

Probing Nuclear Physics with Gravitational Waves

Dixième Assemblée Générale du
GdR Ondes Gravitationnelles
5 Octobre 2026

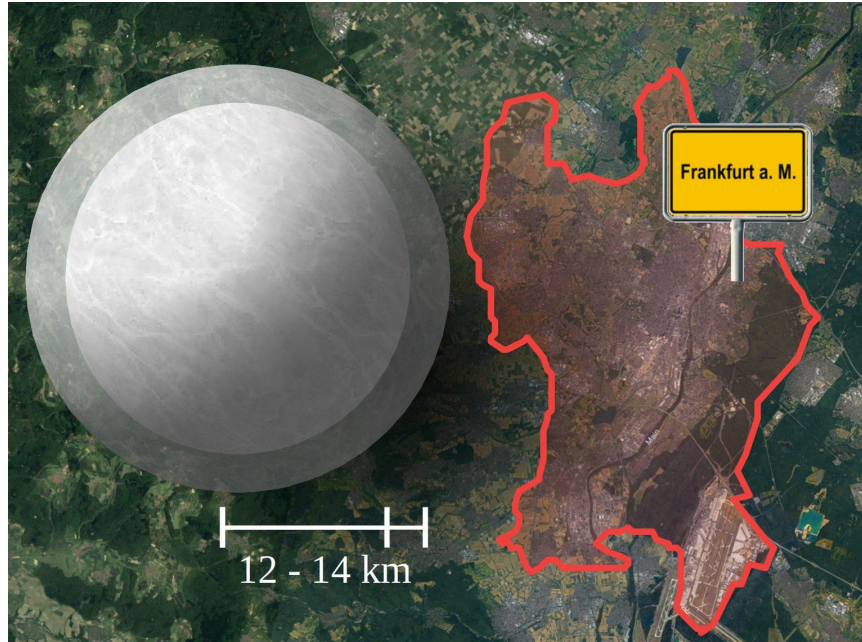


Lami Suleiman

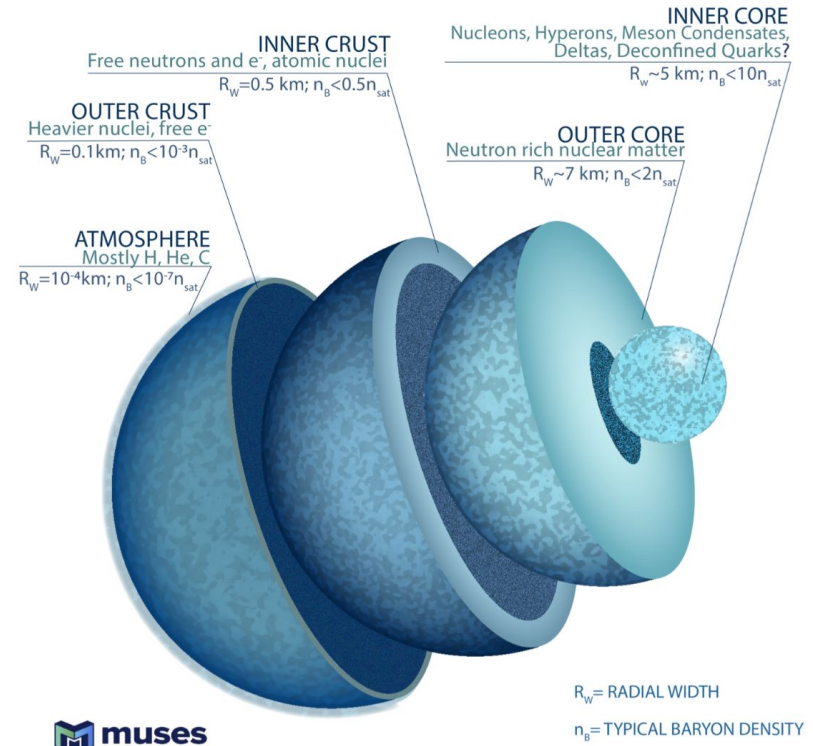


Neutron Stars (NSs) as probes for Nuclear Physics

