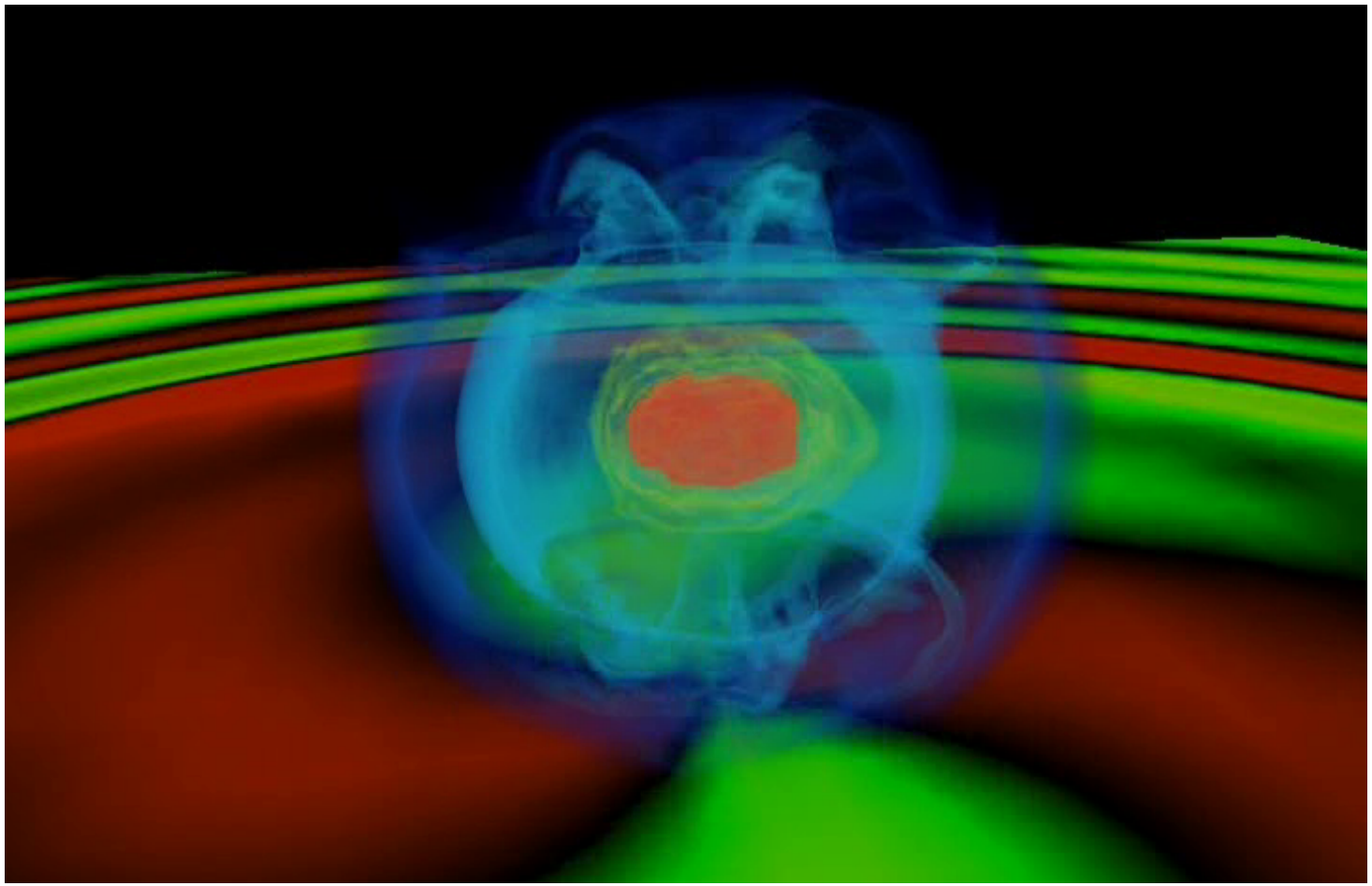
# Gravitational waves from stellar collapse simulations



I. Hawke (University of Southampton)

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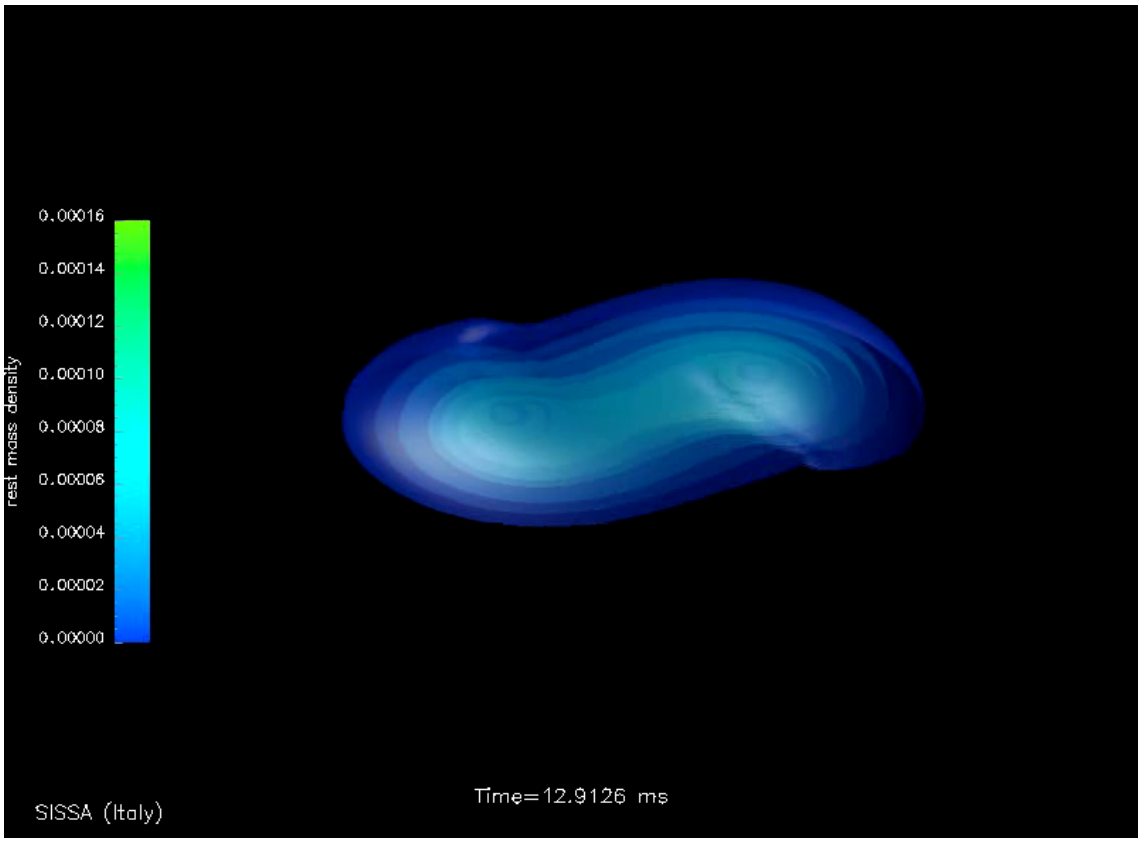

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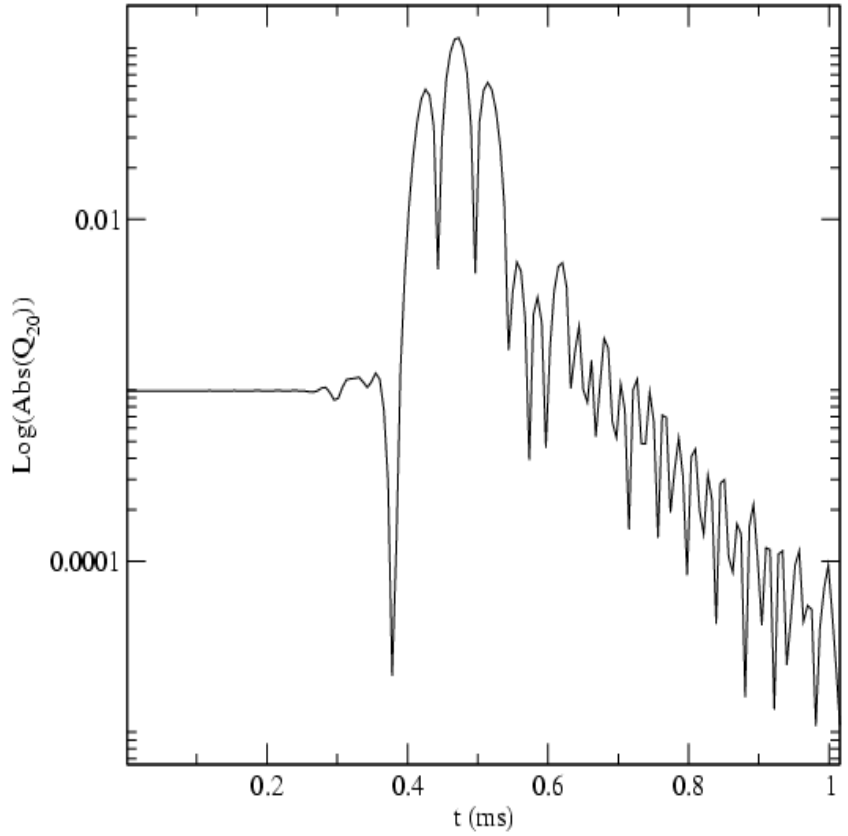
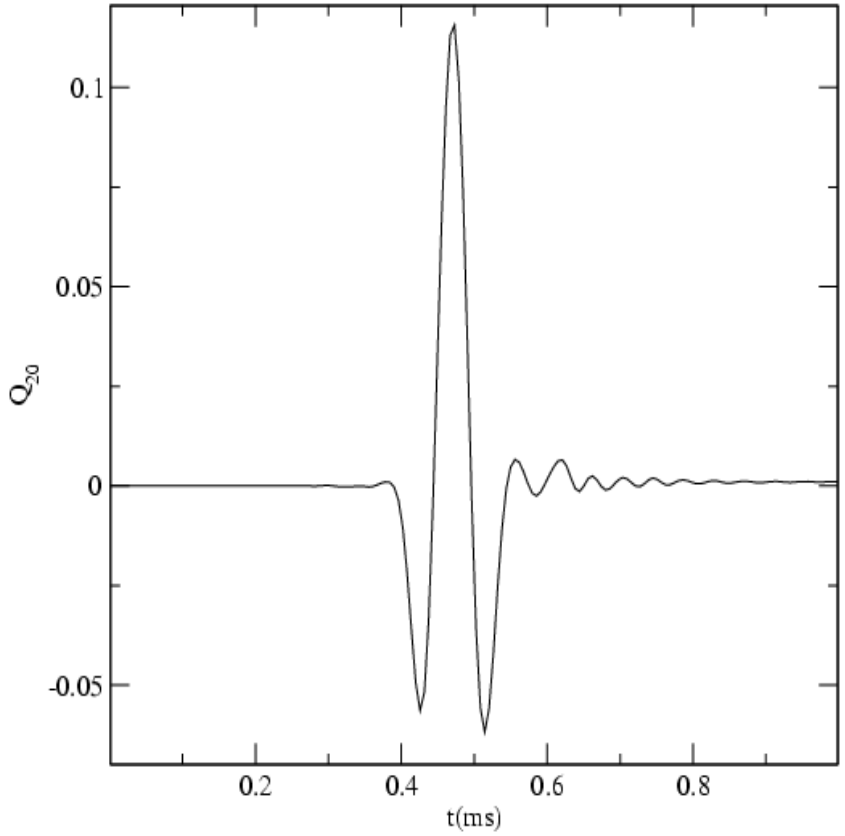
Neutron star oscillation modes



