Adaptive Mesh Refinement Simulations of Relativistic Binaries

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High Energy Astrophysics Division Meeting October 7, 2006

Outline

- Infrastructure Overview

  - ***had***
  - the GR-HD code ***Flow-er***
  - ***GR-MHD*** code

- Example calculations with ***Flow-er***

- Infall of a NS + BH pair with ***GR-MHD*** code

Infrastructure: the ***had*** code

had is the central piece of software within which physics applications execute.

As an example, independent codes for solving the Einstein equations and the equations of general relativistic hydrodynamics run simultaneously to simulate a BH + NS binary. Lehner *et al*. (gr-qc/0510111)

had provides:

- time integration with Method of Lines
- domain decomposition for parallel execution
- structured adaptive mesh refinement with shadow hierarchy

Infrastructure: GR-HD code ***Flow-er***

Flow-er is a hydrodynamics code based on the Kurganov-Tadmor (2000) scheme. This enables high quality evolutions without requiring full knowledge of the characteristic equations or Riemann solvers.

Features:

- Conservative scheme
- 1, 2 and 3-d evolutions
- Runs within or separately from ***had***
- Choice of 6 spatial reconstruction schemes (currently)
- Choice of 2nd, 4th or 6th order finite difference and interpolation operators
- "Black box", flexible tools for hydrodynamic equations

Infrastructure: ***GR-MHD*** code

Implements the equations of General Relativistic, ideal Magneto-Hydrodynamics. See D. Neilsen *et al*. (gr-qc/0512147) and M. Anderson *et al*. (gr-qc/0605102)

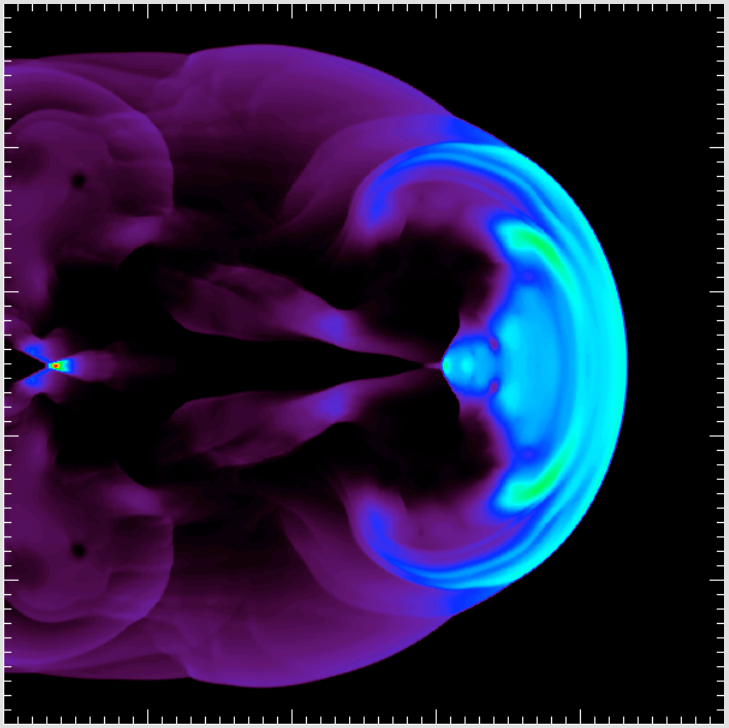
Features:

- Finite difference scheme
- CENO reconstruction with HLLE approximate Riemann solver
- Divergence cleaning for maintaining the monopole constraint
- Better match to available codes for solving the Einstein equations (all quantities are vertex centered)
- Simpler implementation for adaptive mesh refinement

