

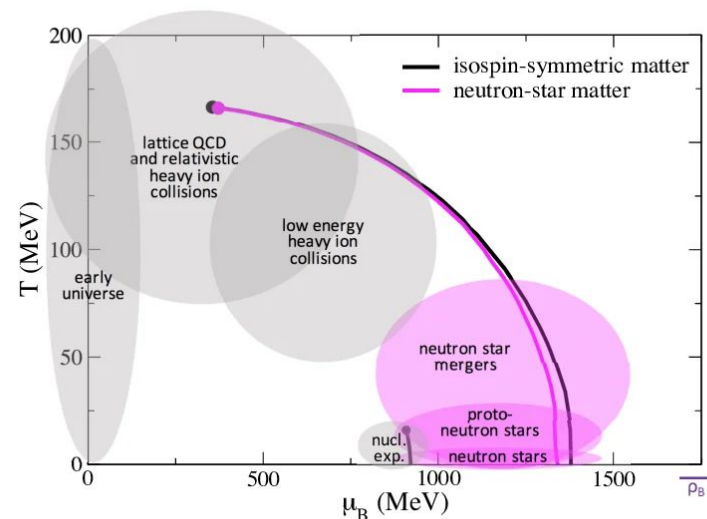
Classifying the Equation of State of Neutron Stars in BNS mergers

Tiago Fernandes

GWsNS-2026 School



- Experiments on Earth constrain the EoS up to nuclear density. To study ultra-high density, **we need astrophysical observations.**
- The **Equation of State** tells us how matter behaves under extreme conditions and sets fundamental properties of Neutron Stars.
- **GW170817** opened a new window for constraining EoS.

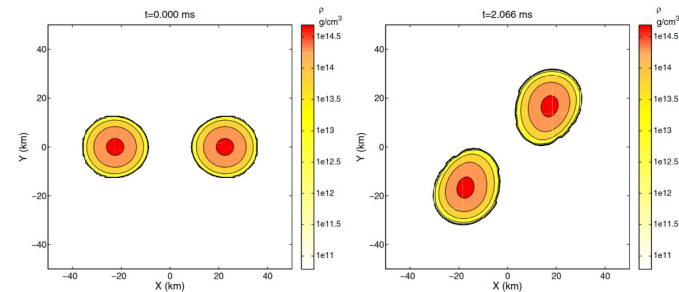


Dexheimer+ 2019, IJMPA

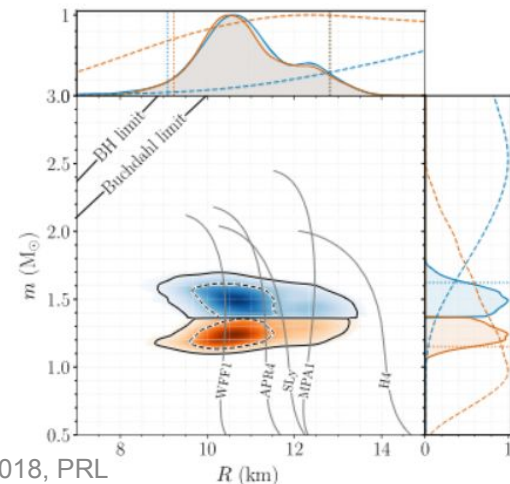
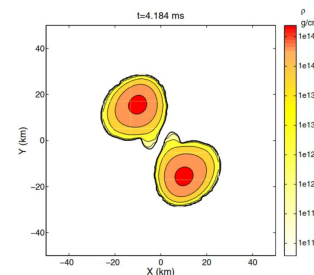
Introduction



- NSs in a binary system undergo tidal deformations, which alter the orbit and **embed the EoS in the GW signal**.
- **GW170817** ruled out “stiff” EoSs and put constraints on the NS radius.
- EoS constraints are obtained from **Bayesian inference**, which is costly.
- Here, we explore an approach based on **Machine Learning**.



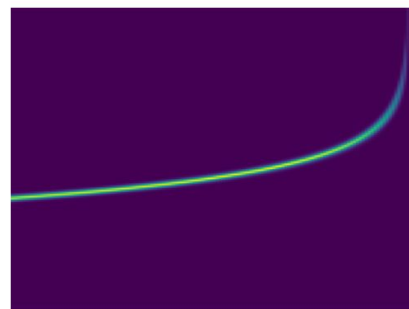
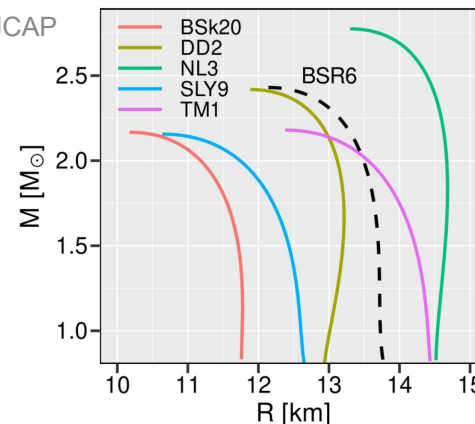
Baiotti+ 2008, PRD



