Resistive MHD test for JETSET code benchmarks

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Outline

- JETSET collaboration
- Need for code tests standard
- Resistive MHD test
- Prospects

JETSET collaboration

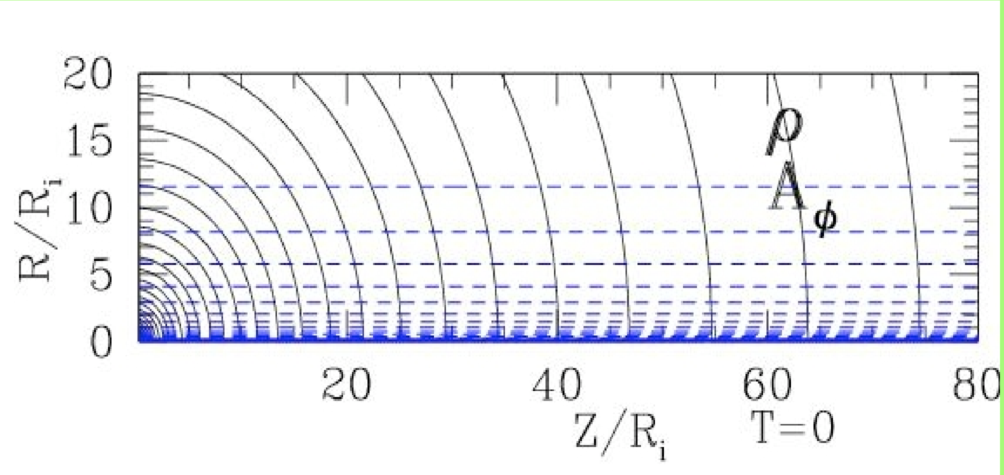
- Marie Curie RTN (Research and Training Network)
- December 2006, Dublin, initial workshop
- January 2007, final list of tests
- Up to summer 2007, webpage with posted tests

JETSET Tests

- Advection of a current-carrying cylinder
- Orszag-Tang Vortex
- MHD Kelvin-Helmholtz Instability
- Under-expanded Jet
- Double Mach Reflection of a Strong Shock
- Oscillatory Instability of Radiative Shocks
- Magnetic Blast Wave propagation
- Cloud-Shock Interaction
- Magnetic diffusion

Magnetic diffusion test

- Disk as a boundary condition
  - **Ideal** MHD, Ouyed & Pudritz, 1997
- Time-dependent **resistive** MHD simulations-ZEUS347, **o**pen field threading the disk, Fendt & Cemeljic, 2002
- Test setup: ZxR=(500x200) grid cells=(80x20)R_i
- Slower propagation of resistive jet



Equations of resistive MHD

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

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

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

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

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

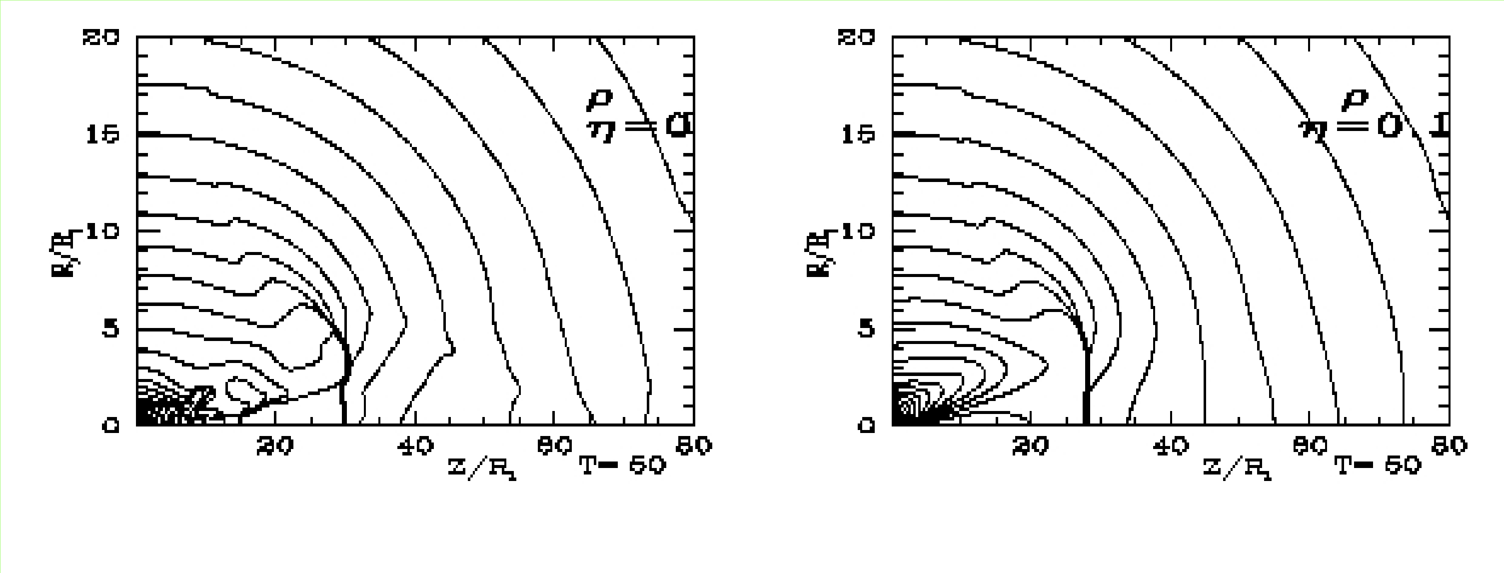
$$\frac{4\pi}{c} \mathbf{j} = \nabla \times \mathbf{B}$$

