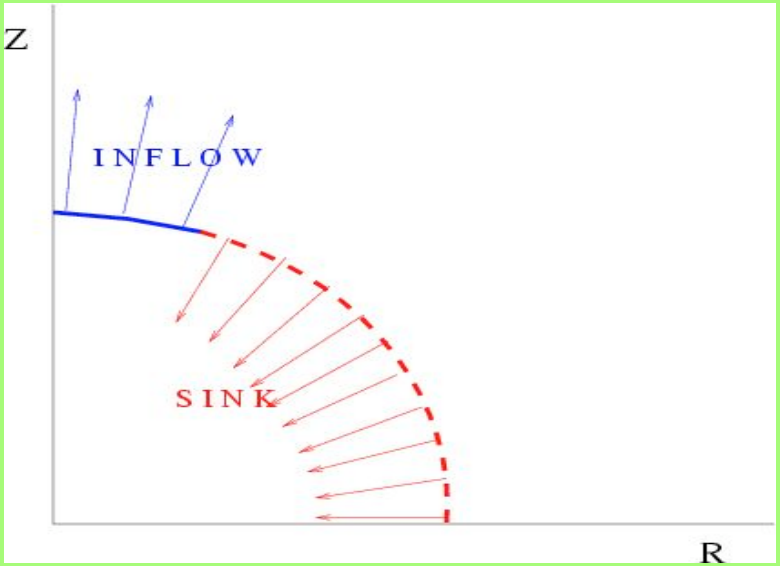
$$p = K\rho^{\gamma}, \; e = \frac{p}{\gamma - 1}, \; \gamma = \frac{5}{3}$$

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{B}) + \eta \nabla^2 \mathbf{B}, \quad \eta = \frac{c^2}{4\pi\sigma}$$

Boundary conditions

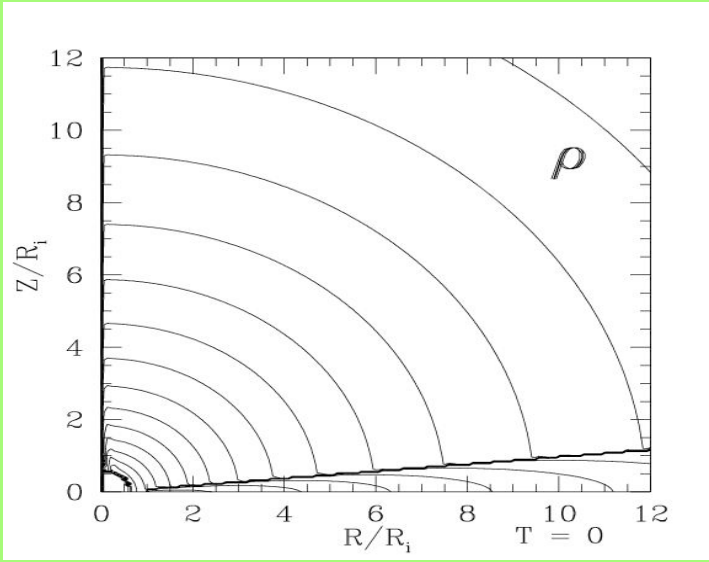
- Time-dependent **resistive** MHD simulations- **ZEUS347, stellar dipole +open field threading the disk**
- Setup: **RxZ= (160x250)grid cells= (12x12)R_i**

