PAX ‘22: Nuclear Physics

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SOC Chairs: P. Landry, E.R. Most

Panelists

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(CITA)

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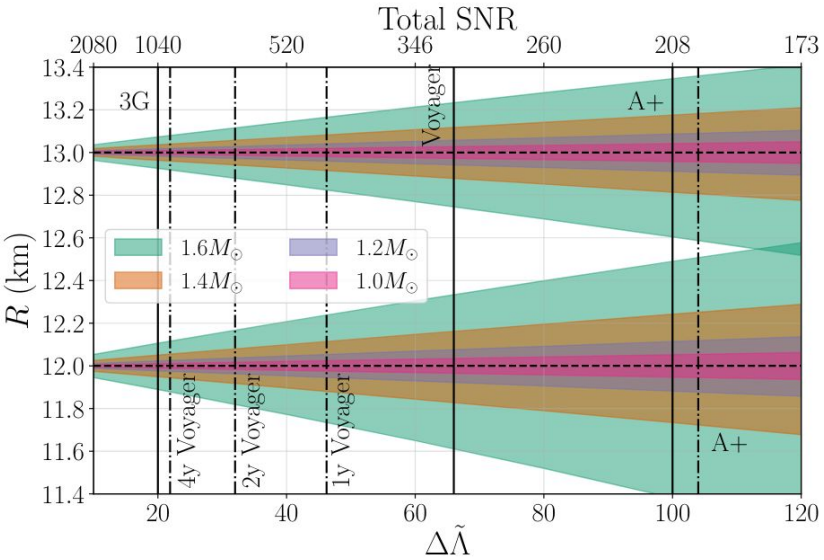
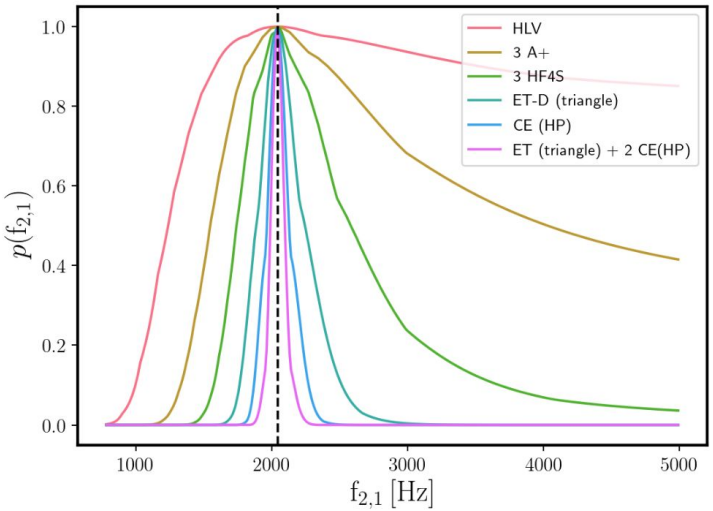
(Princeton/IAS)

3G inspiral EOS measurements

- 3G BNS inspirals: O(10^5) detections per year, several hundred above SNR 100 [Evans+ arXiv:2109.09882]
- GW170817 in a 3G network: SNR 2400, $\Lambda_{1,2}$ measured with ~50% uncertainty [Smith+ PRL 2021]



