Rotation profile of neutron star merger remnants

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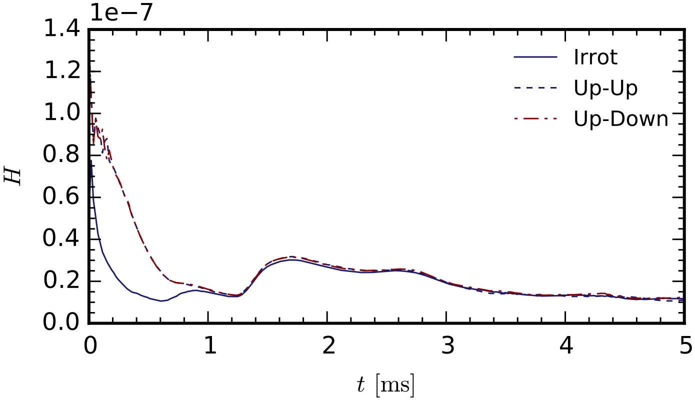
Initial data

- Irrotational, equal mass
- Baryonic mass $2 \times 1.513\ M_\odot$
- Grav. mass of single star $1.4\ M_\odot$
- EOS: G. Shen, Horowitz, Teige
- Maximum TOV baryonic mass $3.33\ M_\odot$
  $\Rightarrow$ Remnant is stable !
- Corner case, probably not realistic
- No magnetic field
- Initial proper separation $57.6\ \mathrm{km} \Rightarrow 4$ Orbits

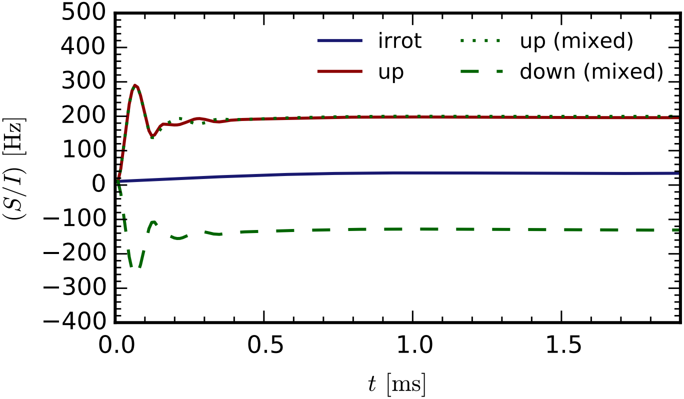
Initial data with spin

- Add rotational velocity field manually
- Violates constraints and hydrostatic equilibrium
- Using CCZ4 evolution scheme
- Additional constraint violation gone after 1 ms



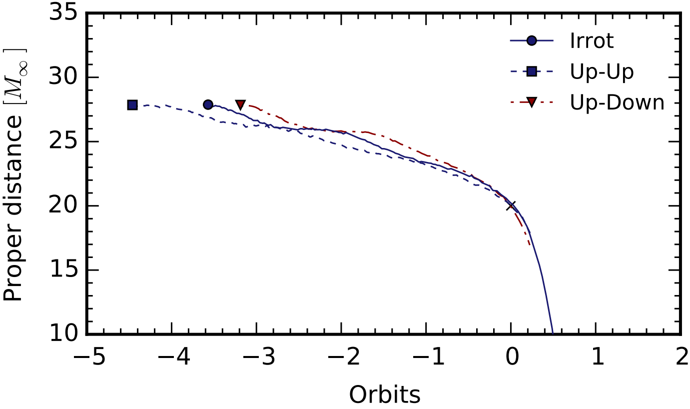
Initial data with spin

- Use Isolated Horizon formalism to measure NS spins
- Spinup/down ≈160 Hz
- Spacetime around star adapts to matter spin within 0.5 ms