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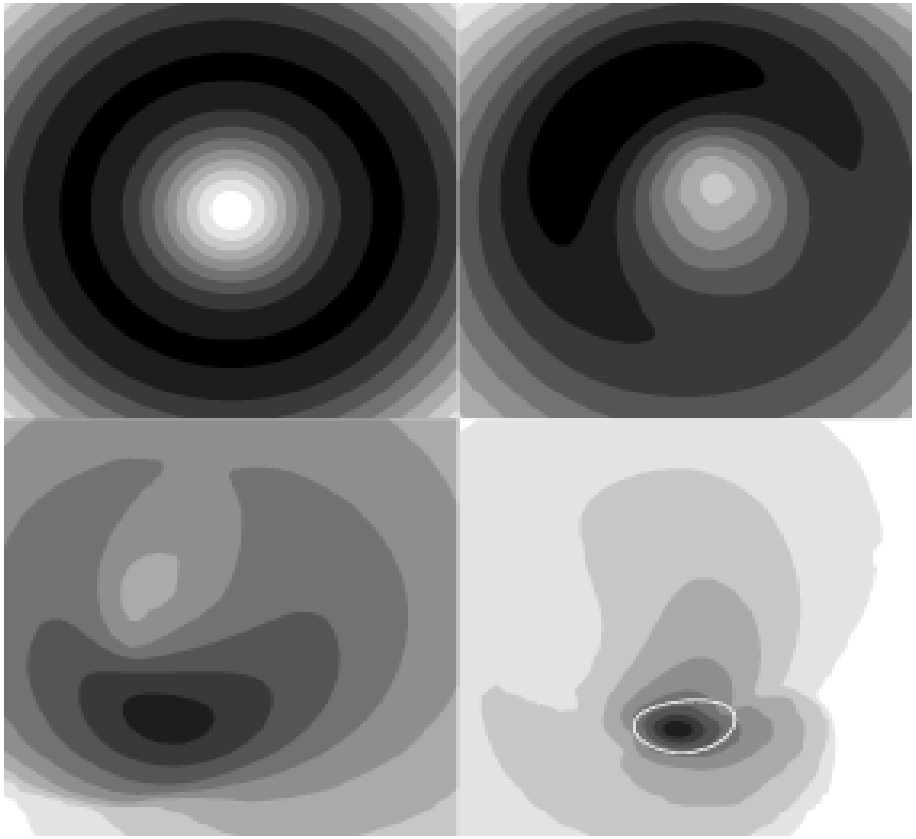

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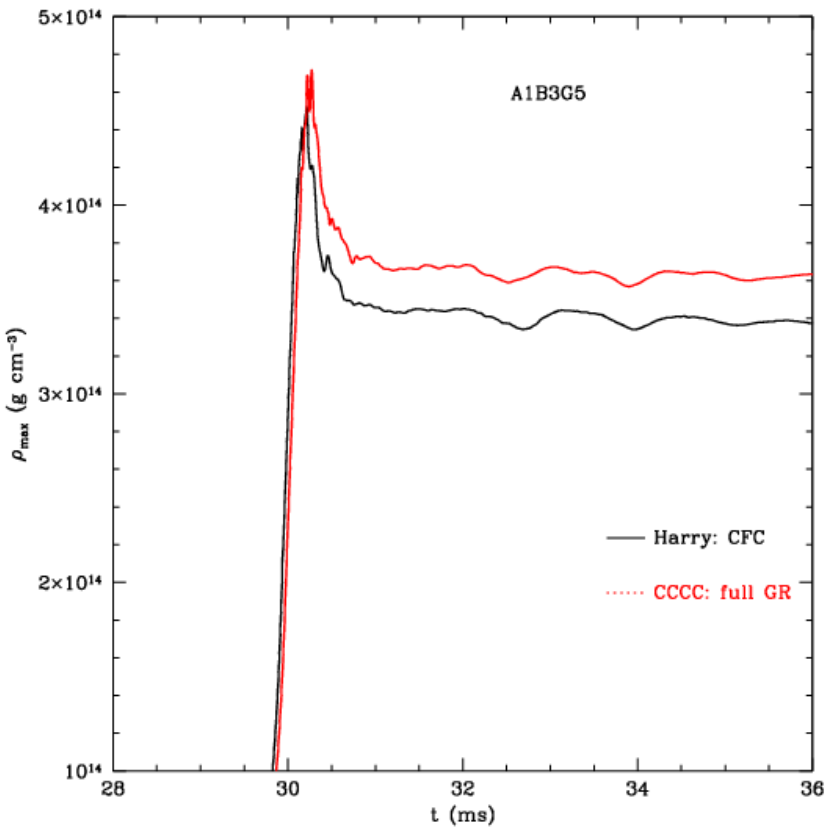
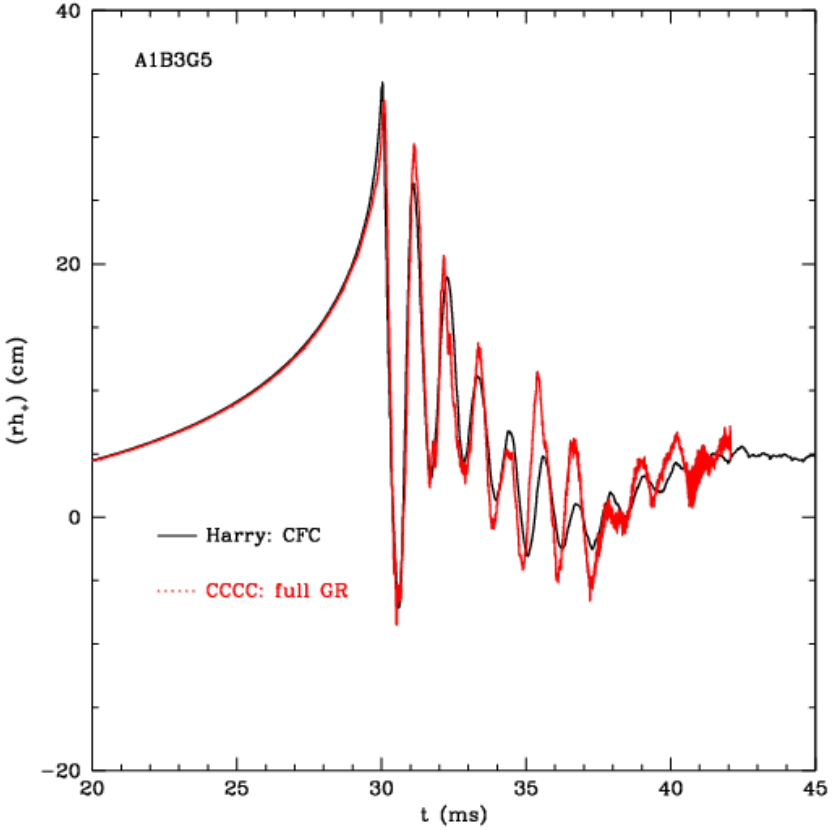
Iron core collapse



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- *Direct gravitational wave emission* (Baiotti, IH, Rezzolla, Schnetter).

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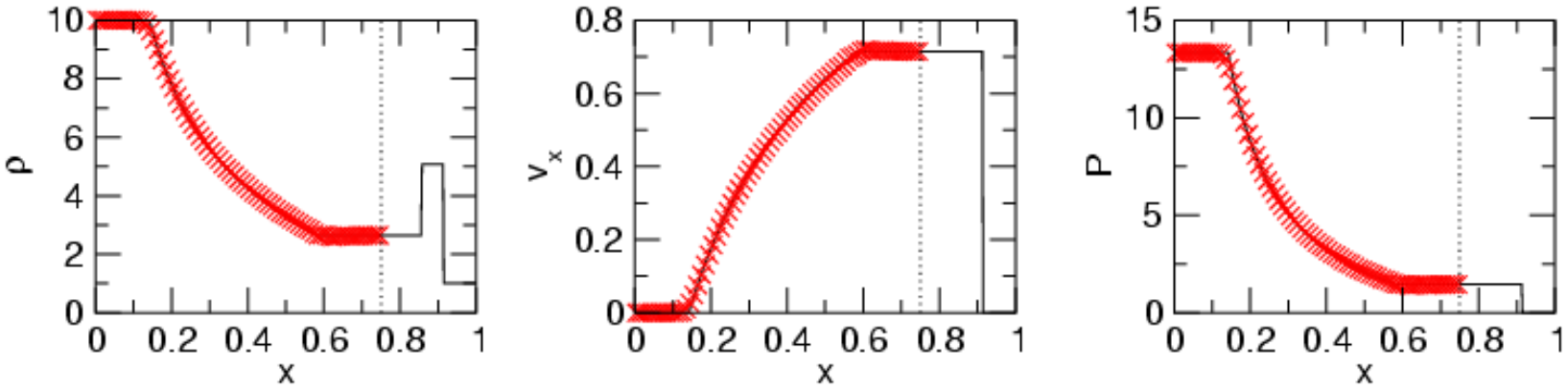