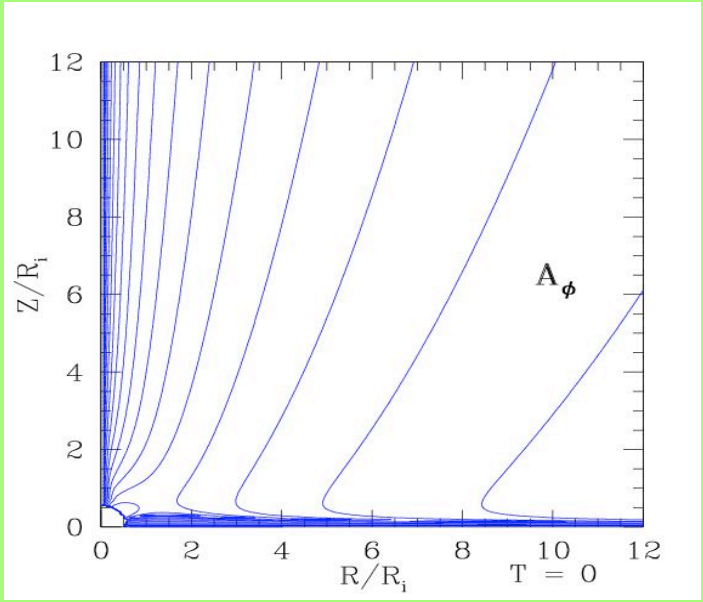




Initial conditions

- Hydrostatic co-rotating corona above the disk in hydrostatic and magnetic forces balance
- Resistive disk, corona effectively ideal-MHD
- Star as a boundary