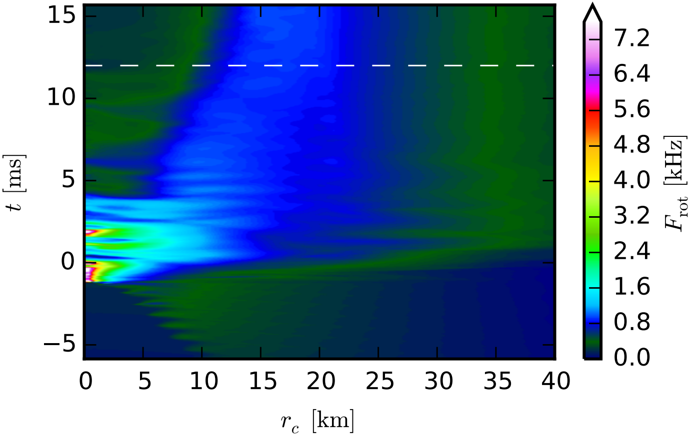
Inspiral

- Observe longer inspiral for aligned spin
- Aligned-Antialigned configuration shows fewer orbits
- Main error source: eccentricity



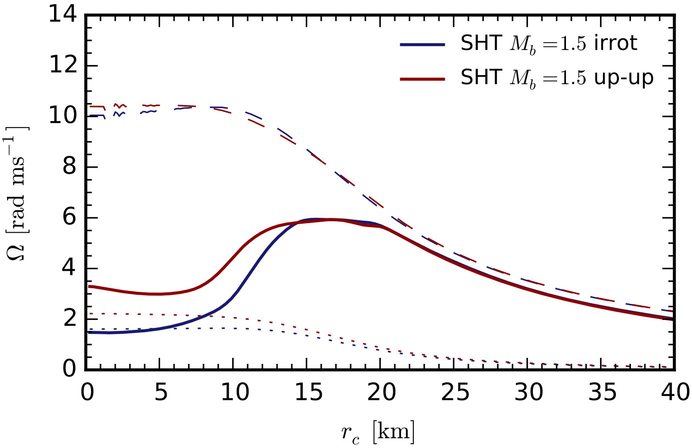
Rotation profile

- Initial rapid rotation in the core quickly redistributed



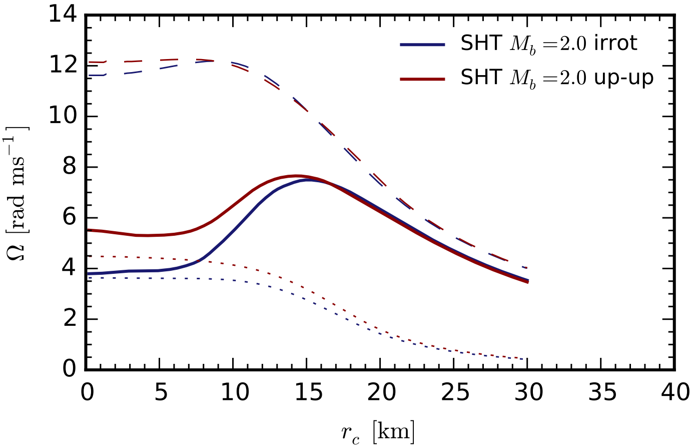
Rotation profile

- Remnant rotation profile has slowly rotating core
- Aligned initial spin slightly increases central rotation



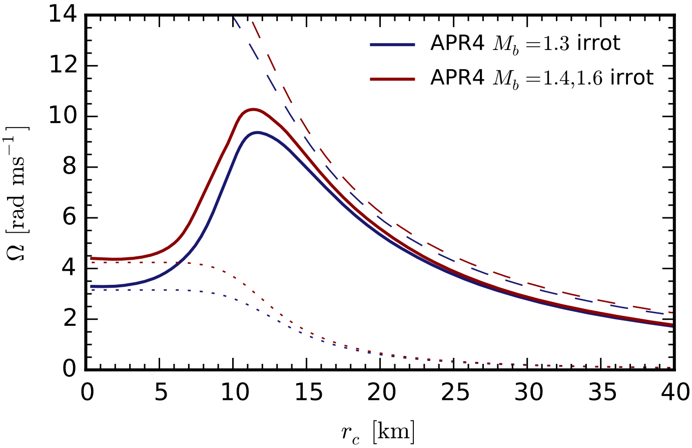
Rotation profile

- Heavier models show faster rotation
- Collapse prevented by centrifugal support of **outer** layers