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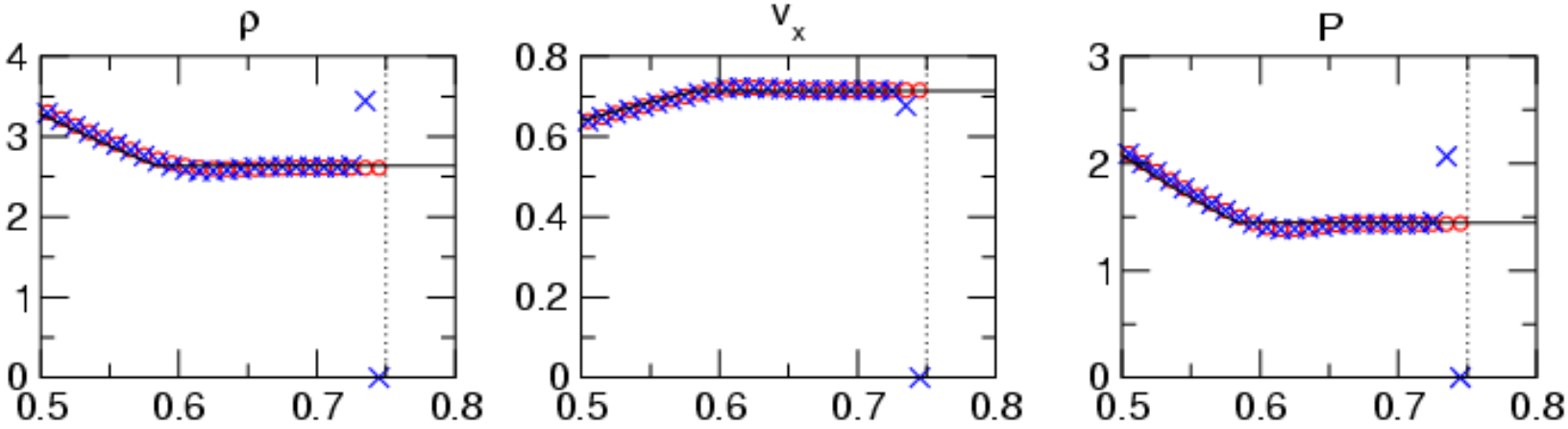

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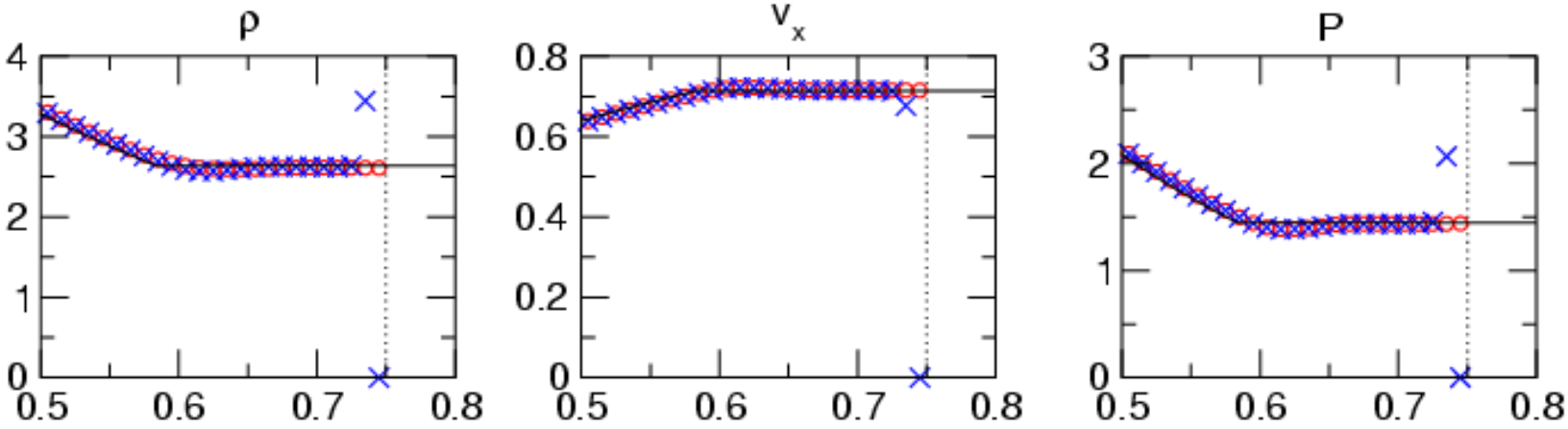
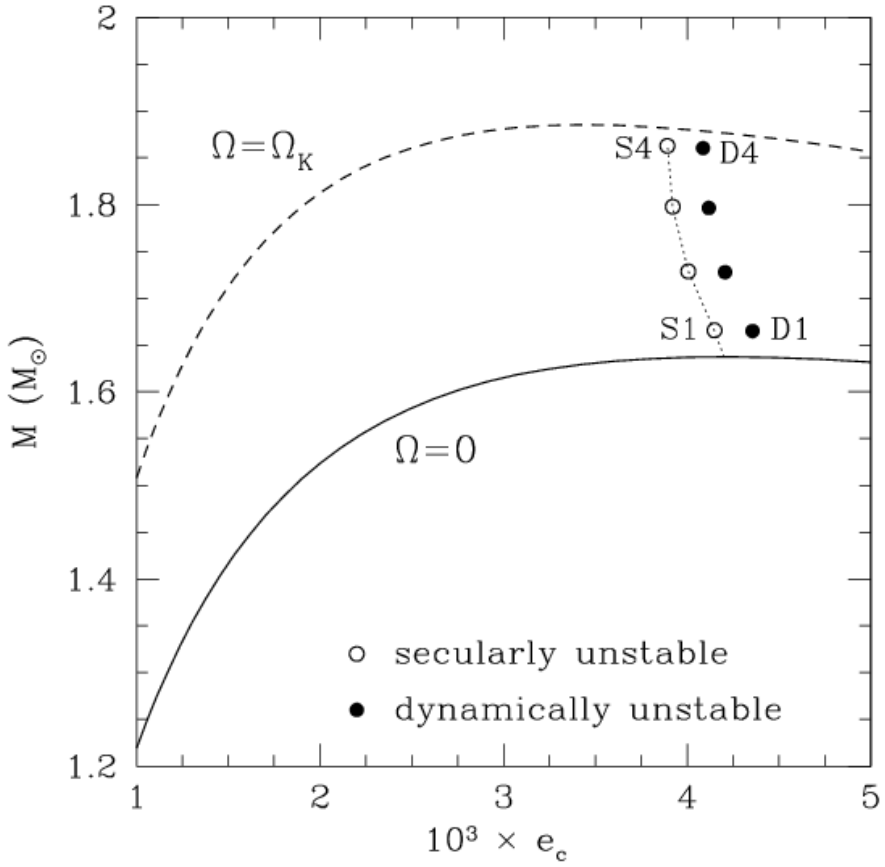
The consistent scheme has worked well in all tests.

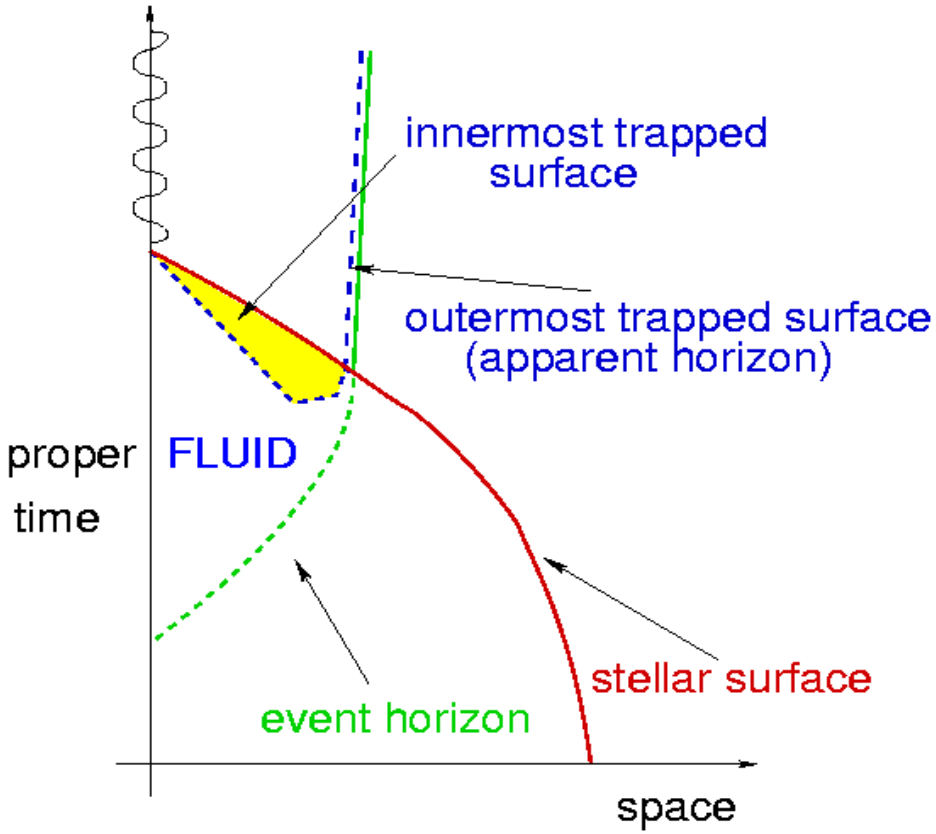


# NS Collapse: Initial data




The initial data is a (slightly perturbed) unstable stationary axisymmetric NS with a polytropic EOS. More realistic initial data and EOS now possible.

