Division 6: Nuclear physics

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Réunion ET France 2025

Next call: October 15th, 9:00 CET
Mailing list: et-osb-nuclear@et-gw.eu

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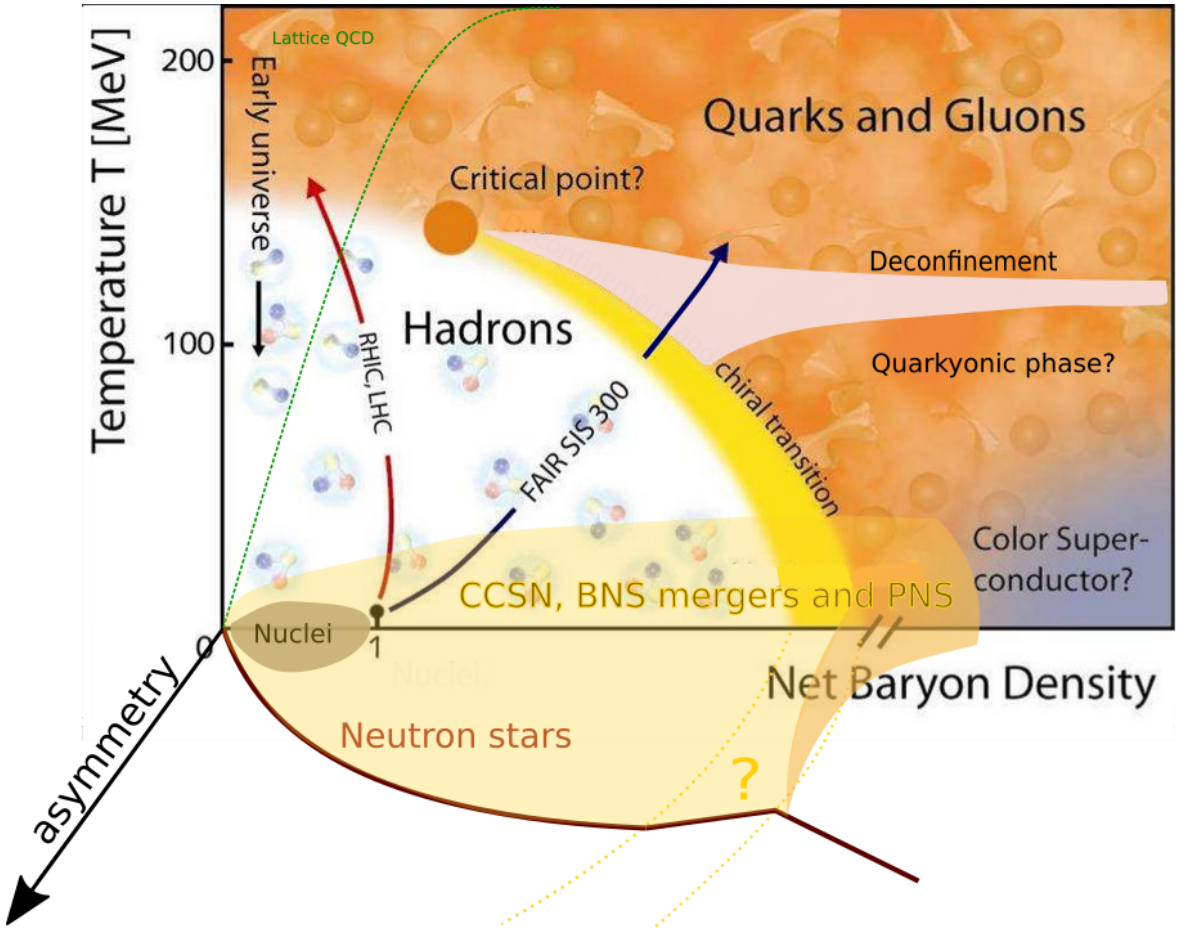
Scientific motivation



Neutron star matter is strongly interacting matter under extreme conditions not accessible in terrestrial laboratories (density, asymmetry) and non-perturbative many-body problem from the theory side

→ What can we learn with ET ?

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Div. 6 Bluebook chapter

https://arxiv.org/pdf/2503.12263/

State of the art

- Modelling the EoS for the different cases
- Existing constraints on the EoS
- Reaction rates to cover out-of-equilibrium effects

What ET is expected to do

- BNS (NSBH) inspiral and post-merger remnant
- Continous GWs (NS mountains, magnetic fields, oscillations)
- CCSN
- Multi-messenger aspects