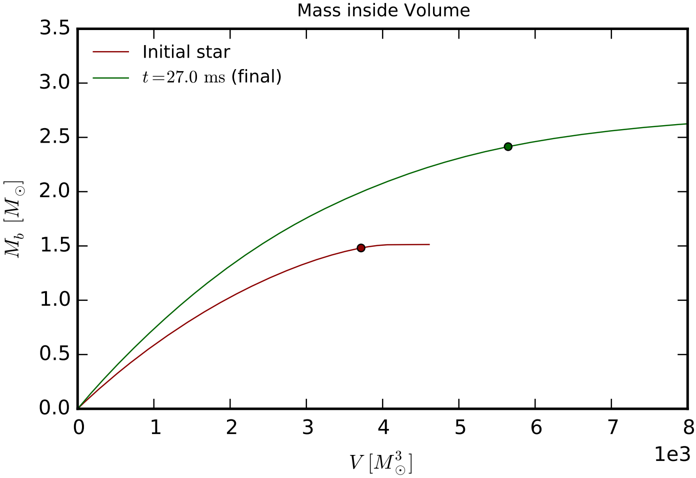
Rotation profile

- Found same for different EOS: SHT, LS220, APR4
- Also for HMNS,SMNS,NS, **unequal mass**



Remnant mass distribution

- Remnant core rotates slowly, expect weak deformation



Remnant mass distribution

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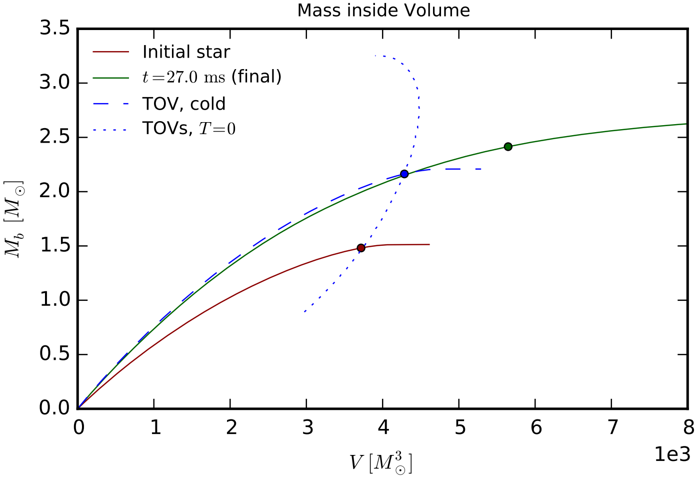
- Can find TOV with matching core profile