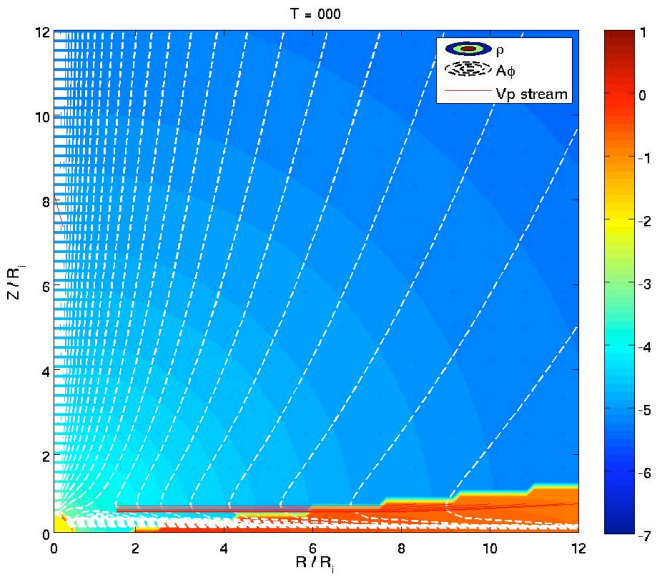


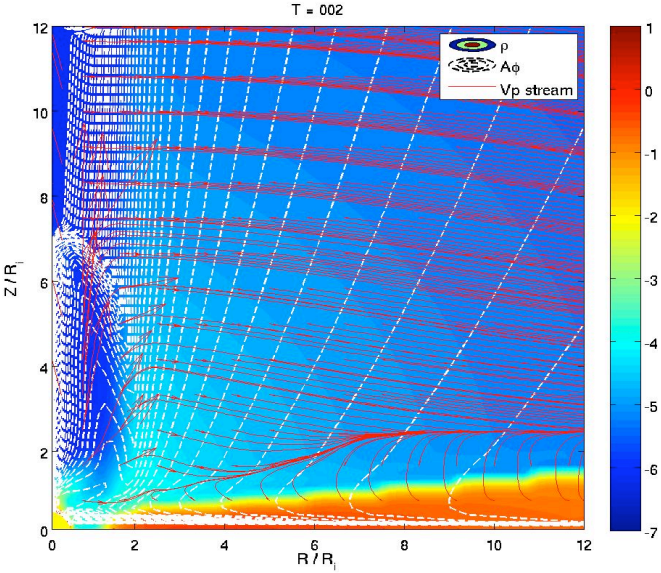


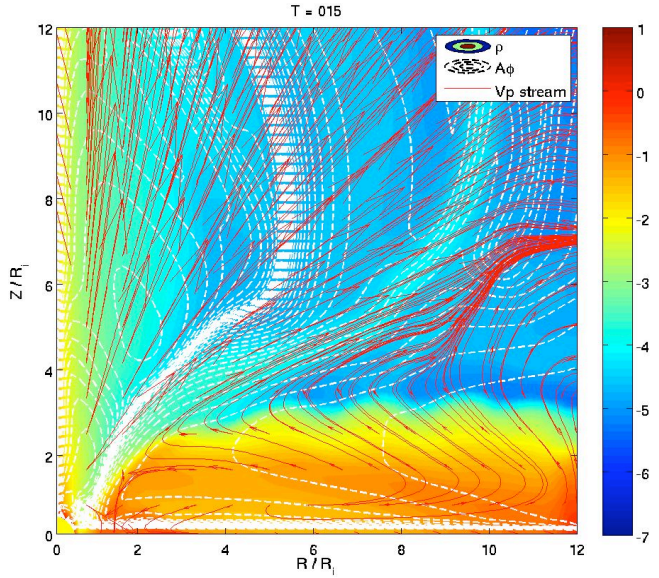
Results 1-animations

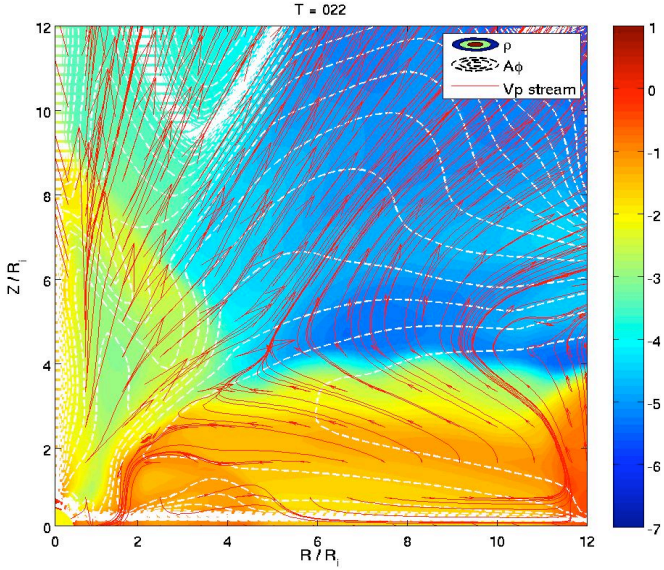
Results 1-animations, zoom

Results 1 - stills

