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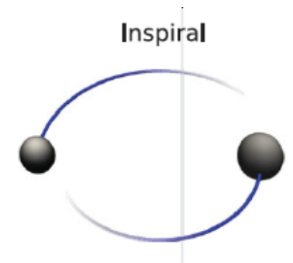
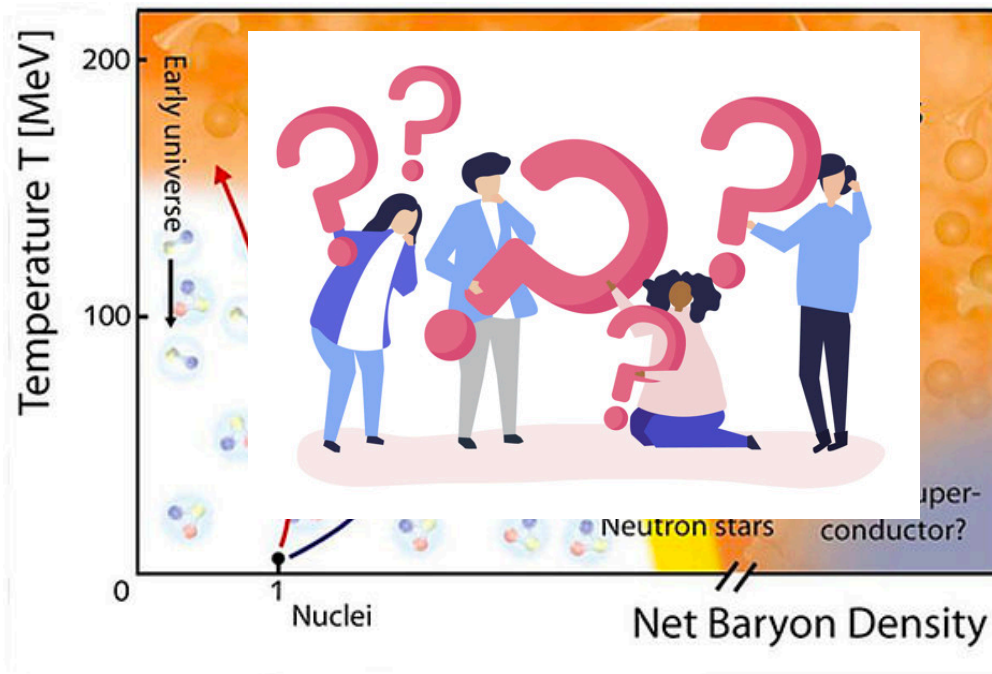
Relativistic Fluid Dynamics: From Heavy Ions to Neutron Star Mergers

Jorge Noronha

Open mic session at the QCD Town Hall Meeting,
MIT, September 2022



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- New constraints on the neutron star EOS from inspiralling neutron stars – that’s great.
- But if we stop there, we will miss a great opportunity.
- Transport is critical for finding new phases of matter (e.g. color superconductivity): we must go beyond equilibrium!

Ideal fluids



Viscous fluids

in flat spacetime

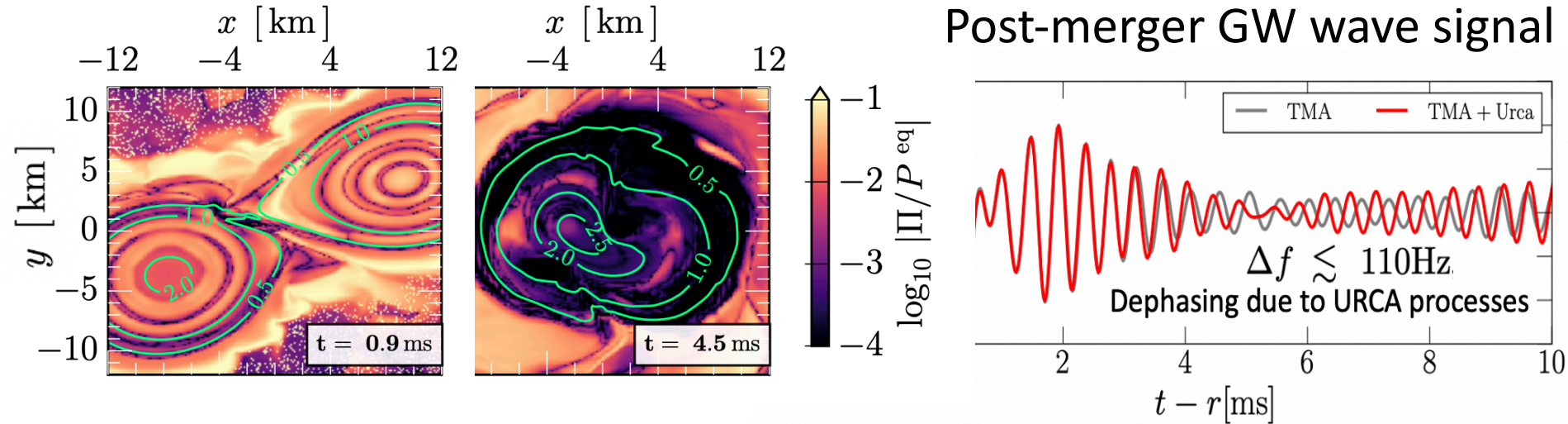
In heavy ions this led to a **paradigm shift** and many insights:

- Nearly perfect fluidity of the quark-gluon plasma
- Better characterization of the initial state
- Emergence of hydrodynamics even far from equilibrium
- Connection to other fields: AdS/CFT, cold atoms, astro



Viscous neutron star mergers! $\zeta \neq 0$

E. Most, A. Haber, S. P. Harris, Z. Zhang, M. G. Alford, and JN, arXiv:2207.00442 [astro-ph]



- Beta equilibrium deviations = bulk viscous hydrodynamics

$$\mu_n - \mu_p - \mu_e \sim \Pi$$

- Same viscous hydro theories used in heavy-ions!

- Neutron star mergers should also give us key information about hot and dense QCD matter out of equilibrium.

NEW OPPORTUNITIES!!!

NEW QUESTIONS!!!

- The developments and discoveries in relativistic hydrodynamics made in heavy ions will be crucial here.

NEW CHALLENGES!!!

- Synergy between heavy-ions and neutron star mergers is bound to unravel new phenomena in hot and dense QCD.

THINK BIG, BOLD, DEEPER

NP Long Range Plan should be driven by new questions, new challenges, pushing the envelop as much as possible to create new opportunities.