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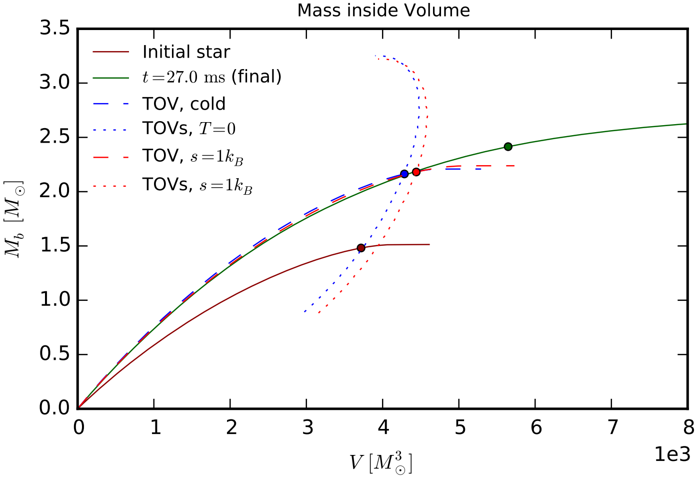
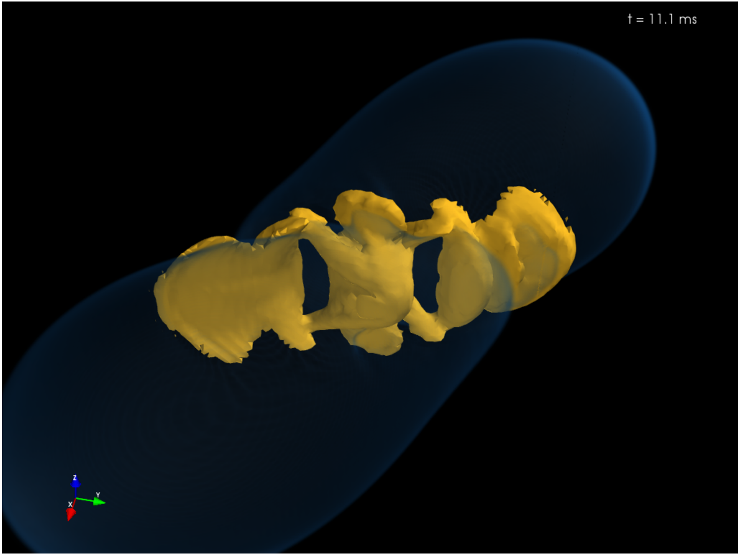
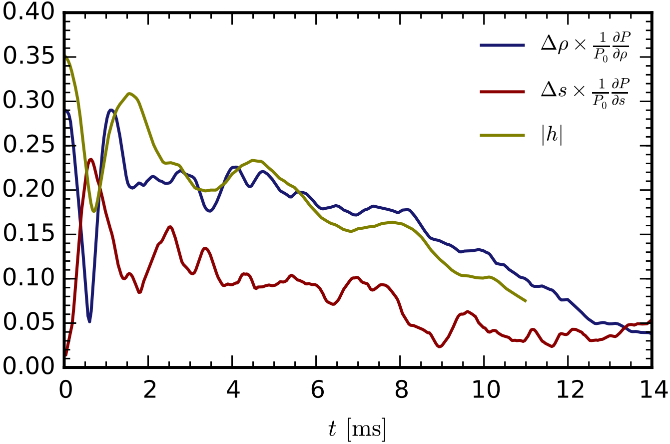


Deformation and hotspots



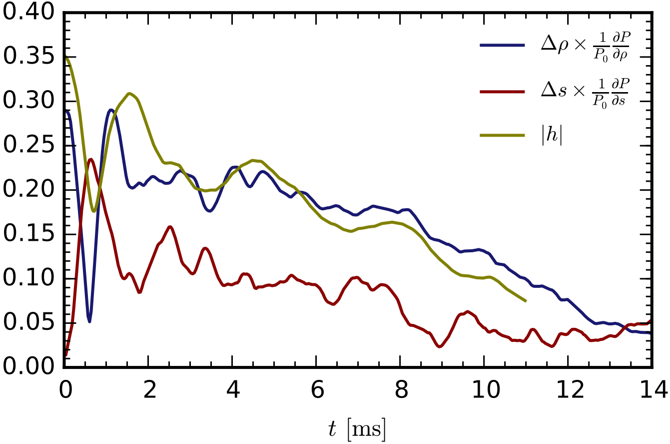
Deformation and hotspots

- Compute $m = 2$ moments of ρ and S in the equatorial plane
- Compute corresponding pressure change around average state



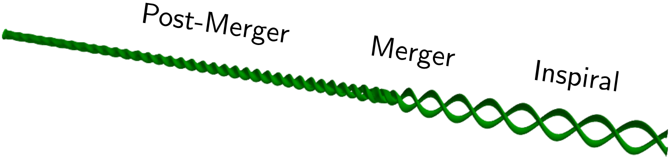
Deformation and hotspots

- Compute $m = 2$ moments of ρ and S in the equatorial plane
- Compute corresponding pressure change around average state
- Hot spots seemingly caused by local compression of fluid flow
- Backreaction on perturbation likely



Deformation and hotspots

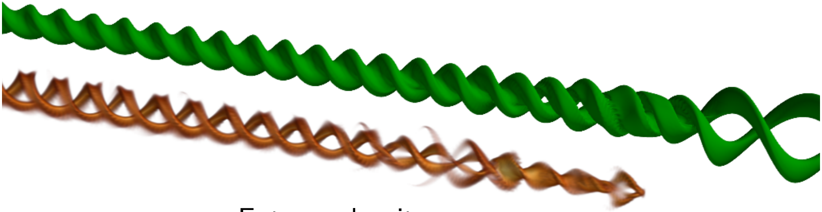
- Visualize evolution in equatorial plane as *xy*-*t*-diagram