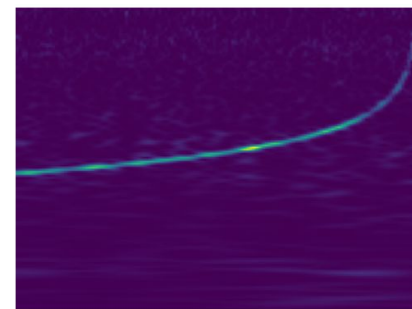
LIGO-Virgo 2018, PRL

- Dataset with inspiral waveforms from 5 EOSs, using IMRPhenomPv2_NRTidalv2, in spectrogram representation:
 - noiseless (baseline)
 - LIGO noise
- ML approach: supervised classification using state-of-the-art architectures (**ResNet** and **EfficientNet**)

Gonçalves+ 2023, JCAP



noiseless



SNR [50, 60]

noiseless



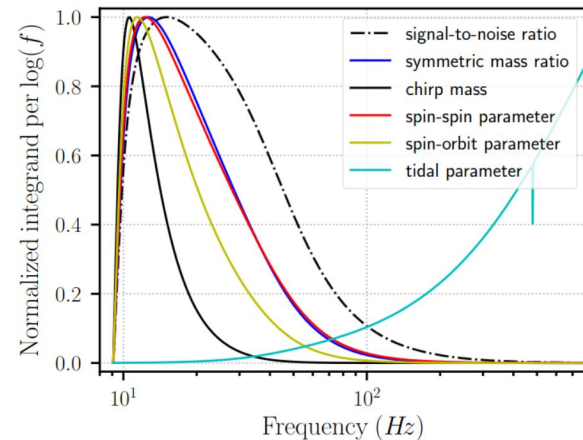
accuracy: 97.9%

SNR [50, 60]



accuracy: 46.7%

- In the noiseless scenario, distinguishing the EoS from the inspiral of BNS mergers is possible with an high accuracy.
- When we add noise, the task is much harder.
 - 2G GW detectors have lower sensitivities in the frequencies corresponding to the last orbits
 - Q-transform may be losing important phase information
- Next steps:
 - Focus on the final cycles of the merger
 - Test phase-preserving time-frequency representations



Harry+ 2018, CQG

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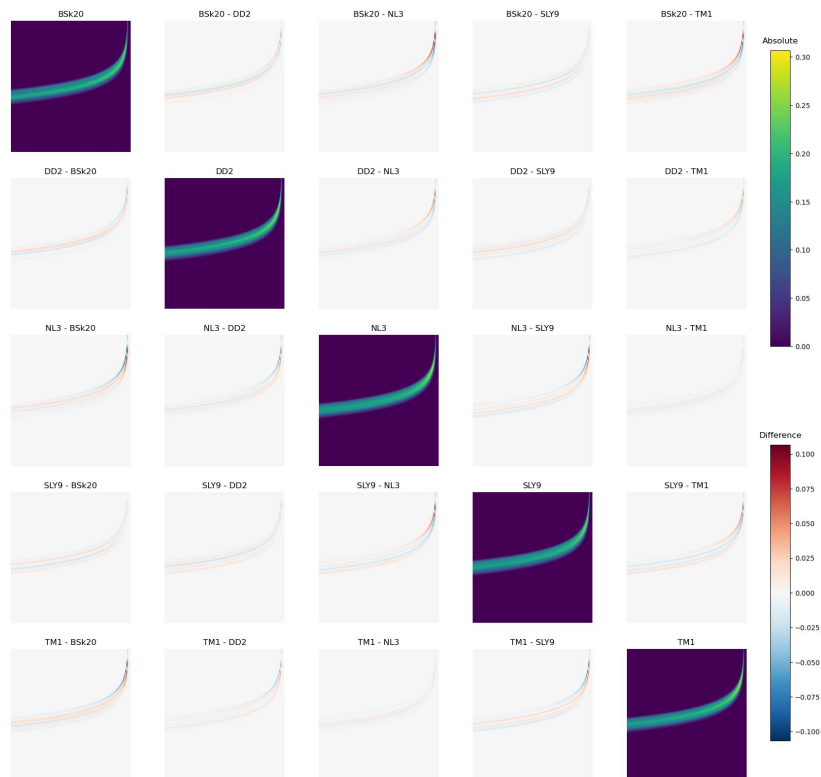
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noiseless



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