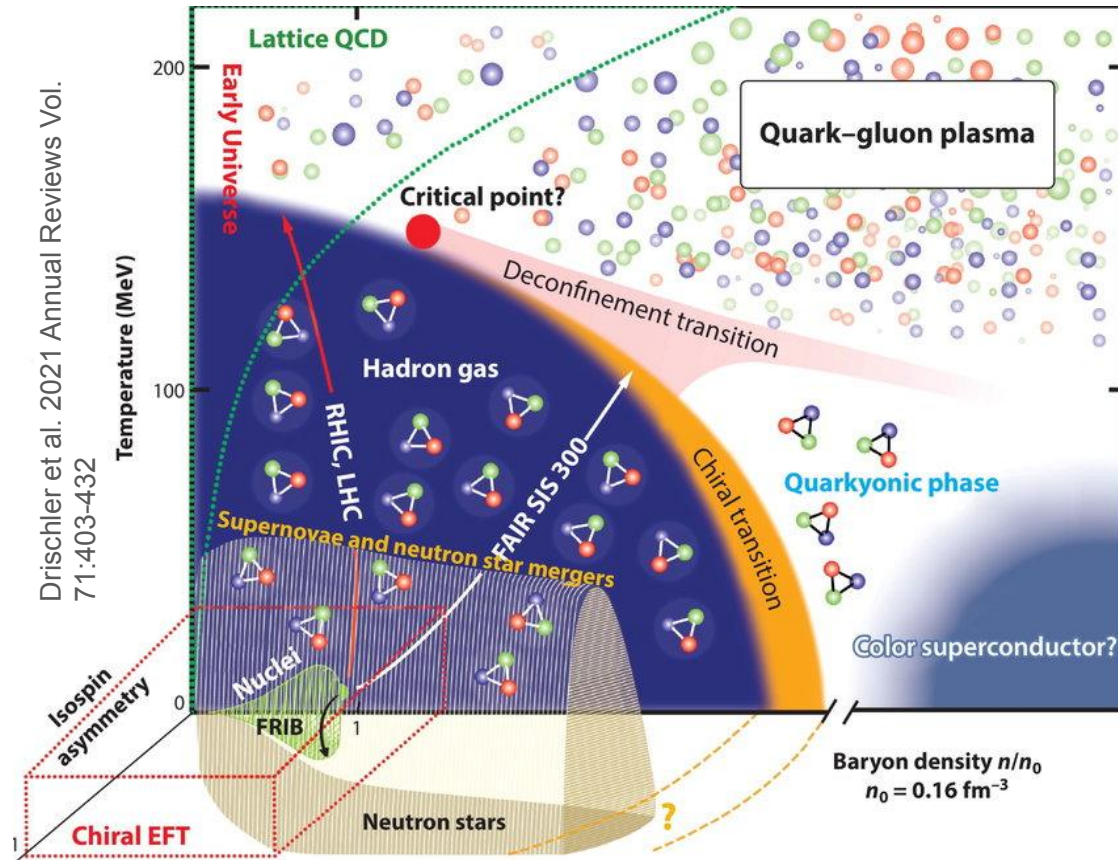
$$M \simeq 1 - 2M_{\odot}$$



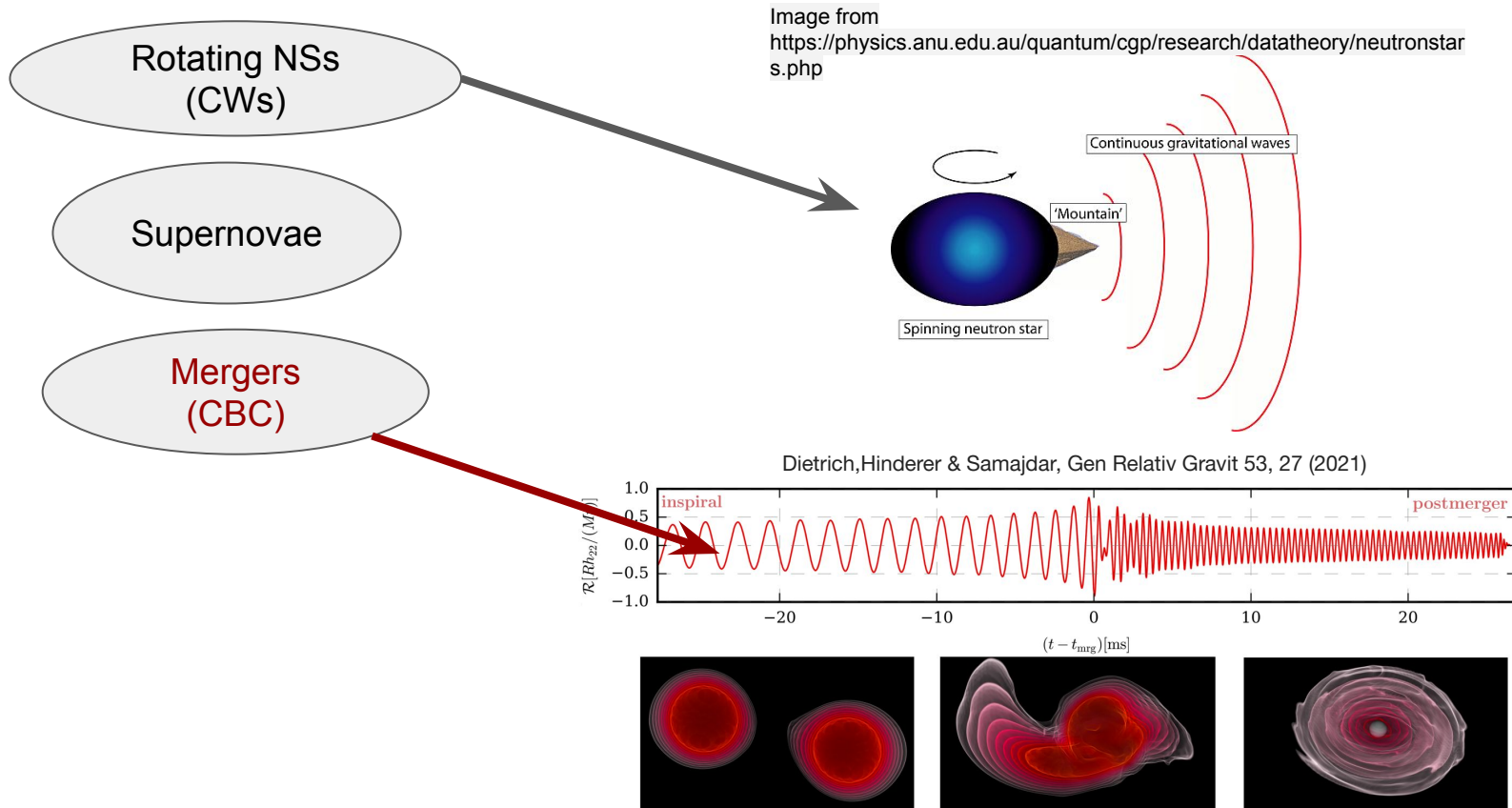
Credit: Lukas Weih, Goethe University



Neutron Stars (NSs) as probes for Nuclear Physics



Gravitational Wave (GW) detections of NS involved events

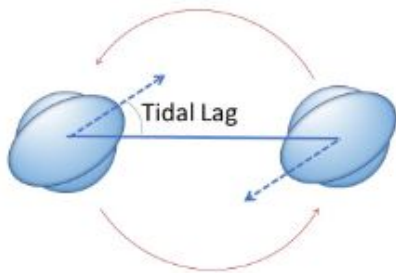


Gravitational Wave (GW) detections of NS involved events

Rotating NSs
(CWs)

Supernovae

Mergers
(CBC)

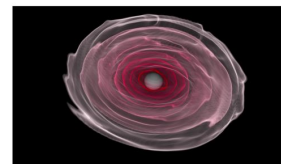
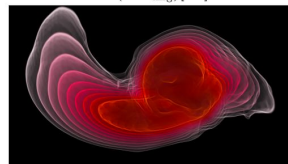
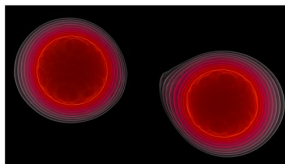
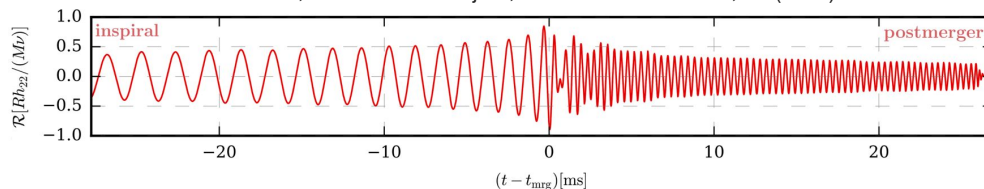