Isodensity surfaces containing 0.25 of total mass

Deformation and hotspots

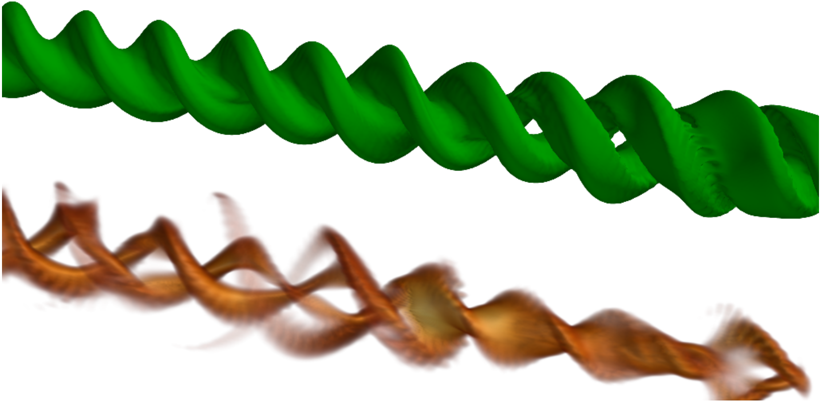
- Hot spots and density perturbation phase coupled



Entropy density

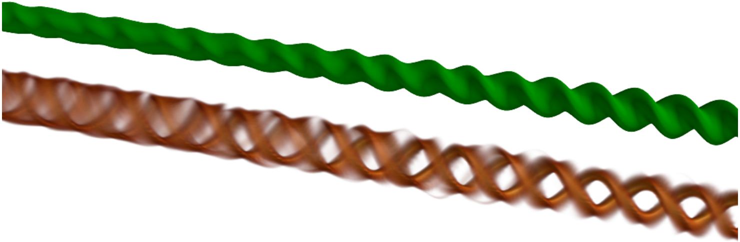
Deformation and hotspots

- Short double core phase after merger
- Separated by hot region



Deformation and hotspots

- In the end, entropy becomes more axisymetric

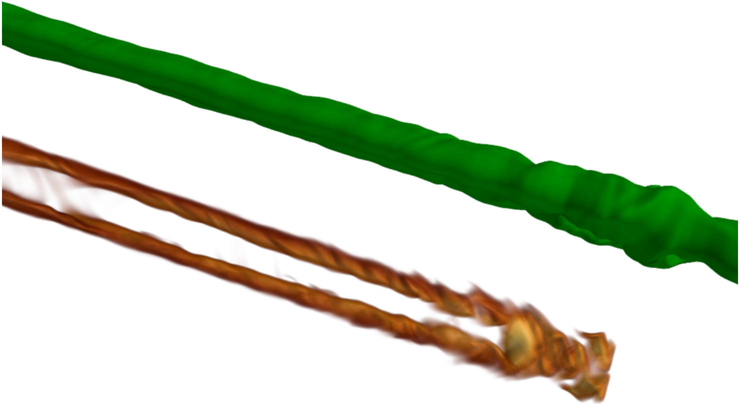


Deformation and hotspots

- Possible contribution of hotspots to GW signal?
- Untwist *xyt*-diagram, aligned to GW phase

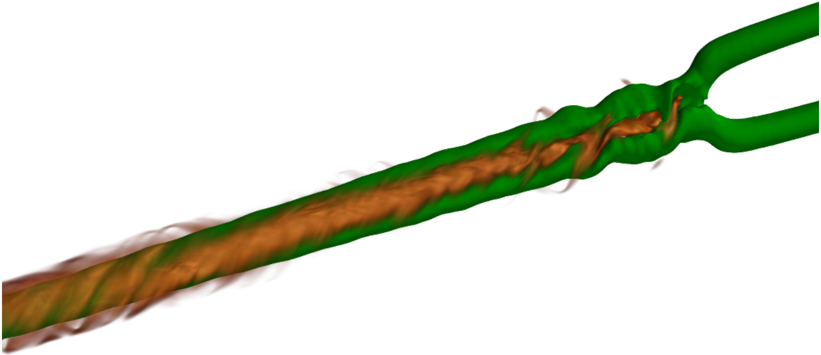
Deformation and hotspots

- Possible contribution of hotspots to GW signal?
- Hot-spots phase locked to density and GW