# Collapsing NS dynamics: I




The expected behaviour of a collapsing star

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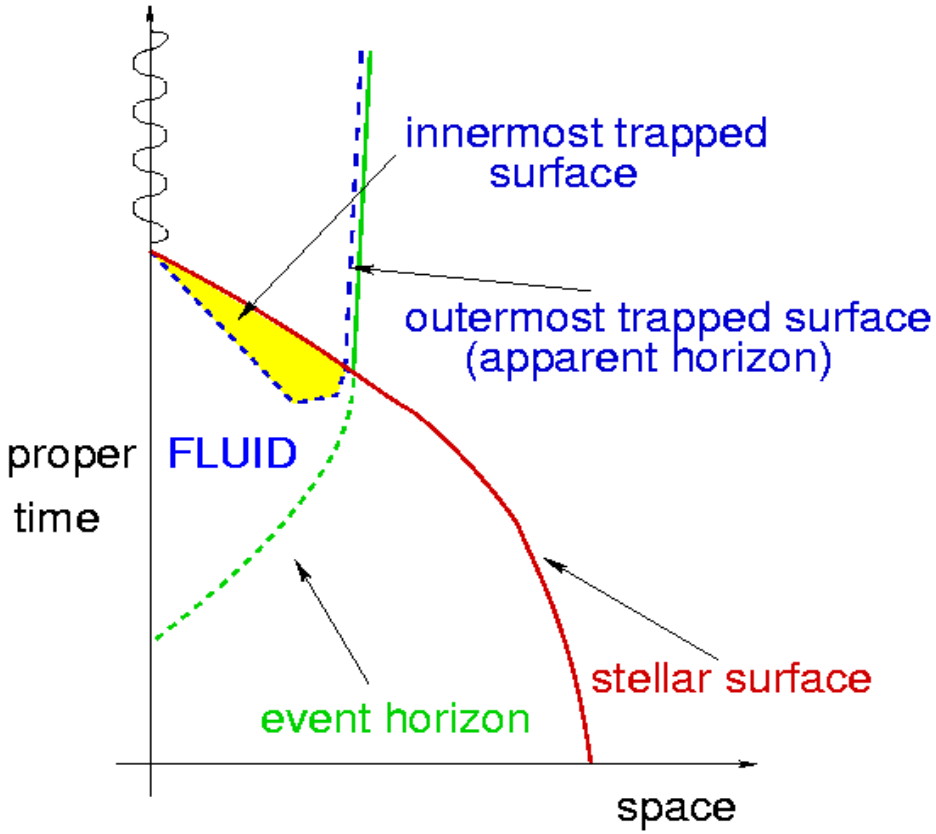
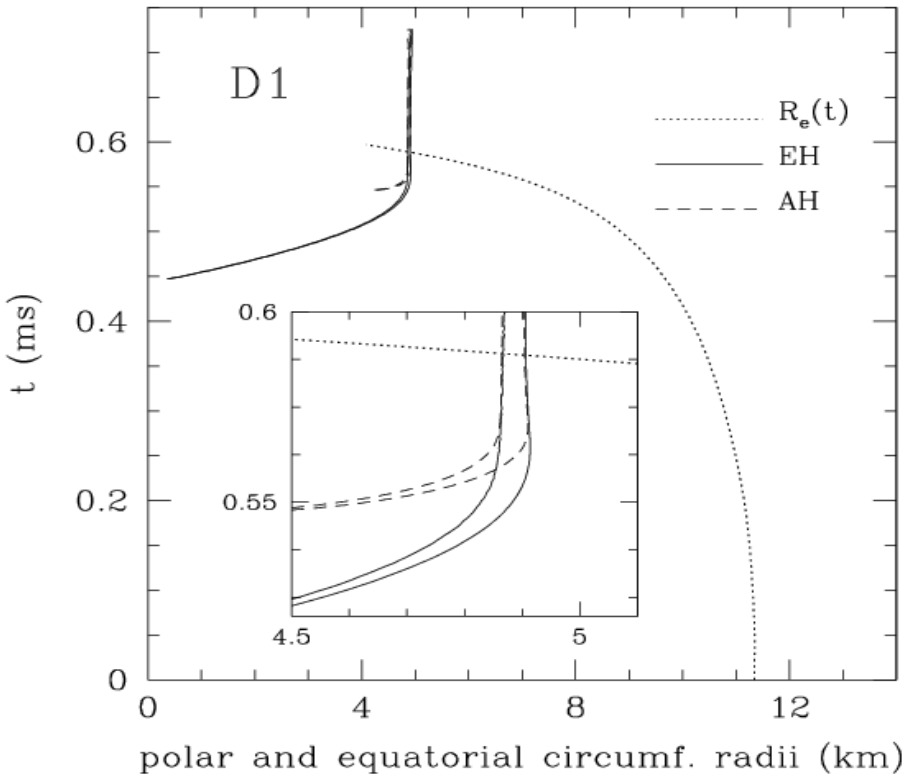
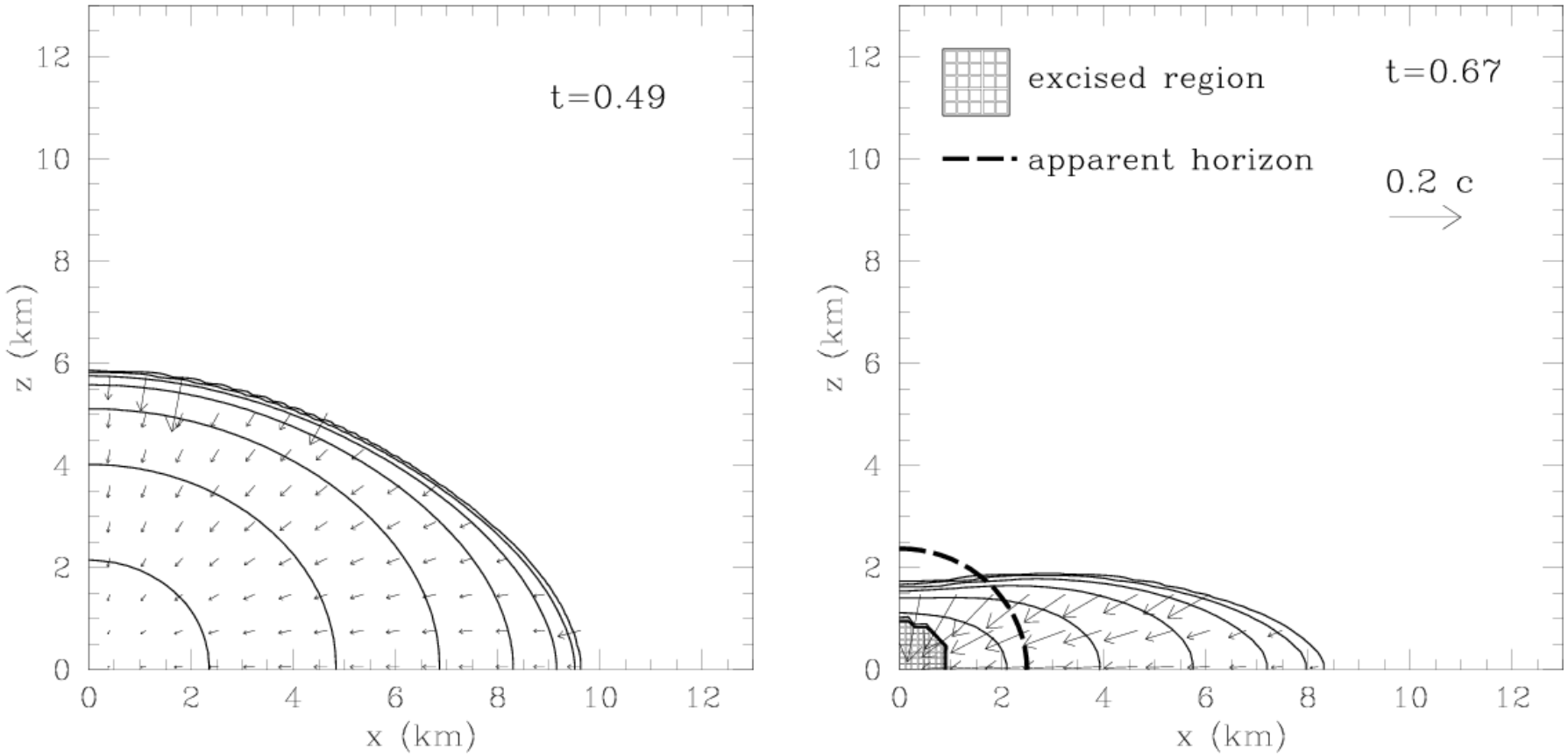


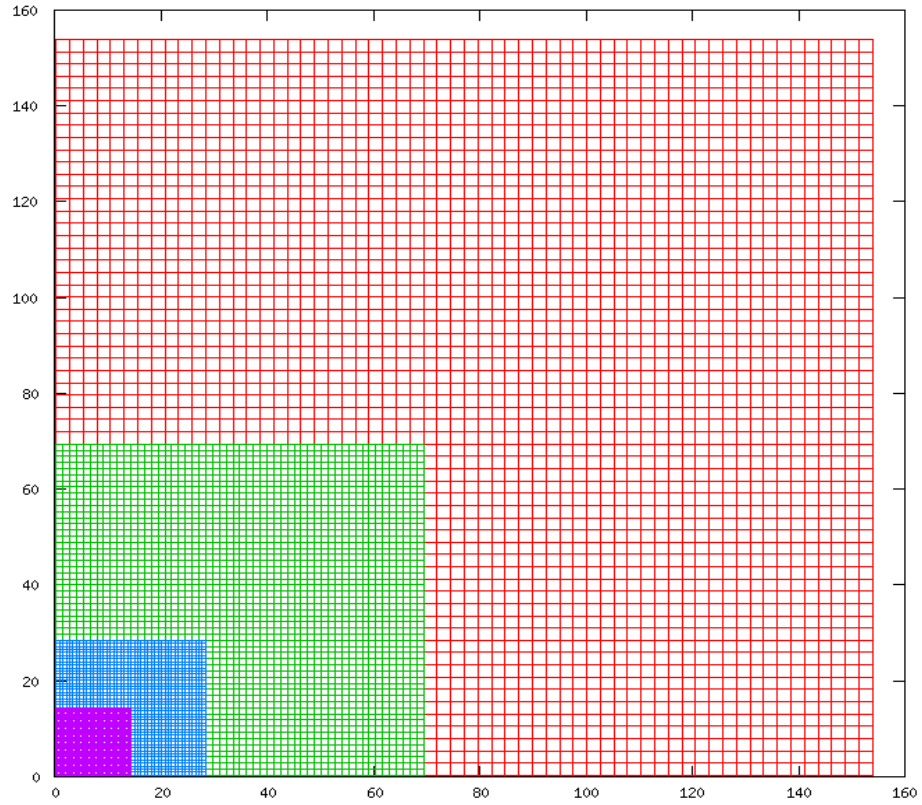

The expected behaviour of a collapsing star is reproduced in simulations of initially slowly rotating models.

