

High-Frequency Gravitational Waves from Phase Transitions in Nascent Neutron Stars



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02.09.2025



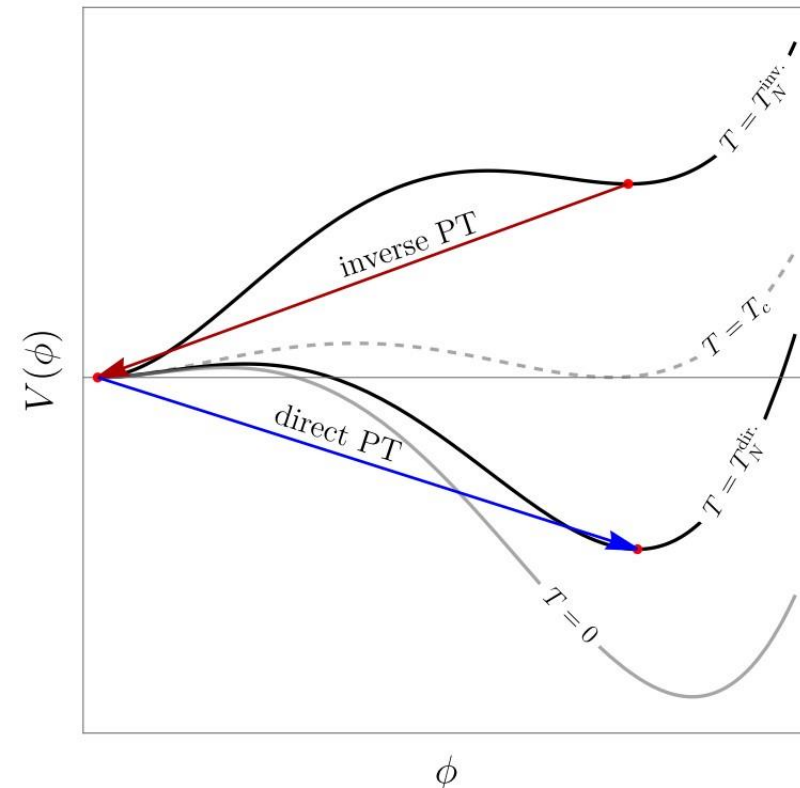
In collaboration with Joachim Kopp (CERN, JGU), Jiheon Lee (KAIST)
and Jorinde van de Vis (CERN)

Introduction



- Core could consist of deconfined quark matter
- Phase transition from hadronic matter to quark-gluon plasma

- If 1st order, bubble nucleation => gravitational wave signal in MHz band
- Unique opportunity for high-frequency GW detectors to probe extreme regime of QCD



Barni, Blasi, Vanvlasselaer, arXiv:2406.01596v2

Characteristic Strain

$$h_c^2 = \frac{8\pi G}{2\pi^2} \frac{\rho_{GW}}{f_p^2}$$

$$\rho_{GW} = 8\pi G (e + p)^2 \left(\frac{3}{4} |\alpha_N| \kappa \right)^2 (\tau R_*) \tilde{\Omega}_{GW}$$

- Peak frequency (~MHz, from bubble separation)
- Energy density and pressure (from equation of state)
- Phase transition strength (from equation of state)
- Efficiency factor (from bubble dynamics)
- Time duration of the source (min. of light crossing time and shock formation time)
- Mean bubble separation (from timescale of phase transition and bubble wall velocity)
- Numerical constant (from previous simulations)
- **Characteristic strain suppressed by [volume fraction]^{3/2} for stalled phase transition**

Pipeline

Define equation of state
(critical and nucleation pressures, phase transition strength, input for TOV solver)

Solve TOV equations

(mass-radius relation, size of quark core)

Calculate bubble wall velocity

(bubble separation, efficiency factor)