Neutron star radii
Chatziioannou PRD 2021



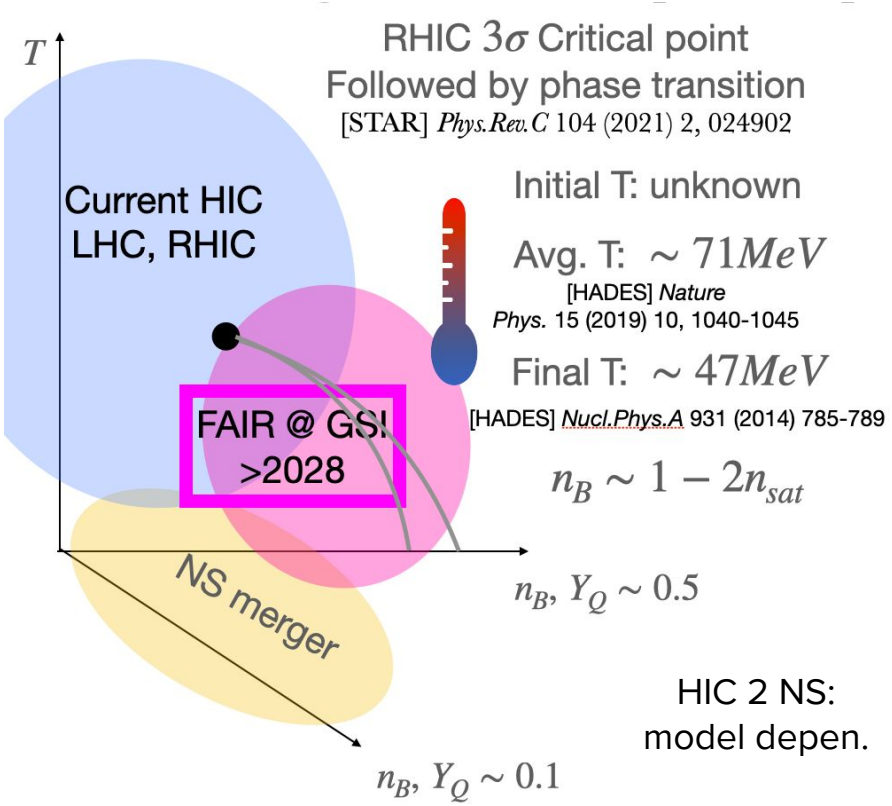
Dynamical tides
Pratten+Schmidt+Hinderer NatComm 2020

Quarks/hyperons at T=0

- 1st-order phase transition: $c_s^2 = 0$ across Δn_B
  - Mass twins, breaking binary love relations
    Alford & Han *Phys.Rev.D* 88 (2013) 8, 083013
    Tan et al, *Phys.Rev.Lett.* 128 (2022) 16, 161101
- Cross-over phase transition: bump in c_s^2 close to causal limit
  Generic bump: Bedaque & Steiner *Phys.Rev.Lett.* 114 (2015) 3, 031103
  Quarkyonic: McLerran & Reddy *Phys.Rev.Lett.* 122 (2019) 12, 122701
  From data: Legend et al, *Phys.Rev.D* 104 (2021) 6, 063003
  - Slope of binary love relation
    Tan et al, *Phys.Rev.Lett.* 128 (2022) 16, 161101