# Collapsing NS dynamics: II




Initially rapidly rotating NSs start to rotate differentially, leading to a short-lived disc of material outside the black hole. The black hole grows as matter is accreted, as shown by the horizons.

# Mesh refinement

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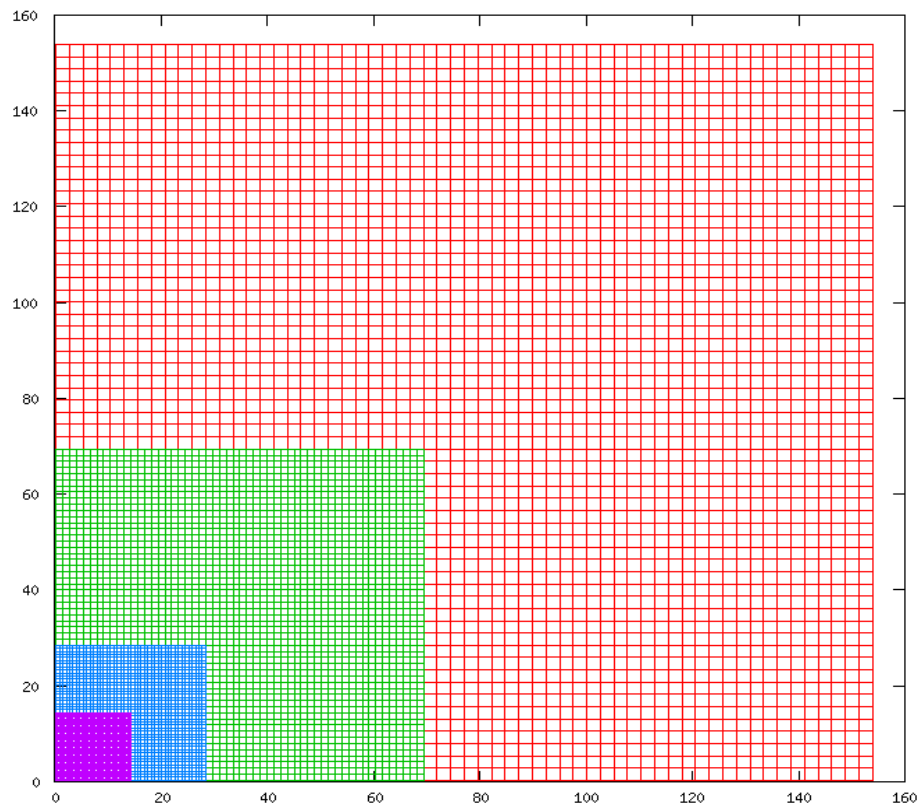


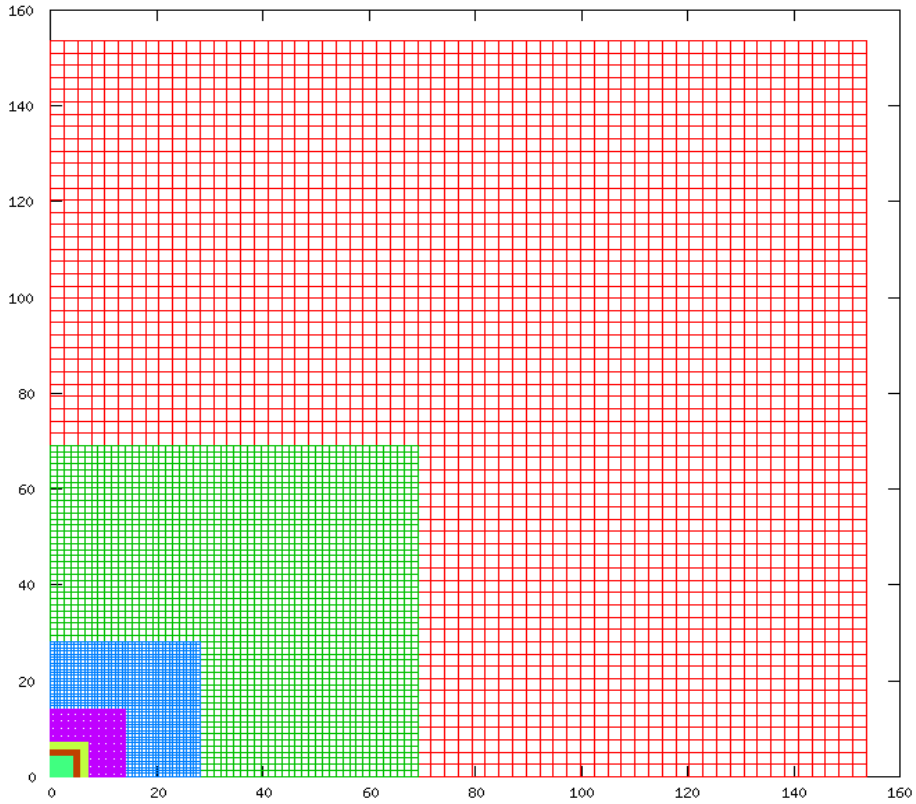


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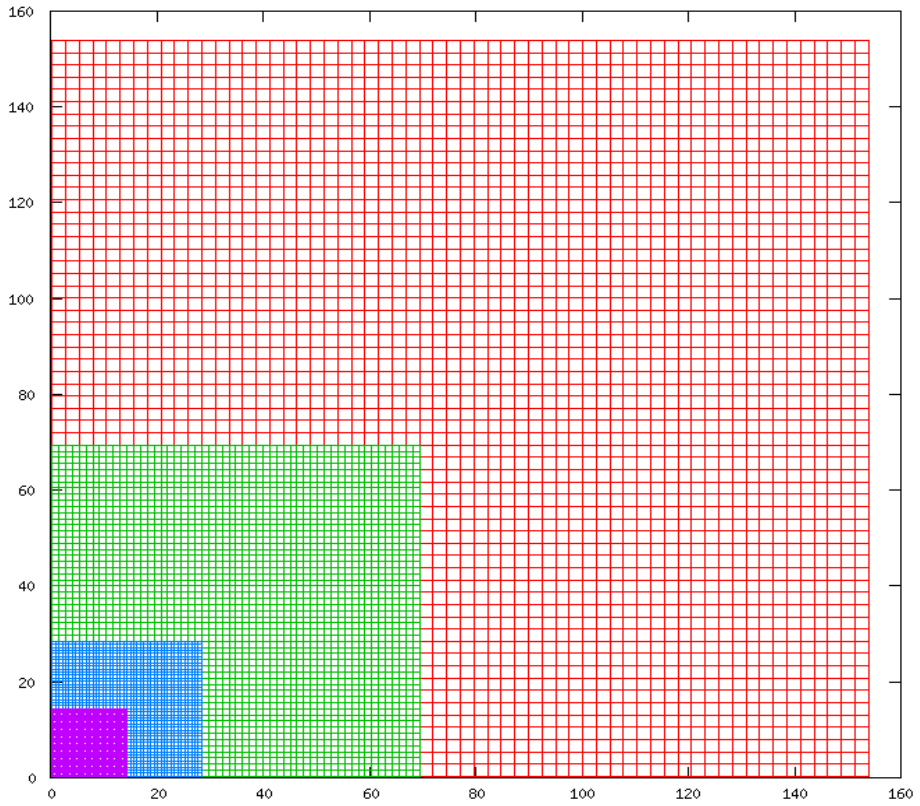
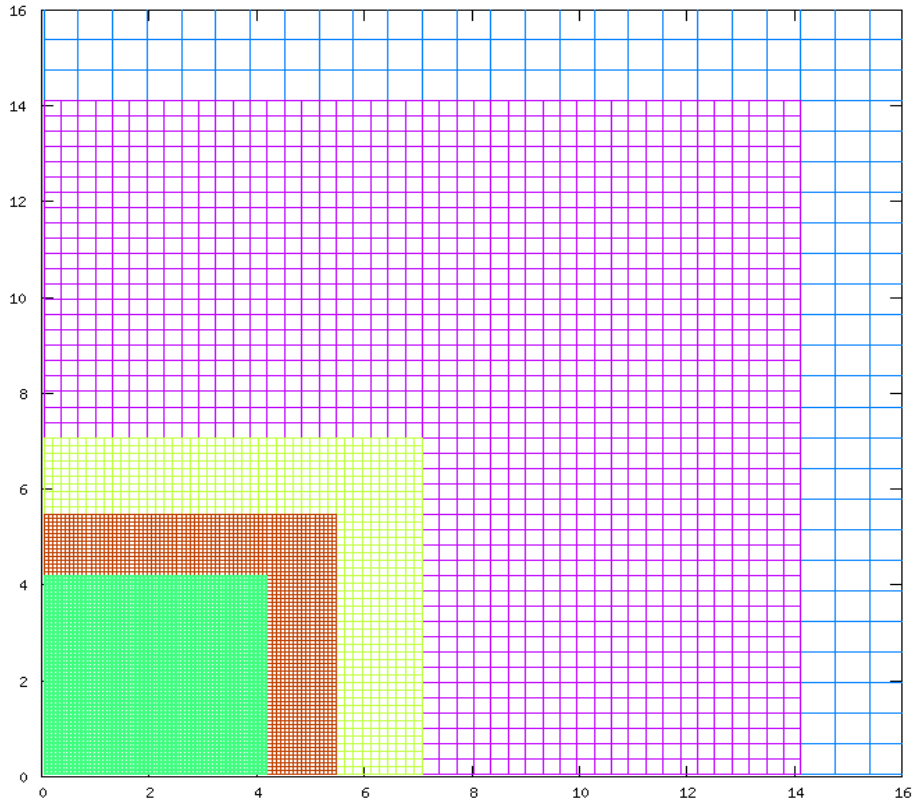
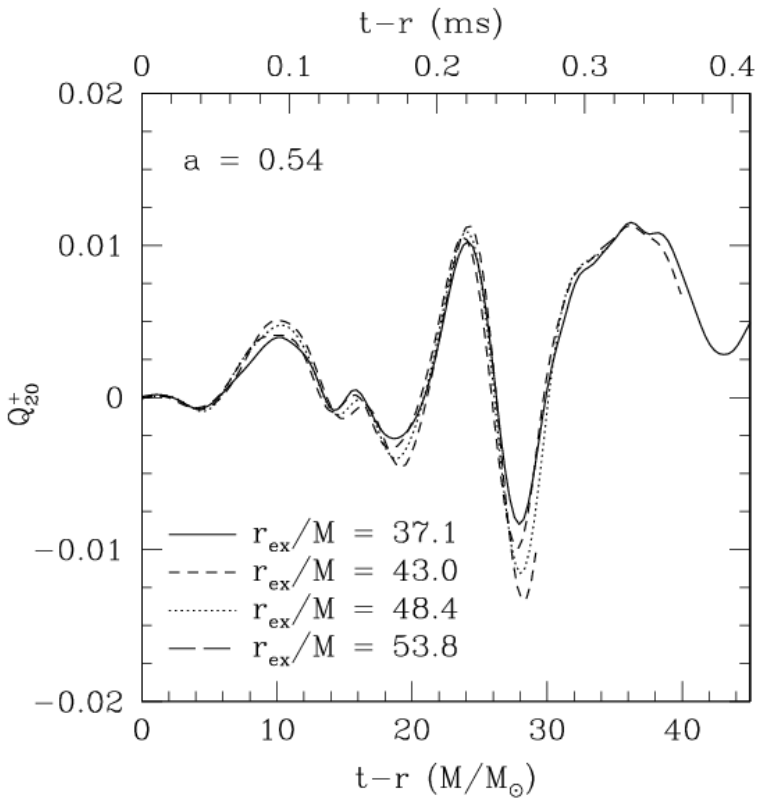