Pipeline

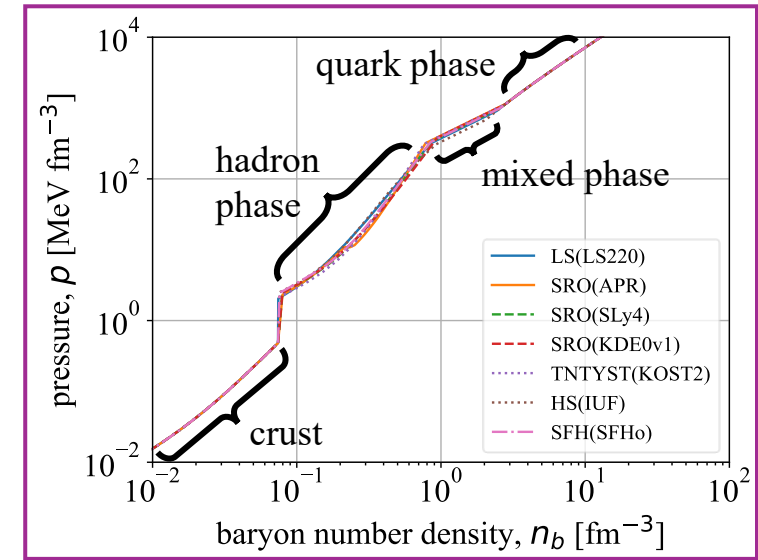
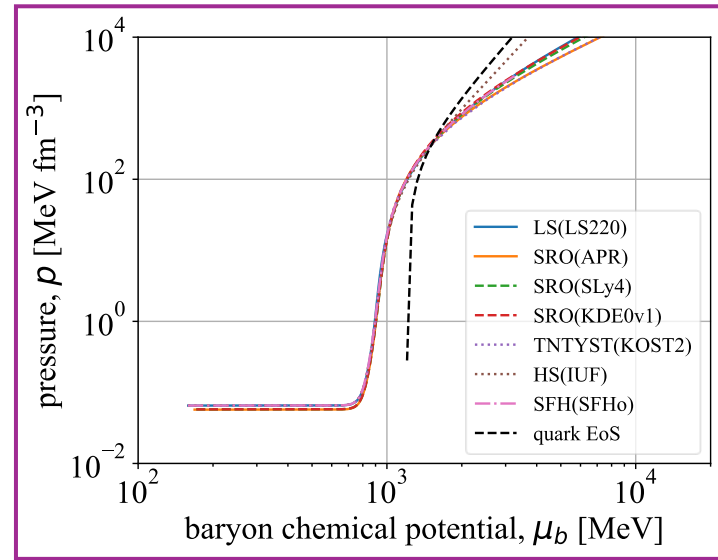
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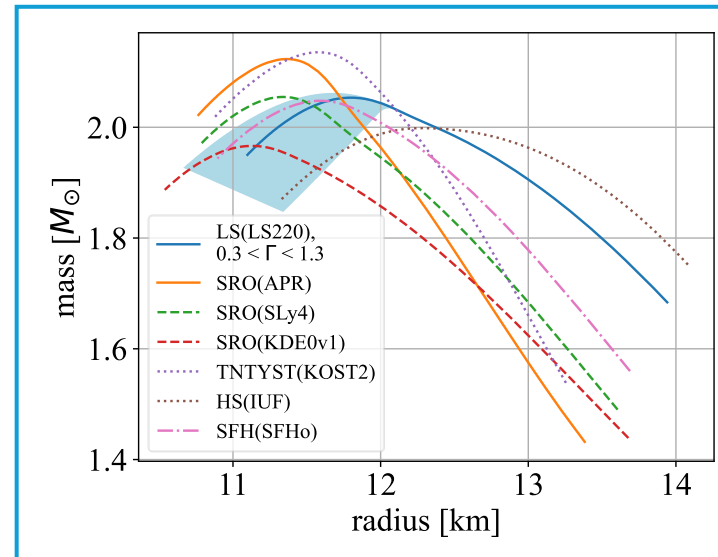
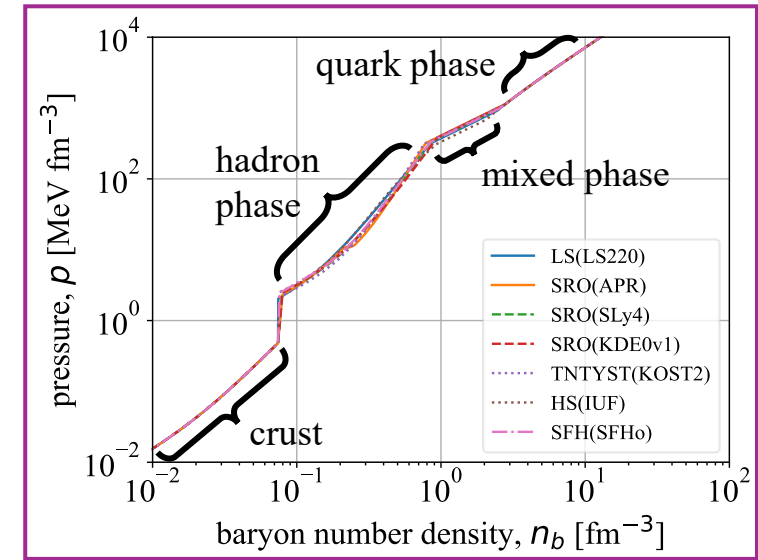
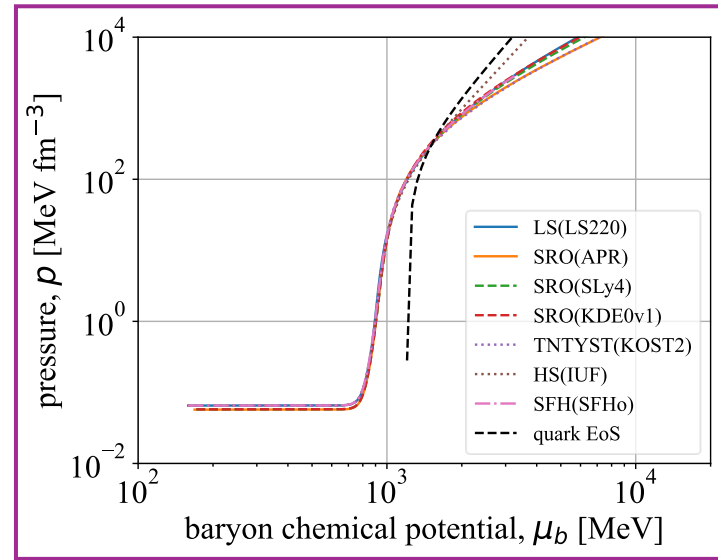
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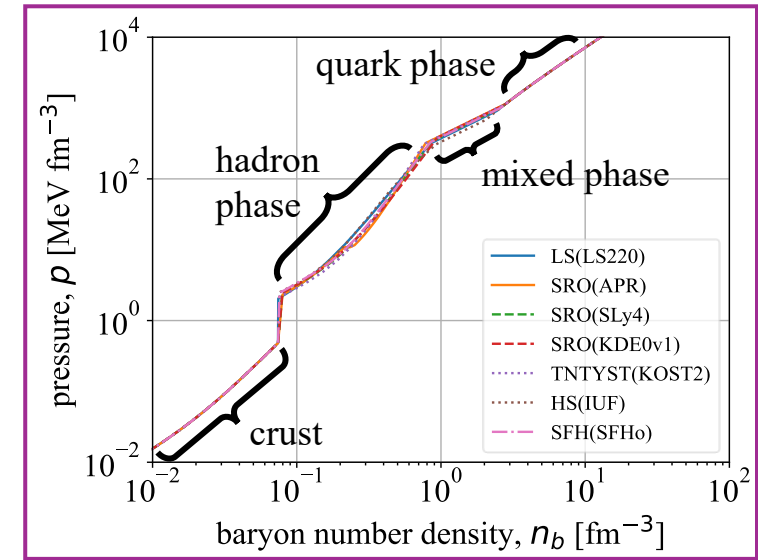
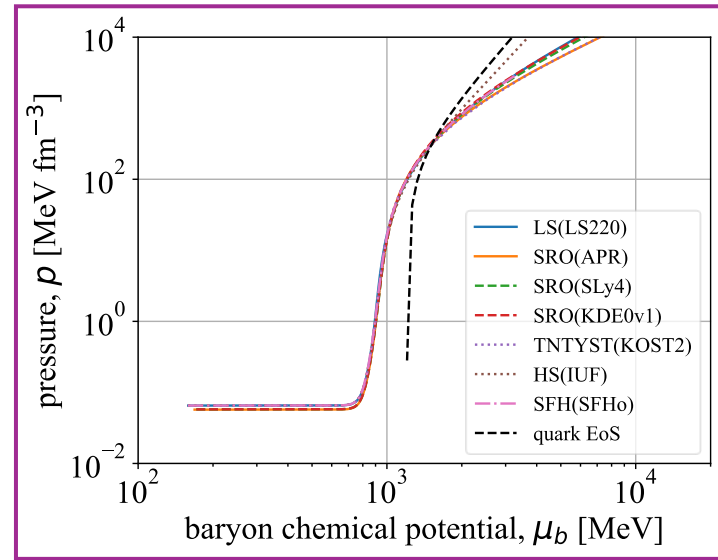
Calculate bubble wall velocity