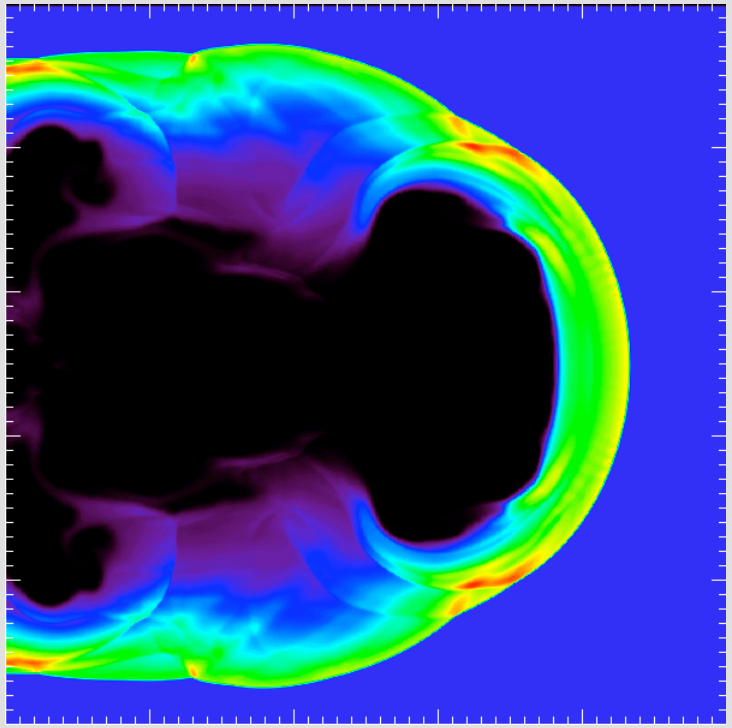
Example Calculations with ***Flow-er***

Planar Relativistic Jet, $v_{inflow} = 0.99$ c (A. Lucas-Serrano *et al*. 2004, A&A **428** p703)