We use Berger-Oliger style mesh refinement where the grids are fixed in space. However, the grids are adaptive in time. By the end of the simulation the entire black hole is contained within a single grid.

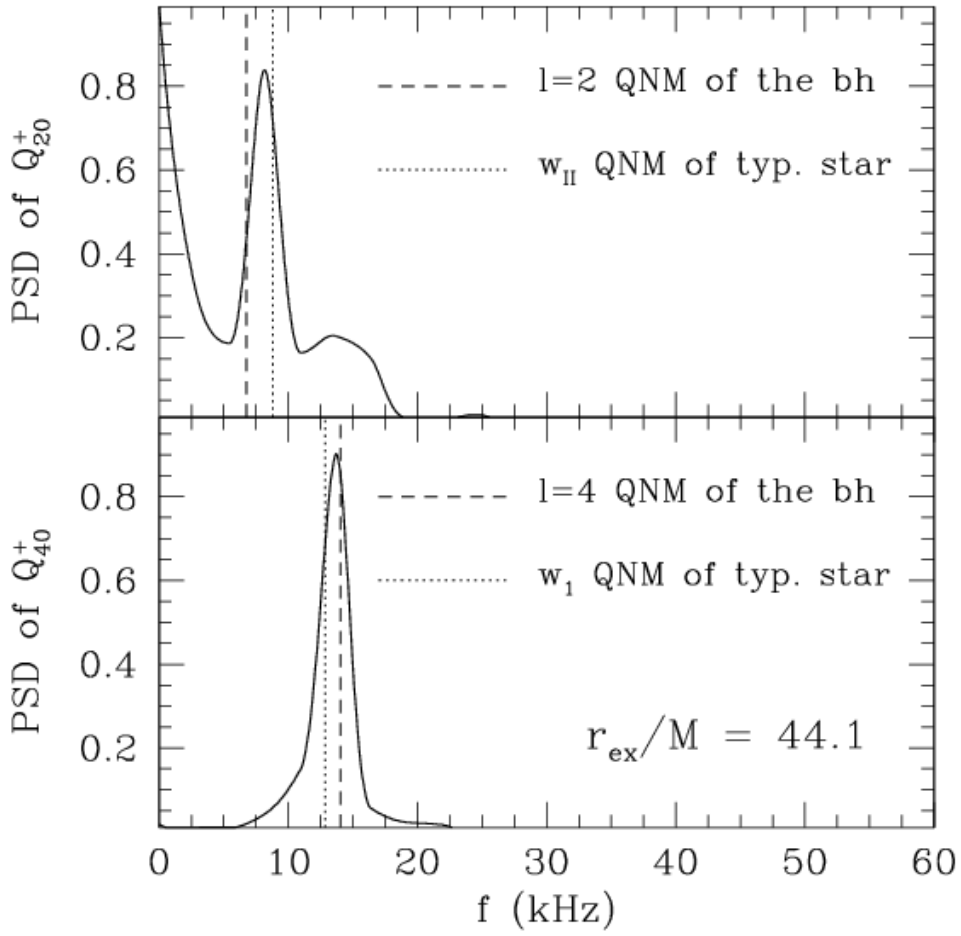
`Carpet` MR code based on `Cactus` framework for parallelism etc.

# Wave extraction




- We use first order gauge invariant Zerilli extraction.
- Near-zone and gauge effects still visible at small radii.
- Quadrupole formula gives poor results. Cauchy characteristic extraction under development.

# Wave extraction (II)




The power spectrum matches our expectations; the peak is bounded by the QNM of the BH and the $w$ modes of the initial NS.

# Computing $w$ modes more accurately

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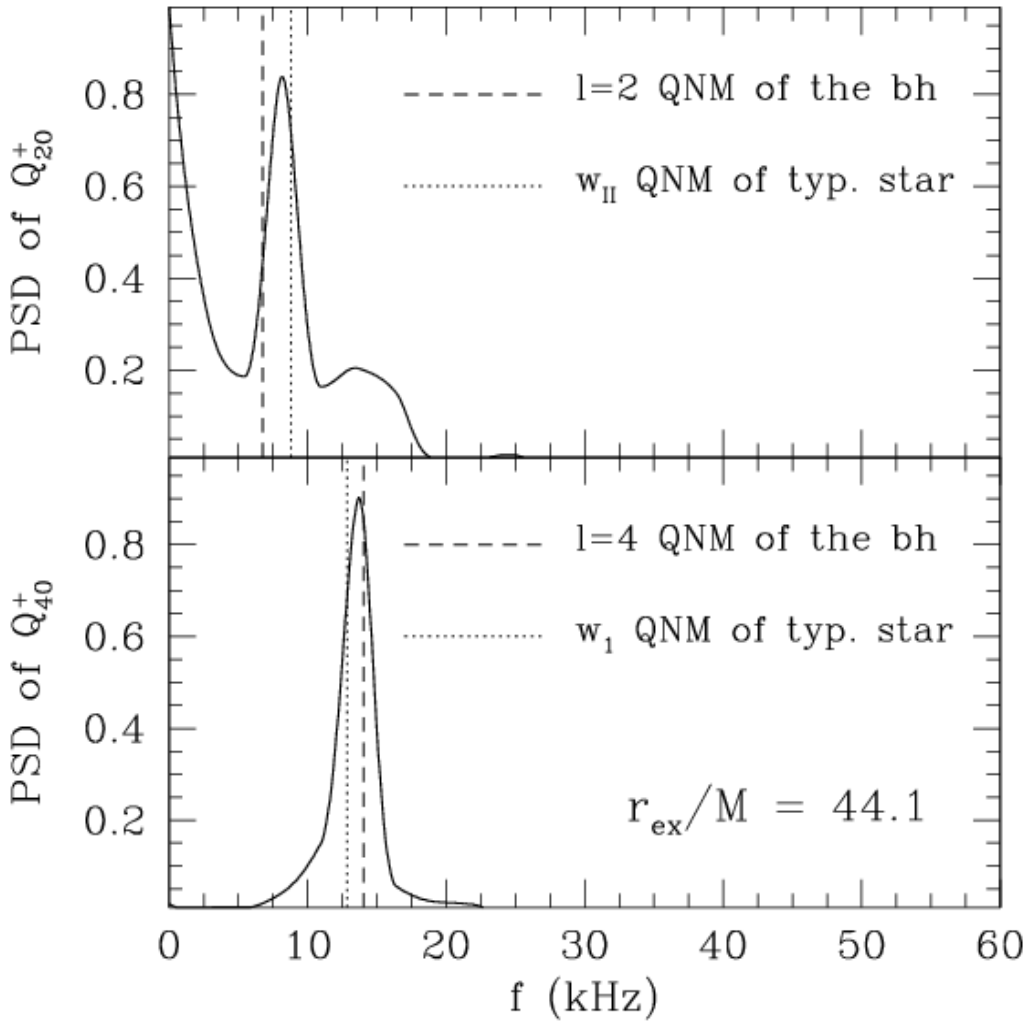

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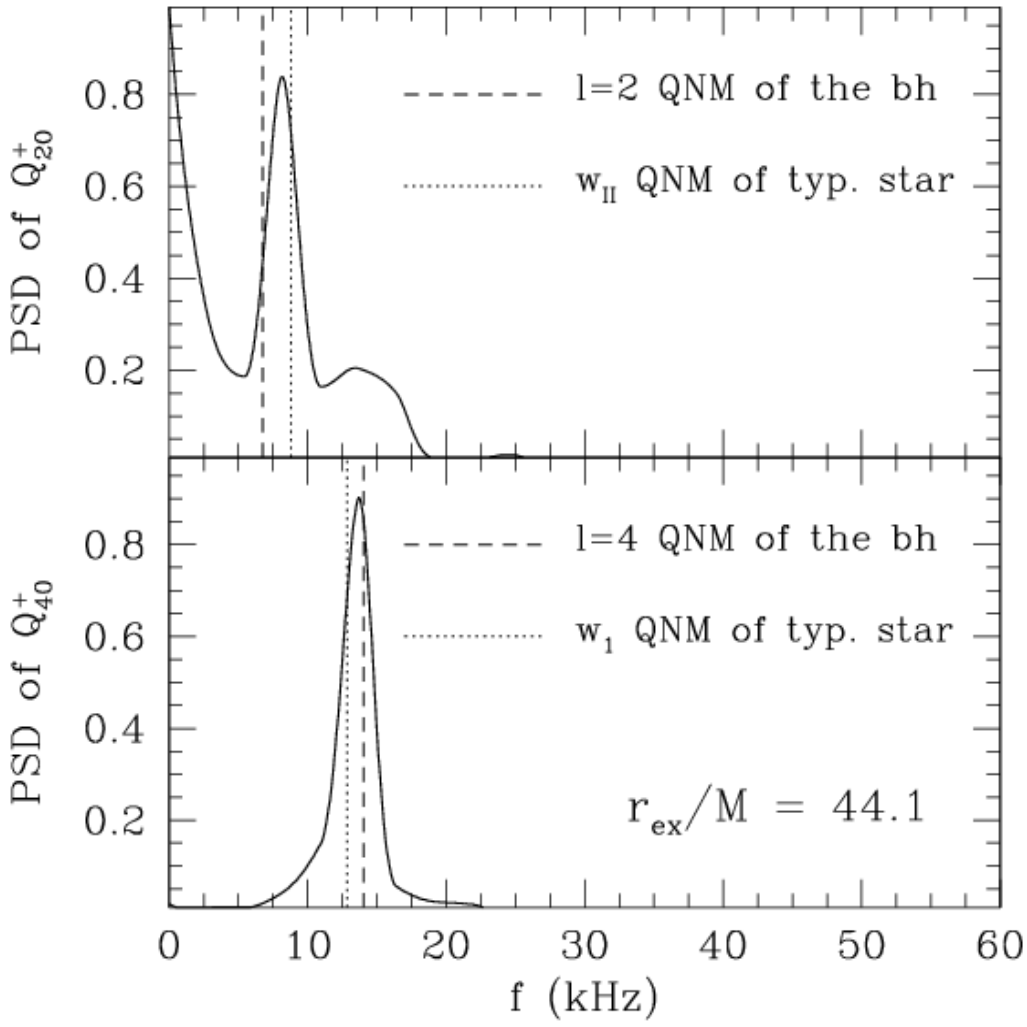