Tidal deformation of the NS

$$\tilde{\Lambda} = \frac{1}{16} \left(\frac{m_1 + 12m_2}{m_1} \Lambda(m_1) + \frac{m_2 + 12m_1}{m_2} \Lambda(m_2) \right)$$

$$\delta\Phi \propto \tilde{\Lambda} \quad \mathbf{5 \text{ PN}}$$

Dietrich, Hinderer & Samajdar, Gen Relativ Gravit 53, 27 (2021)

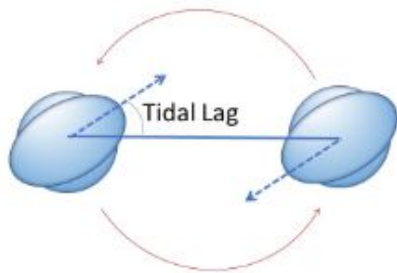


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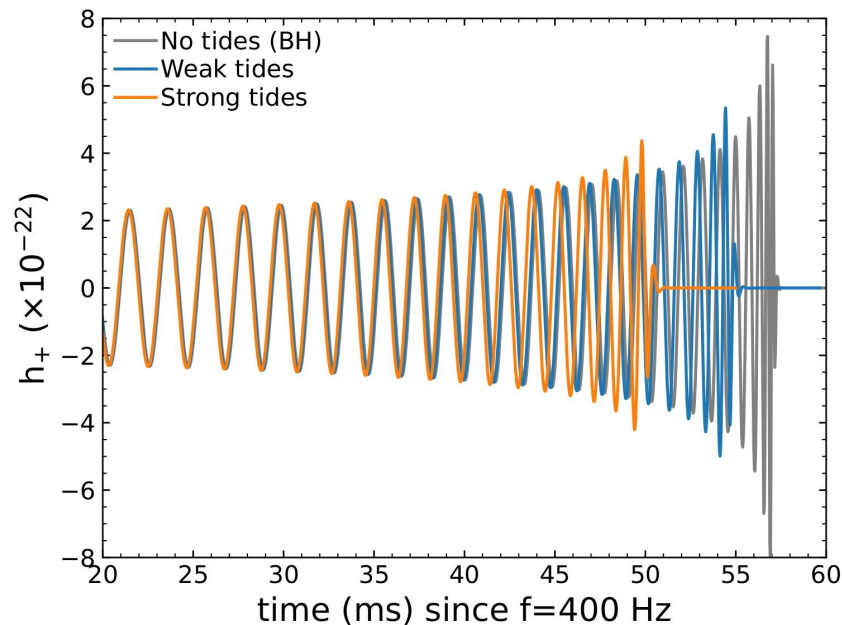
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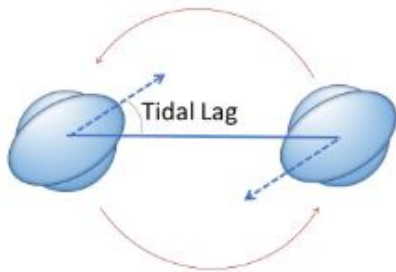