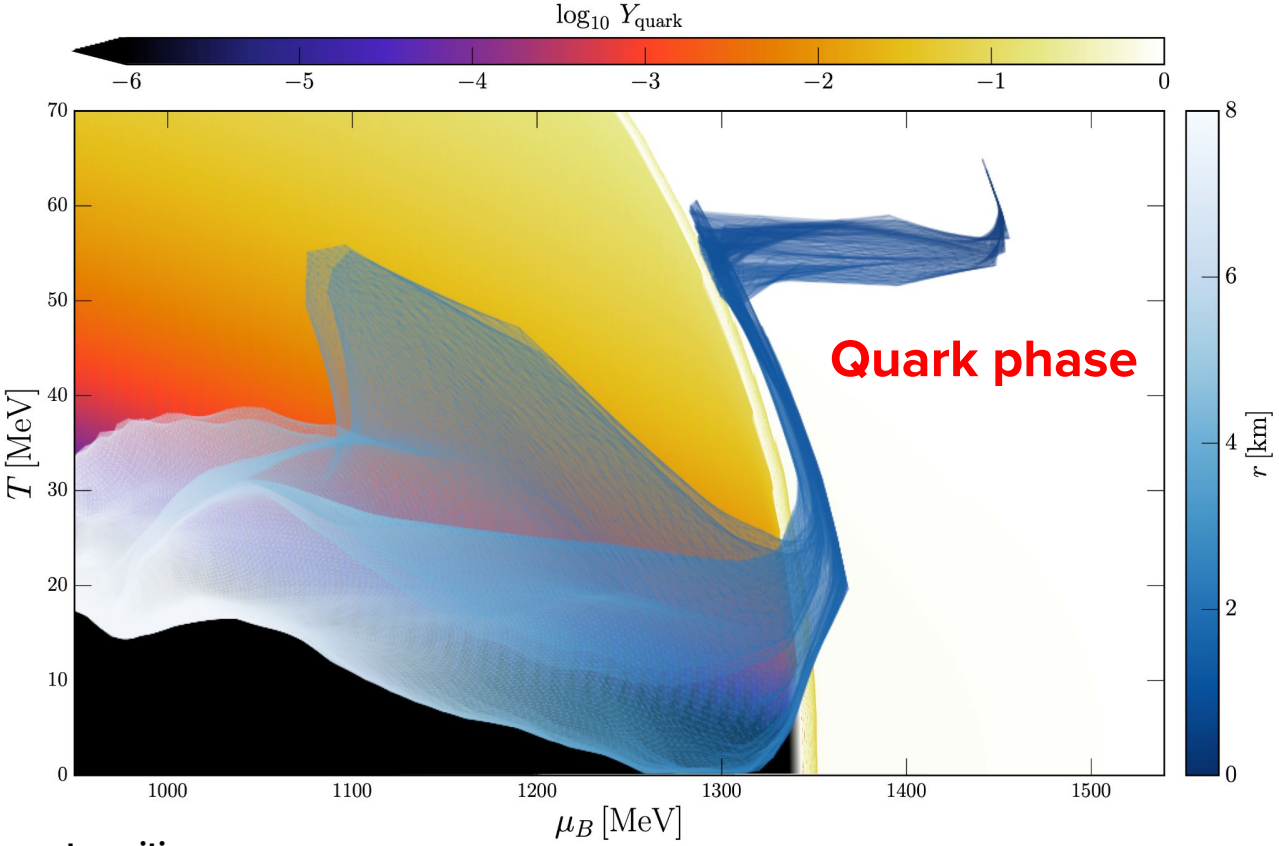
    heavy NS, need Λ for large M!
    Tan, et al, *Phys.Rev.Lett.* 125 (2020) 26, 261104
- Hyperons: small peaks in c_s^2, new constraints from HIC and lattice QCD!
  [ALICE] *Nature* 588 (2020) 232-238; [WB] *Phys.Rev.D* 96 (2017) 3, 034517

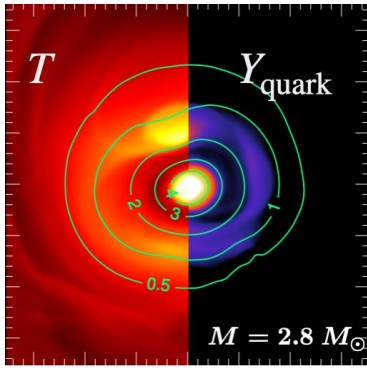
Heavy-ion Collisions



HIC 2 NS:
model depen.