Pressure

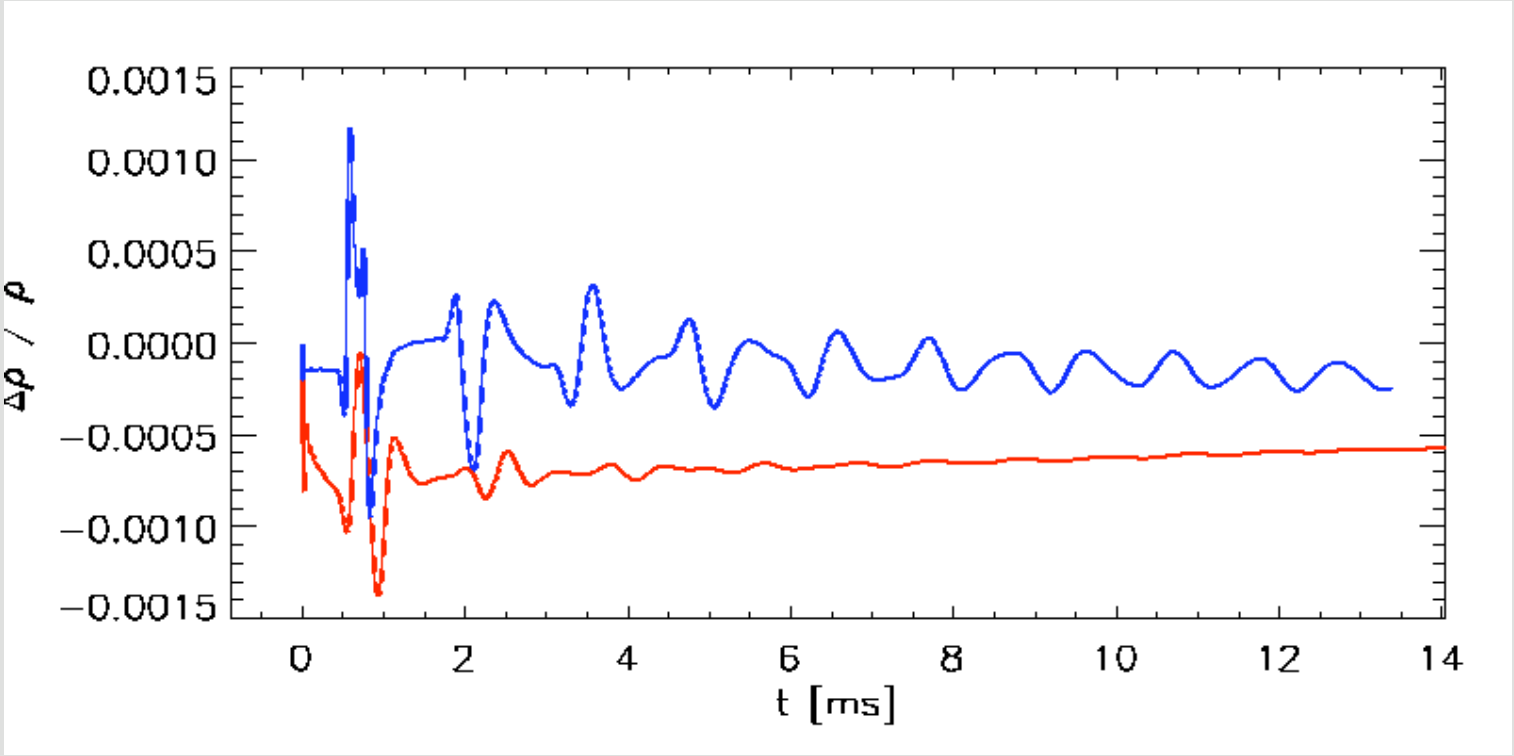


Mass Density



Example Calculations with ***Flow-er***

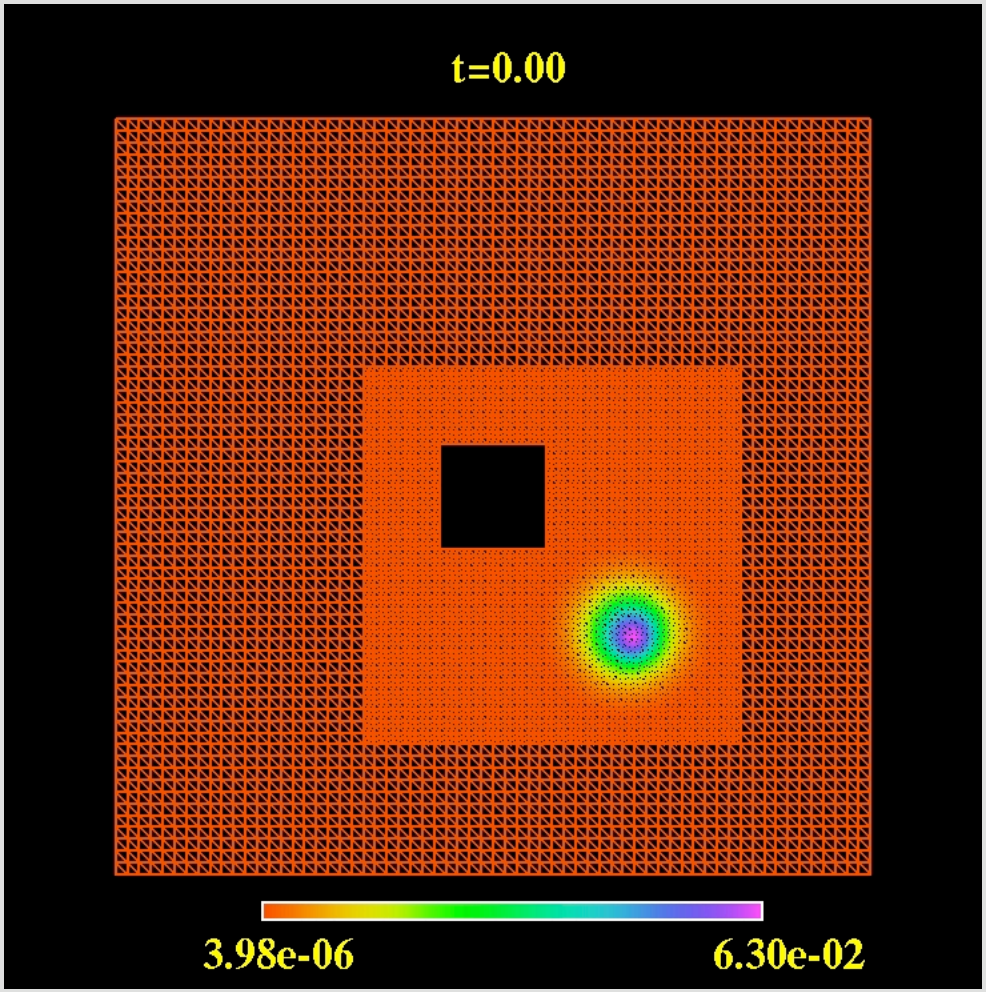
Evolution of a relativistic polytrope (TOV star) in the Cowling approximation. $\gamma = 5/3$ eos.



128^3 64^3

Example Calculation with ***GR-MHD*** code

Infall of TOV star and Schwarzschild Black Hole with Adaptive Mesh Refinement. $M_{\bullet} = 0.25\ M_{NS}$



Acknowledgments

We are pleased to acknowledge support from NSF grants AST 04-07070 and PHY 03-26311 and NASA's ATP program grant NAG5-13430.

Computations were performed at NCSA through grant MCA98N043 and at LSU's Center for Computation & Technology.