Gravitational Wave (GW) detections of NS involved events

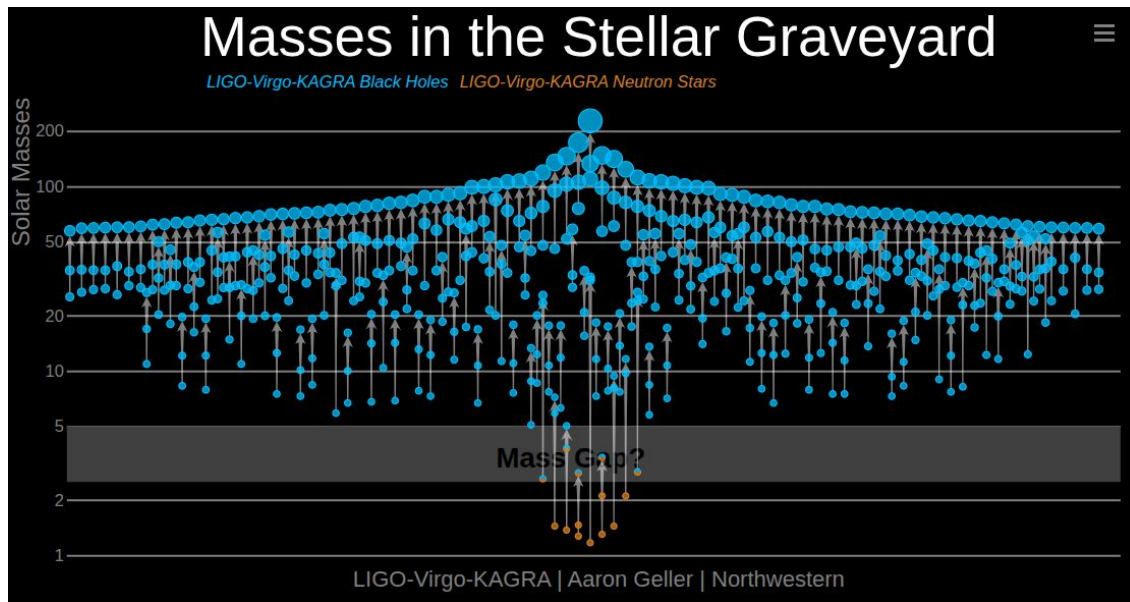
Rotating NSs
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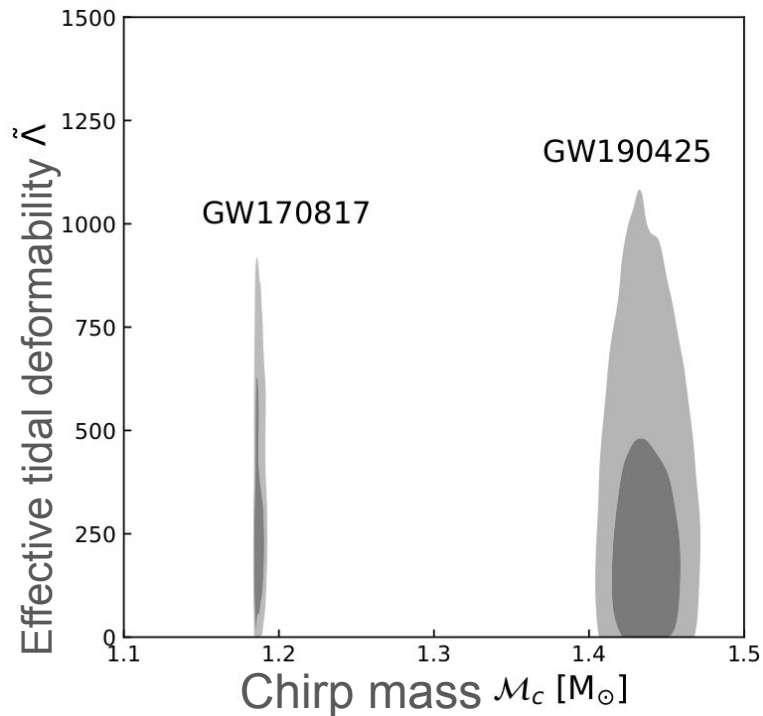
Mergers
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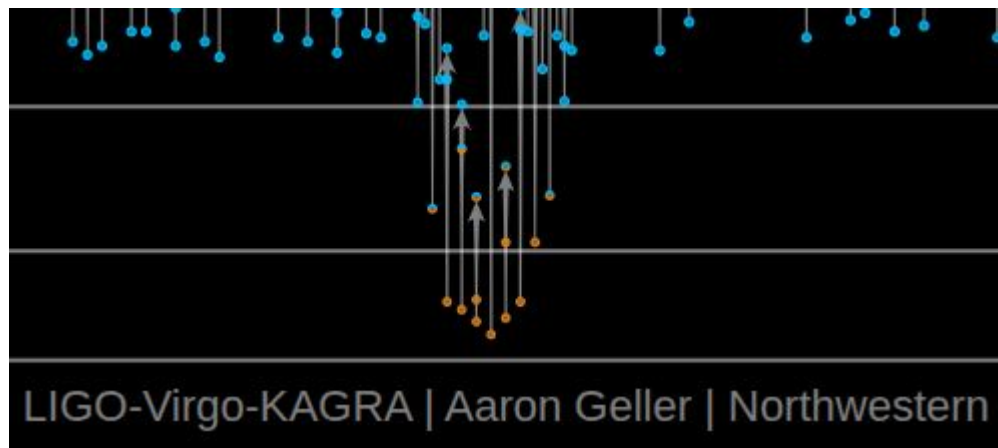
Tidal deformation of the NS