Probing the QCD phase diagram in the post-merger





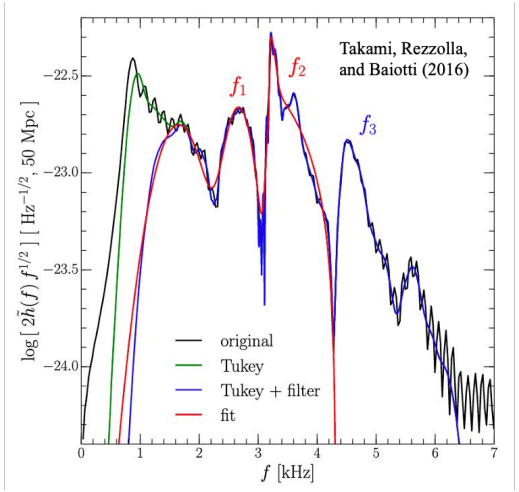
Hadron-quark phase transition

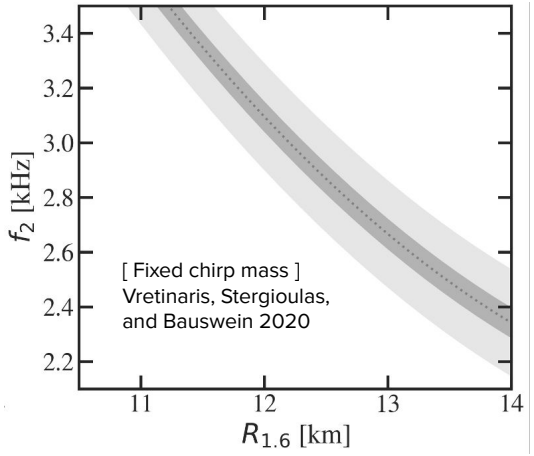
Most, Papenfort, Dexheimer, Hanauske, Stoecker, Rezzolla. 2019, 2020

Post-merger gravitational waves

- What parts of the EOS parameter space will post-merger GWs probe?
    - Higher densities? Finite-temperature effects? Non-equilibrium physics? New degrees of freedom?
- How will this complement / compare to constraints from large populations of Λ measurements with XG detectors?
- How well constrained will the EOS be by the 2030s from current-generation of Λ constraints? From X-ray radii? From nuclear experiments?
- How well will we be able to distinguish spectral features of post-merger GWs? Is there risk of confusing spectral peaks?

[For reviews, e.g.: Baiotti & Rezzolla 2017; Paschalidis & Stergioulas 2017; Bauswein & Stergioulas 2019; Bernuzzi 2020]



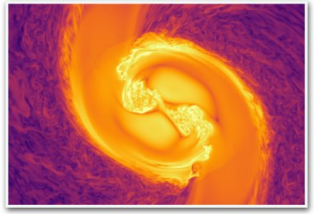


Some considerations

Post-merger gravitational wave emission will be highly degenerate!

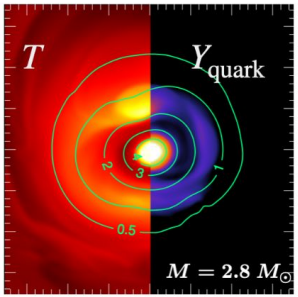
Magnetic fields?

Ciolfi+, Giacomazzo+, Kiuchi+, Palenzuela+,...



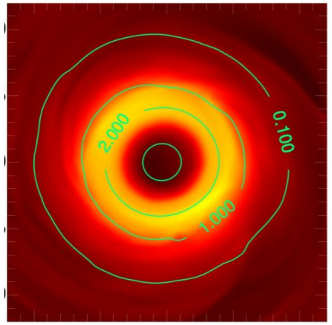
Exotic degrees of freedom?

Bauswein+, Huang+, Most+,Prakash+,
Radice+,Sekiguchi+,Weih+... (+ many more for EoS uncertainty!)



Finite-temperatures?

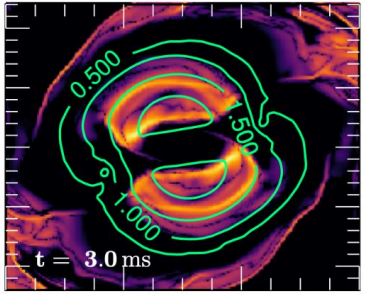
Bauswein+, Figura+,
Hanauske+,Perego+Raithel+...



Neutrino effects?

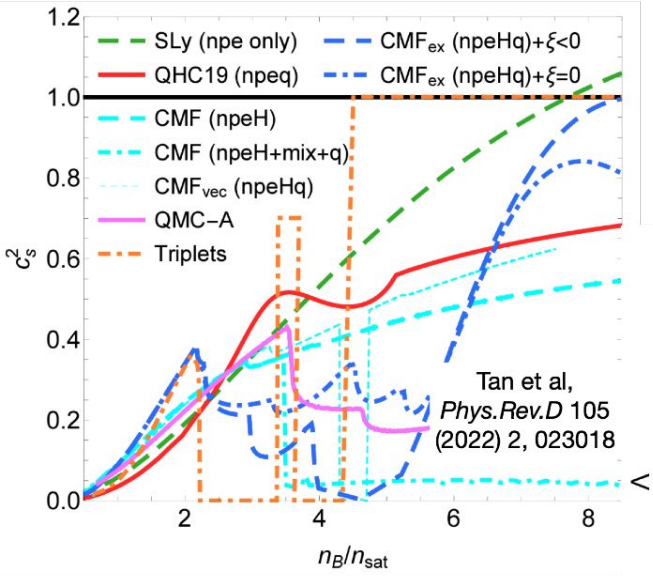
(in dense matter)