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

- Magnetic diffusivity η

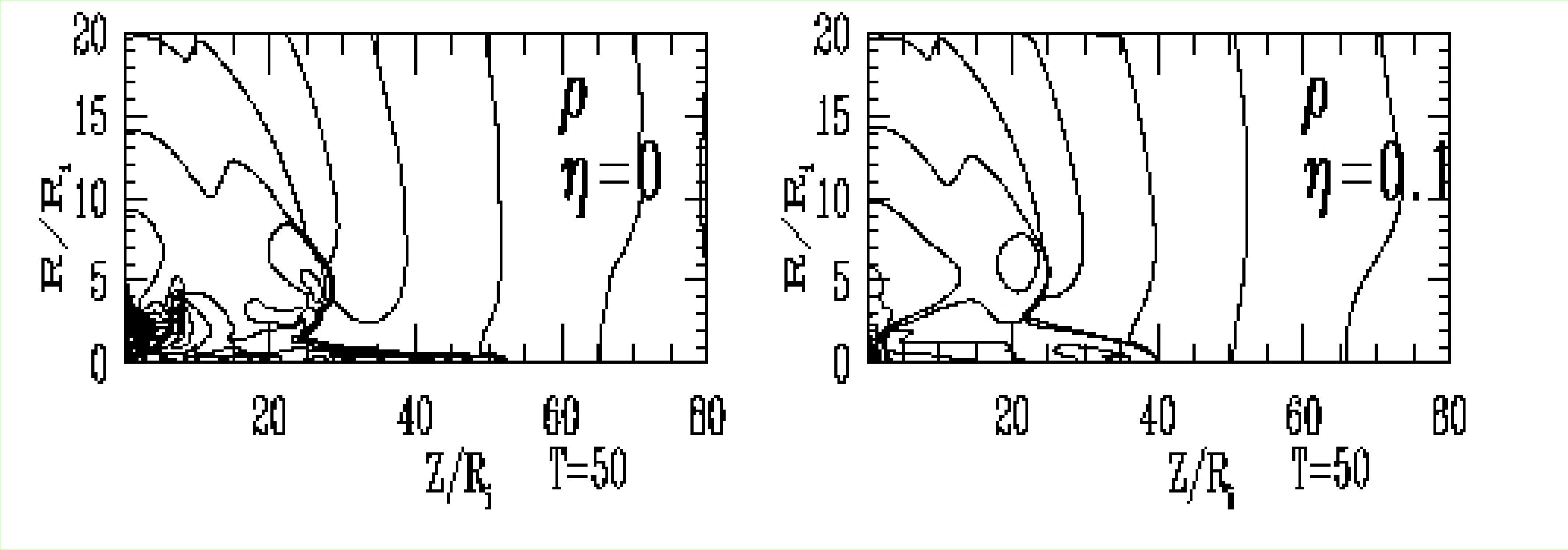
$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{B}) + \eta \nabla^2 \mathbf{B}, \quad \eta = \frac{c^2}{4\pi\sigma}$$

With polytropic approximation



- Result: **Slower propagation of resistive jet**
- But: Irreversible processes forbidden in polytropic approach = shock forming prevented

Energy equation solved



- **Slower propagation of resistive jet**
- Caveat: some features might be boundary-condition dependent
- RESULTS:
- 1) Threshold of numerical resistivity $\eta=0.001$
- 2) Difference in the jet front shock position: $\Delta Z=2.5\ Z/R_i$

Prospects

- Webpage with the test setups and descriptions
- Test results
- Information about results obtained by each code
- Referees of the papers on new codes demand the particular tests to be performed