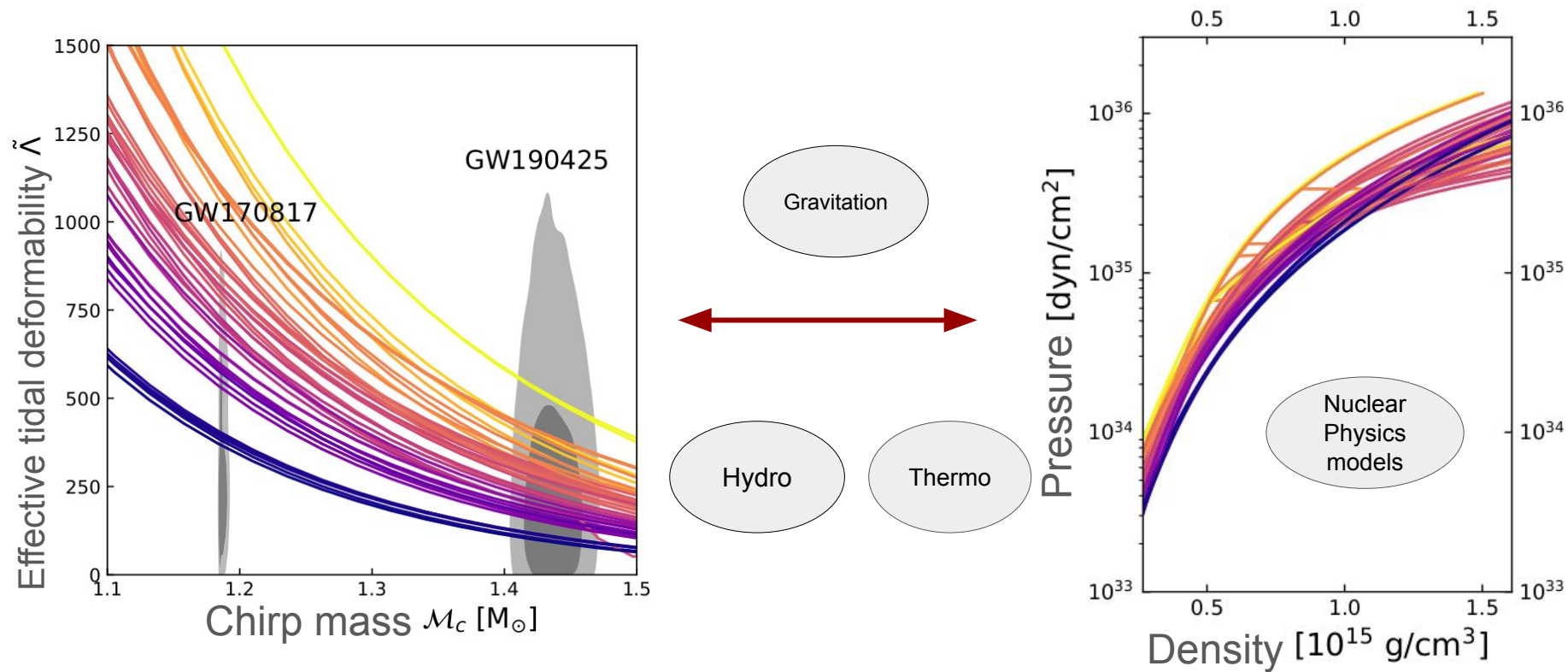
Dense Matter Equation of State inference with CBC GWs