Alford+, Camelio+, Foucart+,
Hammond+, Most+,Radice+,
Shibata+,...



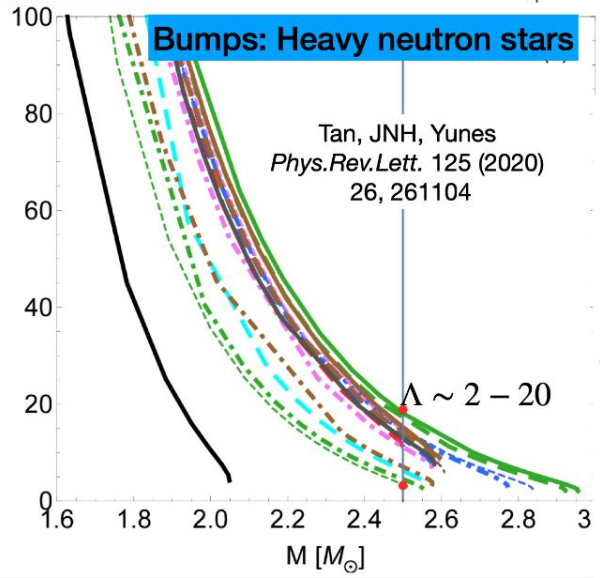
BACKUP: plots of EOS T=0

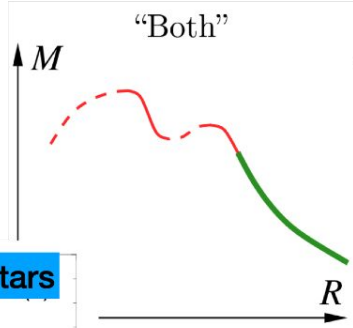
Nuclear physicists: on the quest for ***stable*** hyperons or quarks in neutron stars

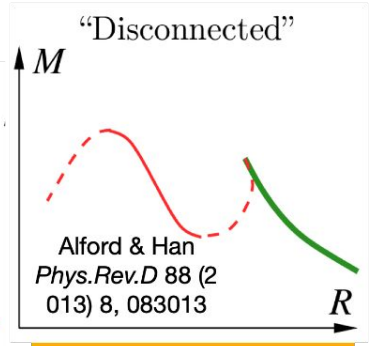


Signature of quarks/hyperons: bumps/kinks/plateaus in

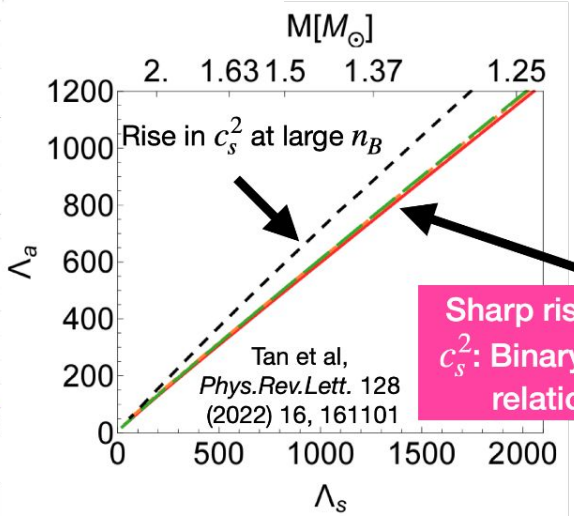
$$c_s^2 = dp/de$$







Plateaus: Mass twins



Sharp rises in c_s^2: Binary love relation