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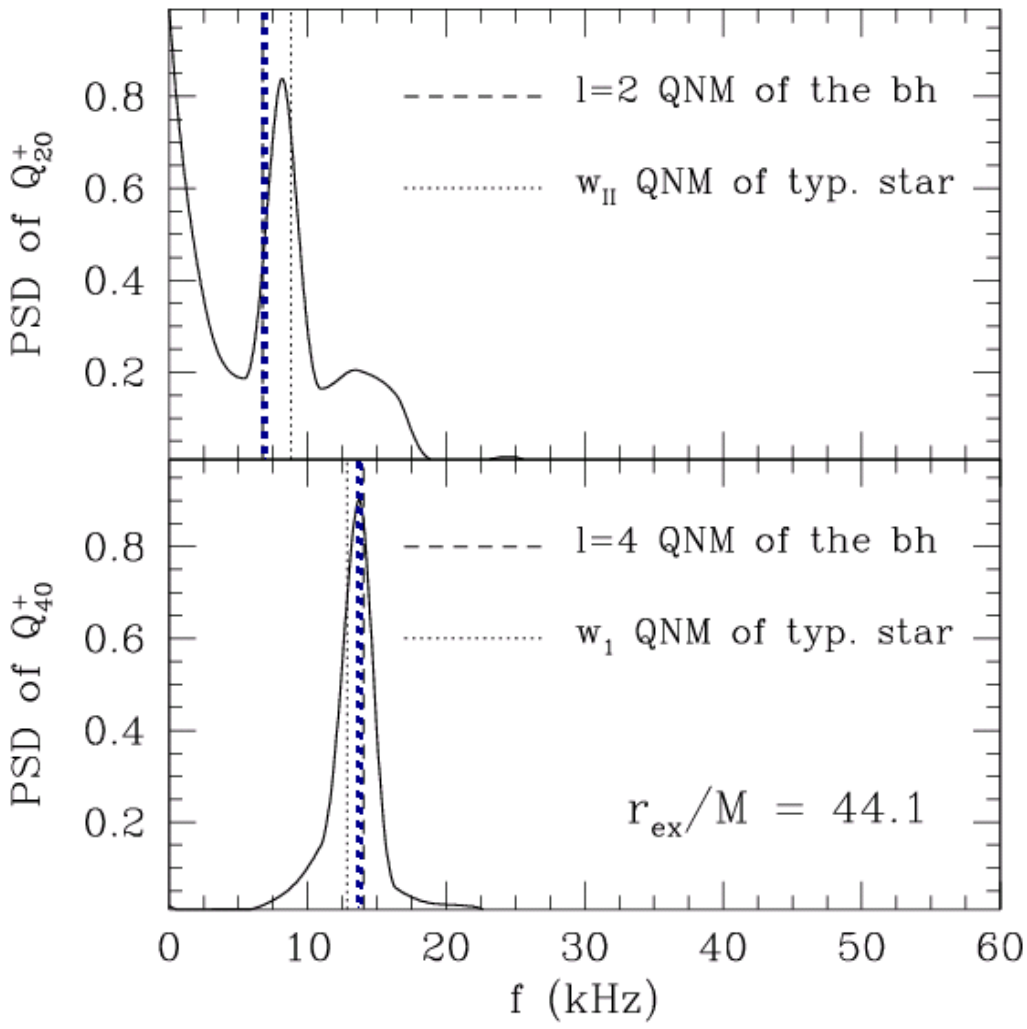
Applied to this model we find that the $w$ modes for the NS background are considerably closer to the BH QNMs.



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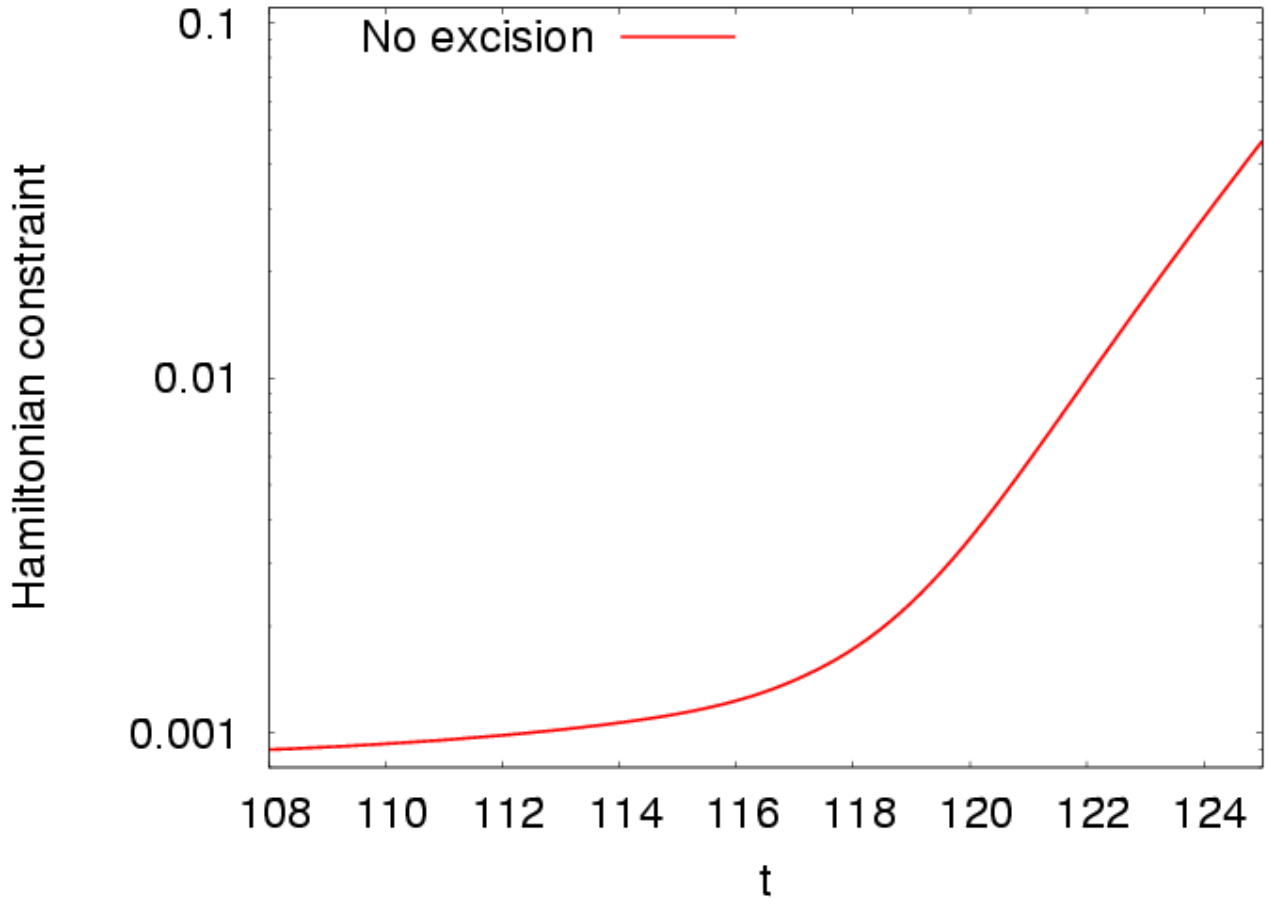