BNSs: GW170817, GW190425
NSBHs: GW200105, GW200115,
GW230529

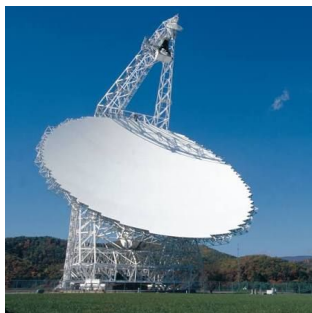


Dense Matter Equation of State inference with CBC GWs

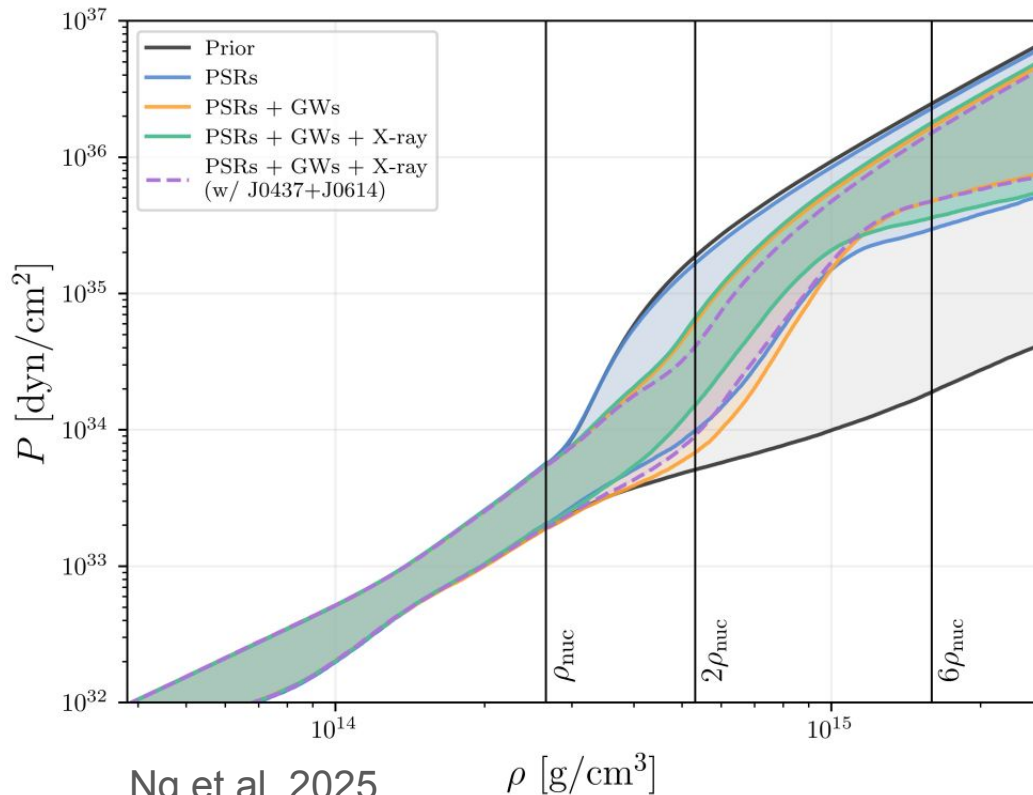


Combining GWs with electromagnetic information

- Radio data:
 - ◆ heavy NSs mass detections
- X-ray data:
 - ◆ hot spots on rotating NSs



Green Bank Telescope



The future of Dense Matter inference with GWs

A lot more sources !

- Enough BNSs to map the mass-tidal sequence
- Constrain EoS in all density regimes

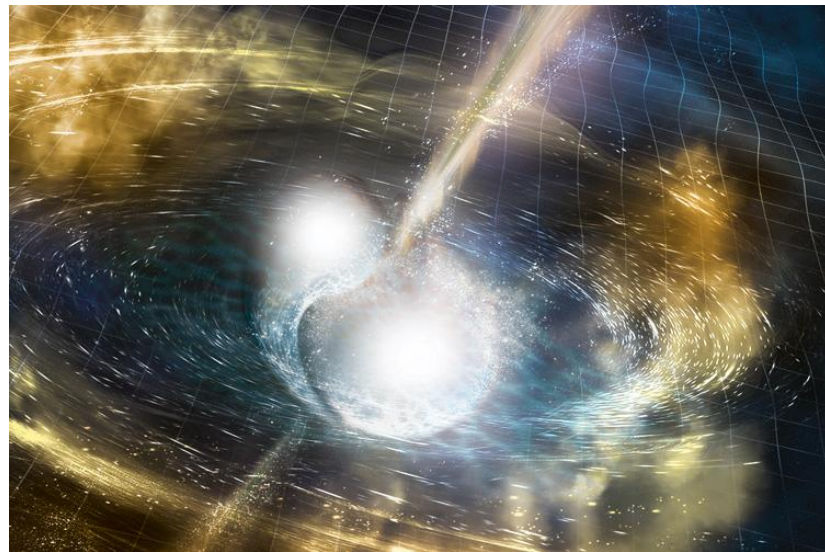
During the inspiral:

- Higher order tidal deformation effects
- Dynamical tides: frequency dependent response or mode resonances
- Spin induced quadrupole

Post-merger:

- f_2 peaks oscillation modes of the remnant
- Collapse time to final remnant
- Complexity of dense matter thermodynamic conditions

Systematic inclusion of effects in waveform modeling



Crédits : Aurore Simonnet for Sonoma State University

Thank you for your attention !
Any questions ?