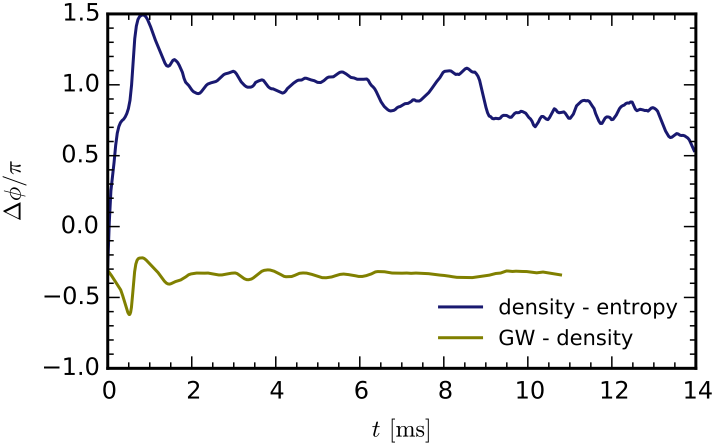
Deformation and hotspots

- Possible contribution of hotspots to GW signal?
- Hot-spots phase locked to density and GW
- Until they dissolve.



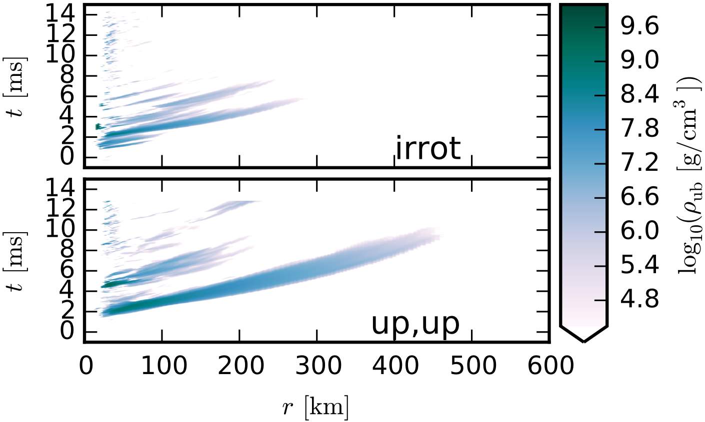
Deformation and hotspots

- Phase between density and entropy perturbation initially locked



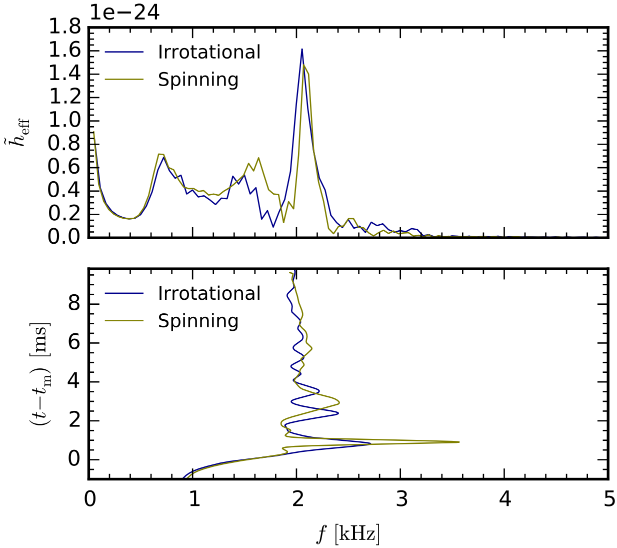
Matter ejection

- Aligned spin: $M_u = 10^{-3} M_\odot$, irrotational: $M_u = 2 \times 10^{-4} M_\odot$
- For the lightweight model, adding spin increases ejected mass



Thanks!

GW signal


1e−24
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$\tilde{h}_{\rm eff}$
Irrotational
Spinning
8
6
4
2
0
$(t - t_{\rm m})$ [ms]
Irrotational
Spinning
0
1
2
3
4
5
f [kHz]