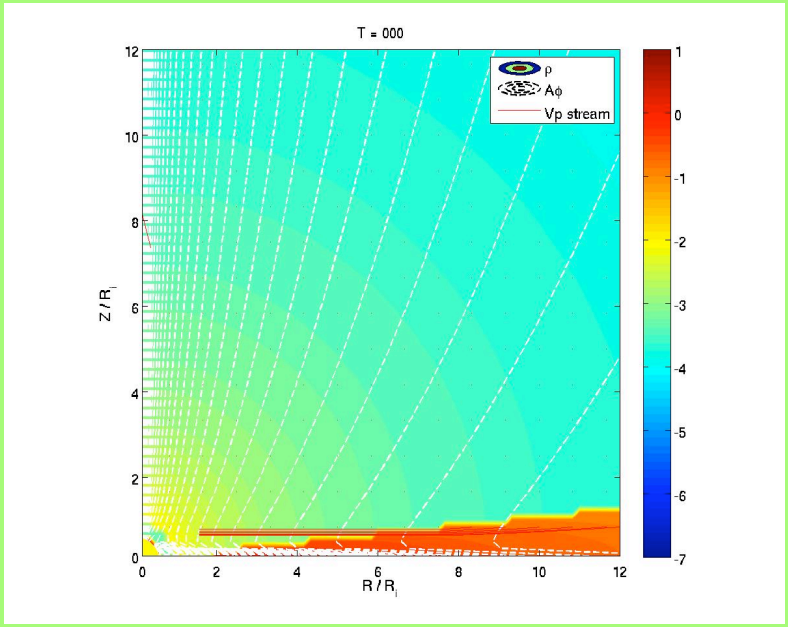


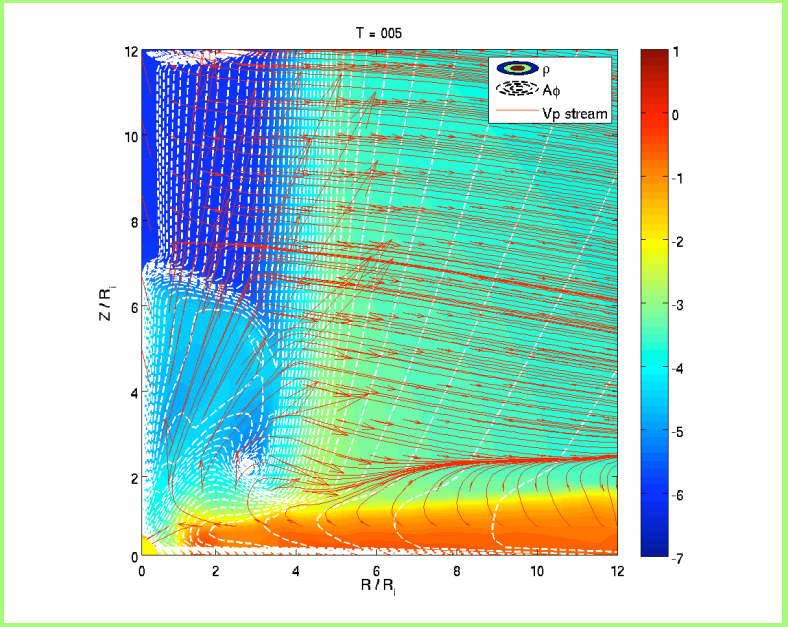


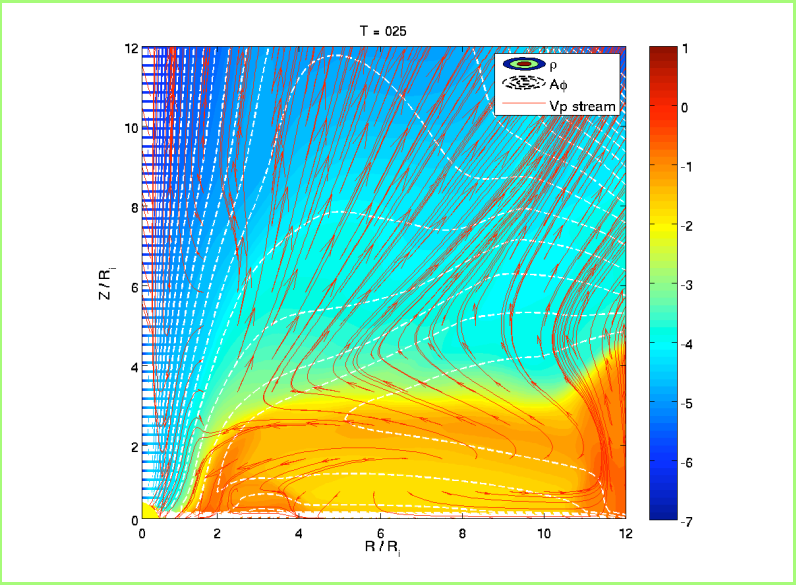


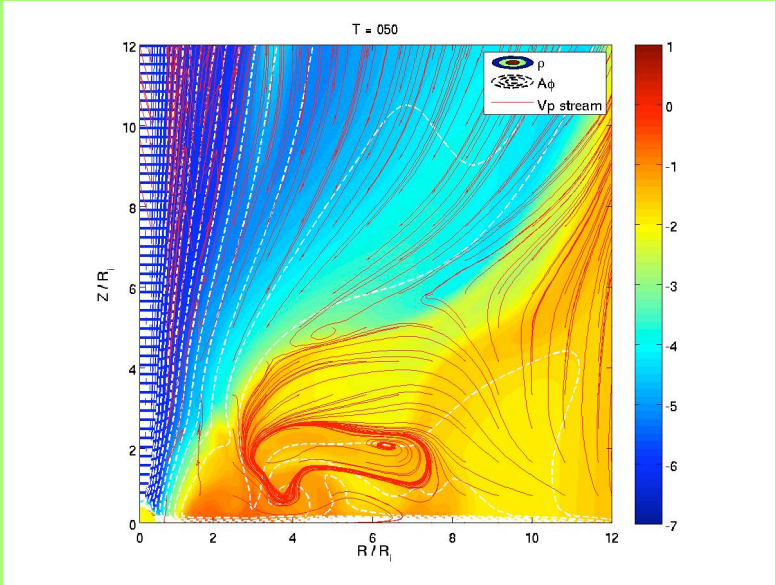


Results 2- stills

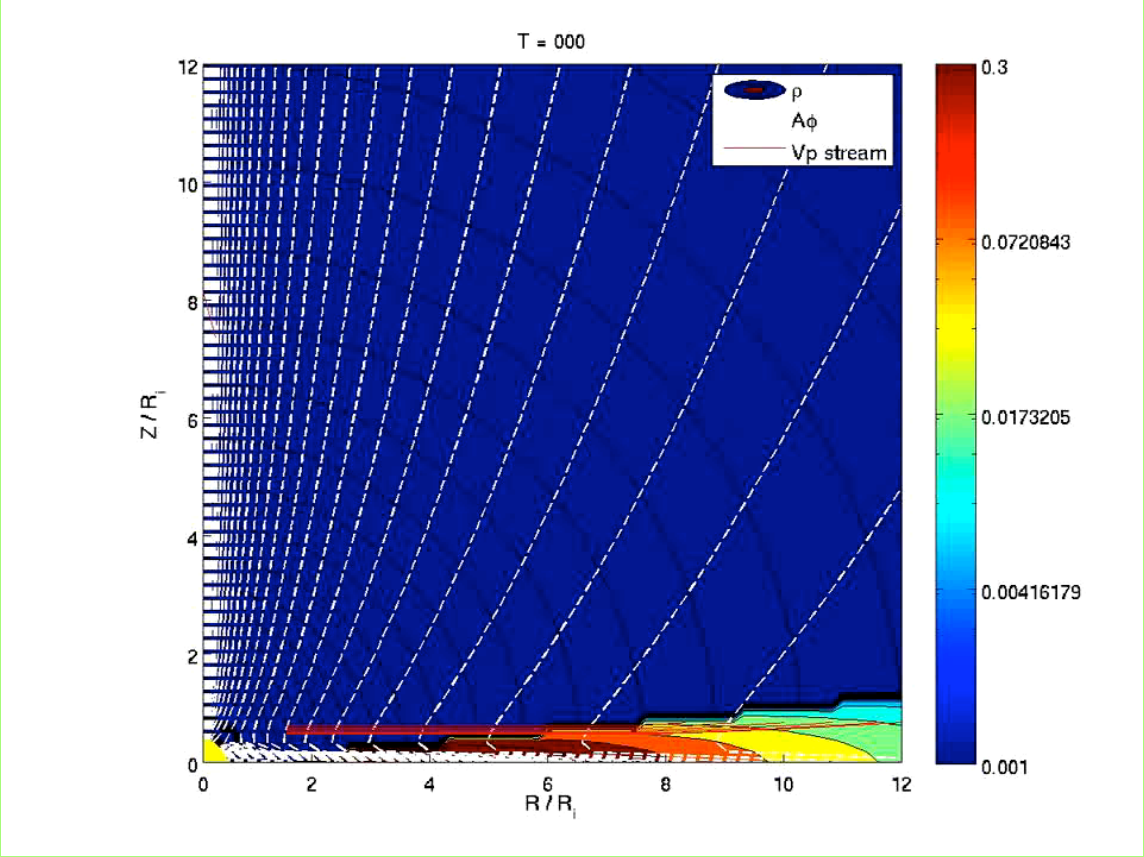








Results 2-animations



Results 2-animations, zoom

Summary

- Numerical simulations in various geometrical setups
- Magnetic fields from simpler to more complicated
- Close vicinity of the star
- Prospects:Accretion disk & Full 3D simulations