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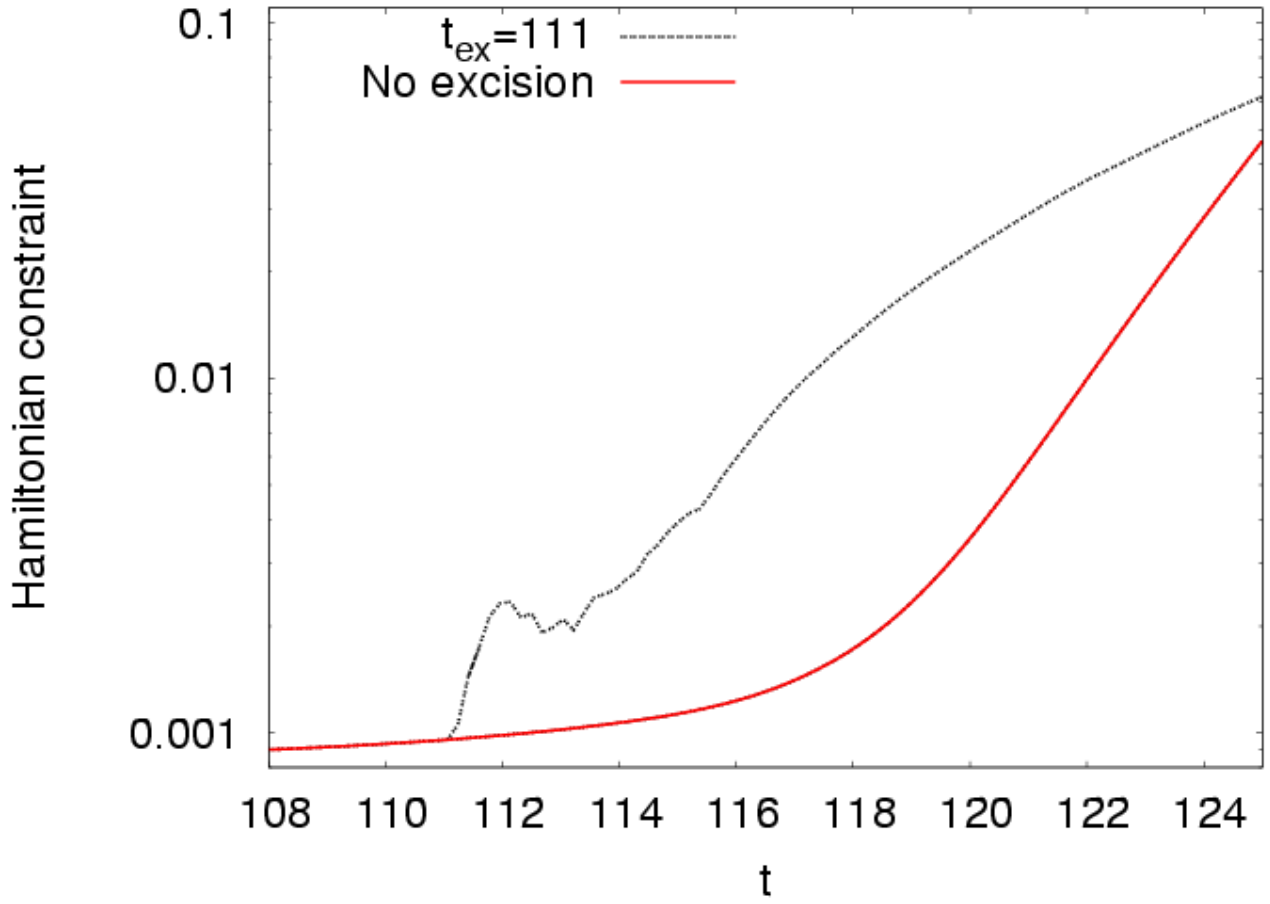

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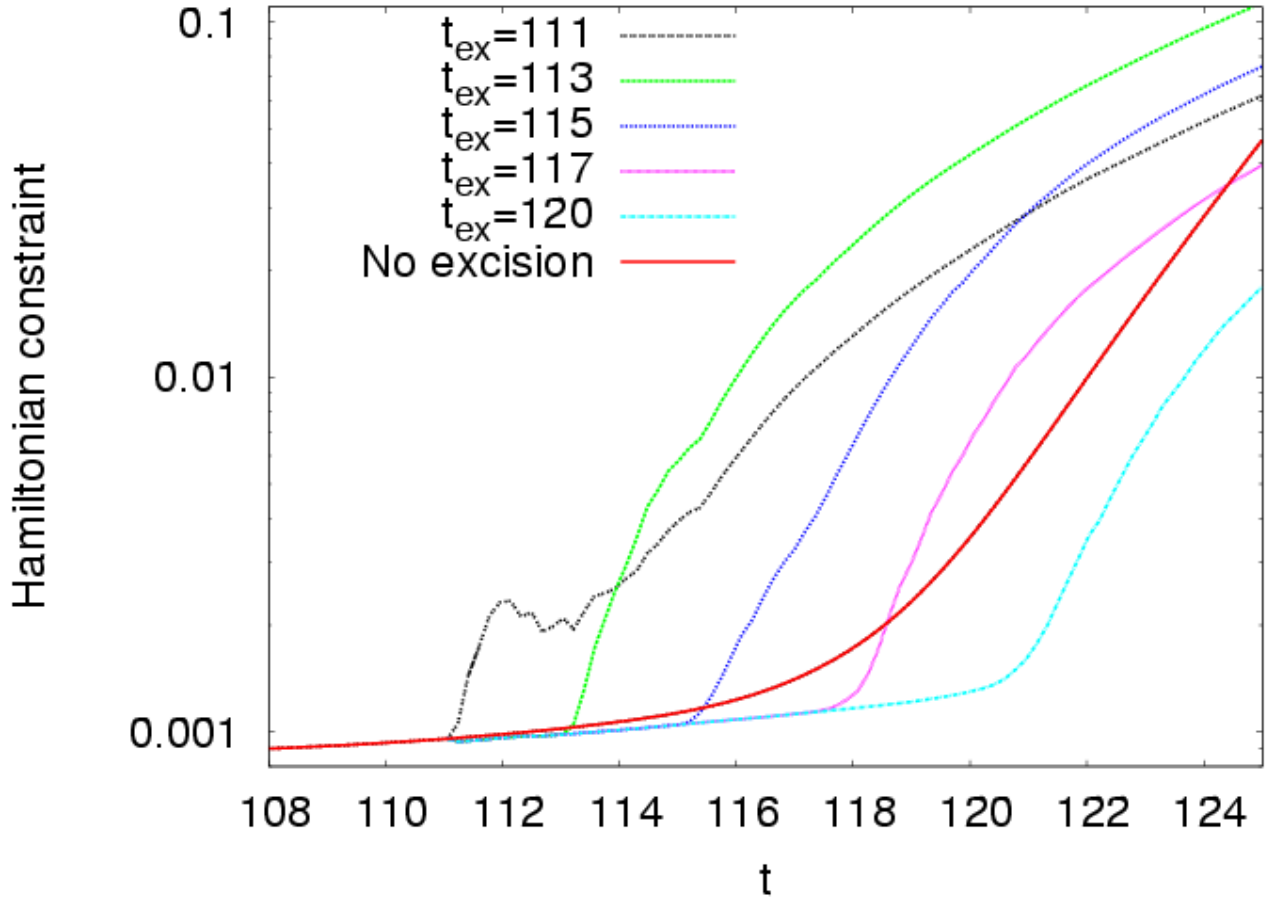

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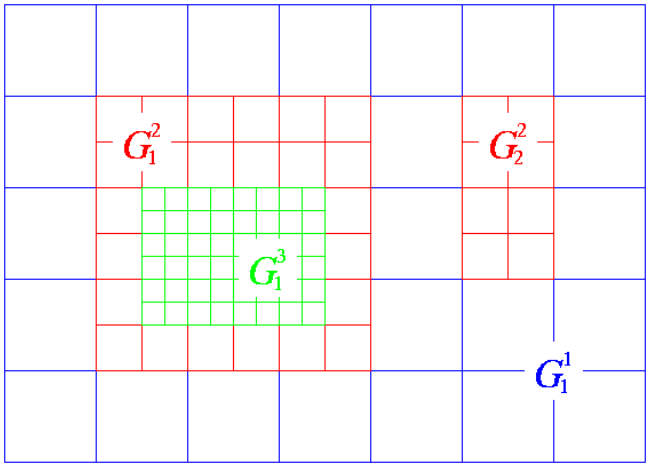


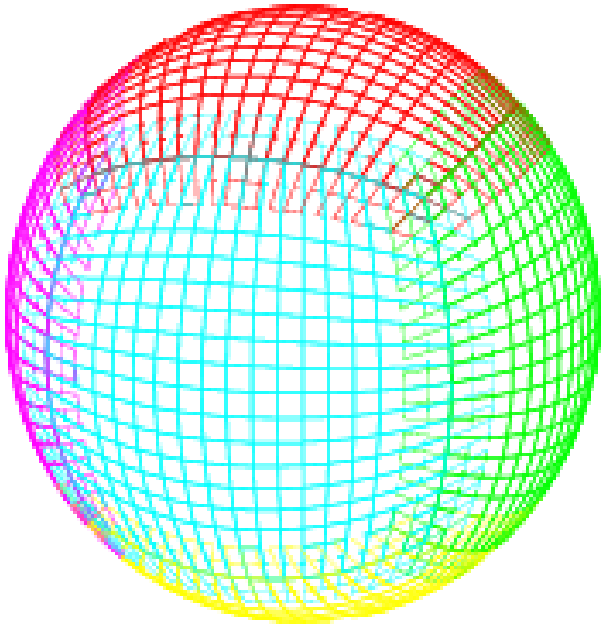

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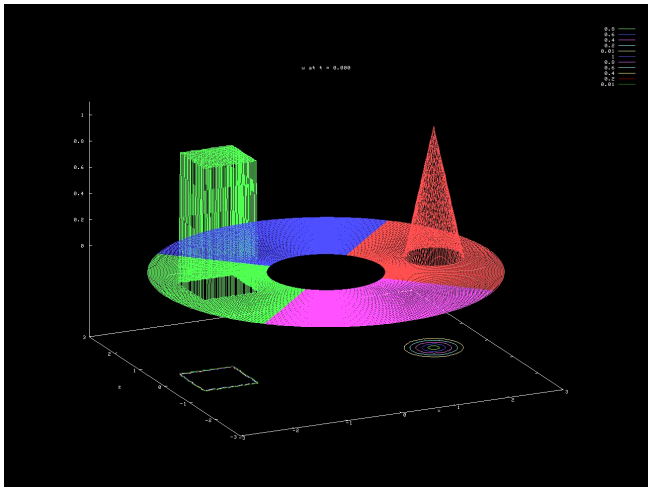
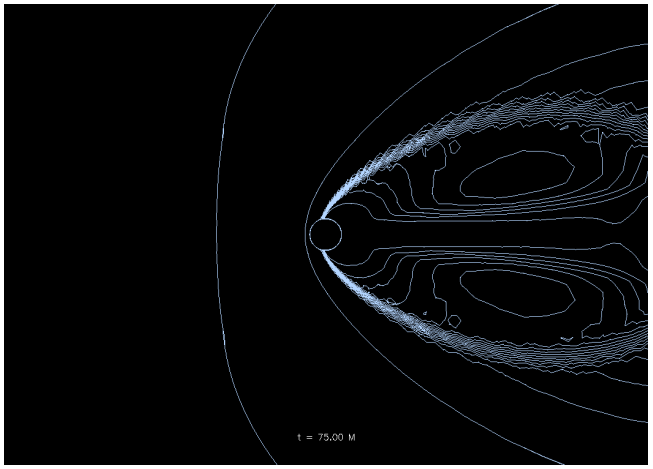


Using this approach discontinuities can be smoothly propagated through grid boundaries, and tests such as wind accretion involving shocks performed.



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