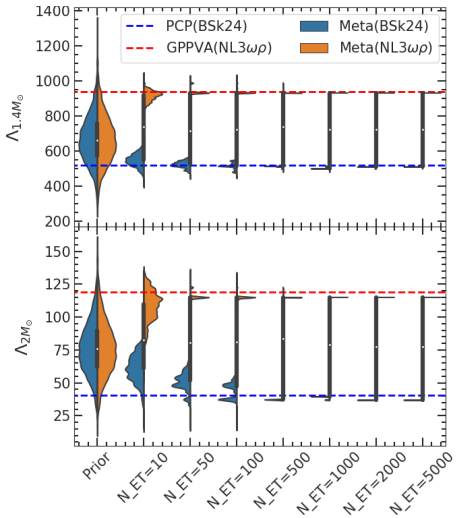
Uncertainties

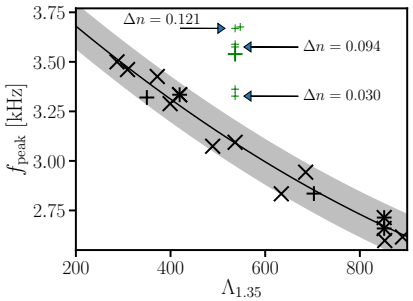
- Waveforms
- Numerical simulations and microphysics input
- Degeneracies with alternative theories of gravity and BSM particles

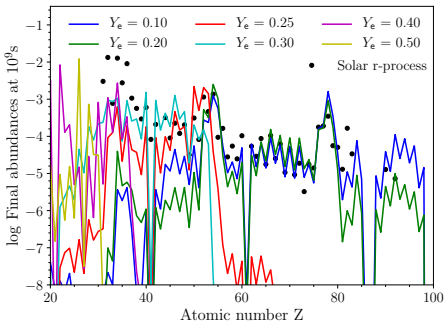
Highlights

BNS mergers

- Inspiral : NS EoS can be determined very precisely with 3rd generation detectors
- But : no information a priori about composition in absence of a phase transition
- During inspiral, a strong PT with a low density onset probably detectable, high density onset masked
- Post-merger : characteristic imprint of PT in dominant oscillation frequency







- Multi-messenger analysis with source properties and nuclear physics as key ingredient

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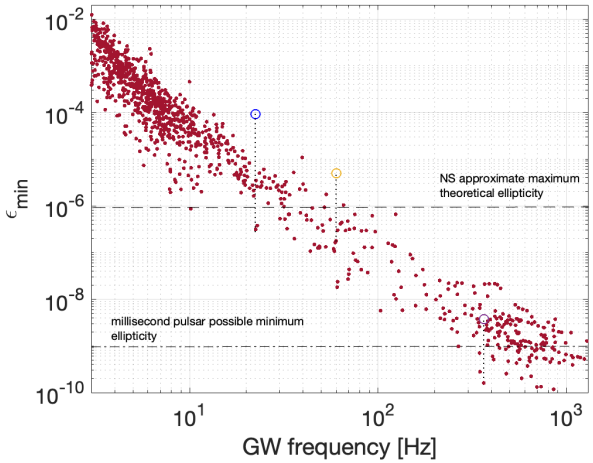
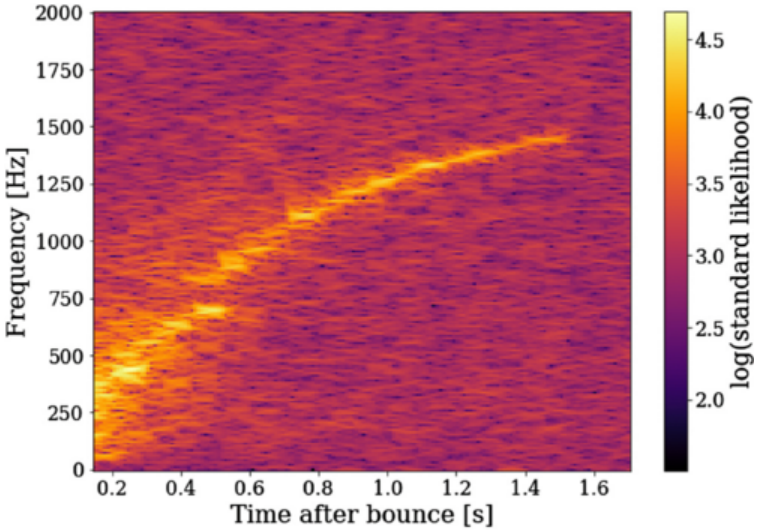
Highlights

CCSN and continous waves

- Detection of at least one continuous GW signal likely
- Constraints below the maximum predicted ellipticity (NS mountains)





- GWs detectable for a galactic event with oscillation frequencies of PNS giving information on matter properties
- Potential PT lead to a distinct rise in GW amplitude

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Future work : OSB roadmap

Work on well-defined science questions

Work in smaller teams on specific questions

- Systematics in EoS inference from BNS inspiral
- How to lift degeneracies in matter properties from EoS information ?
- Relation of post-merger properties to MM signal with more realistic physics input
- ...

Interaction with other division's efforts

- Development of more physically realistic waveform models $\longrightarrow$ Div. 8
- Degeneracies with new physics $\longrightarrow$ Div. 1

Connection to other boards

- How do remaining design choices impact the questions ?

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Linked to ongoing efforts on Science Traceability within Cosmic Explorer, keep global vision