(bubble separation, efficiency factor)



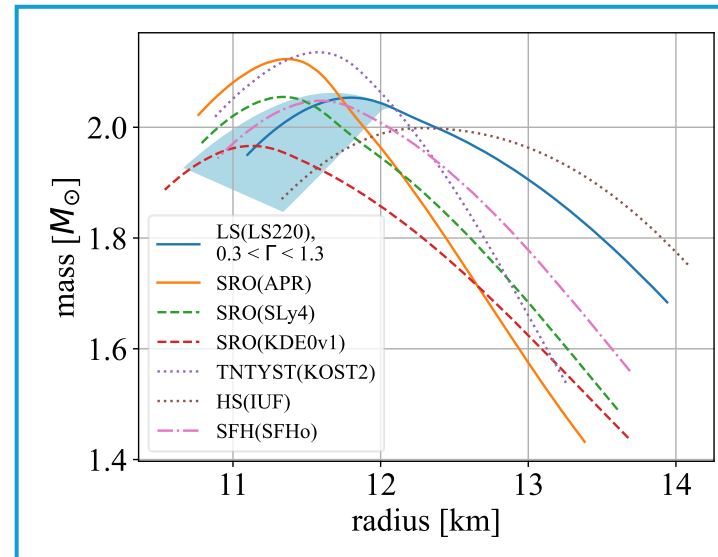
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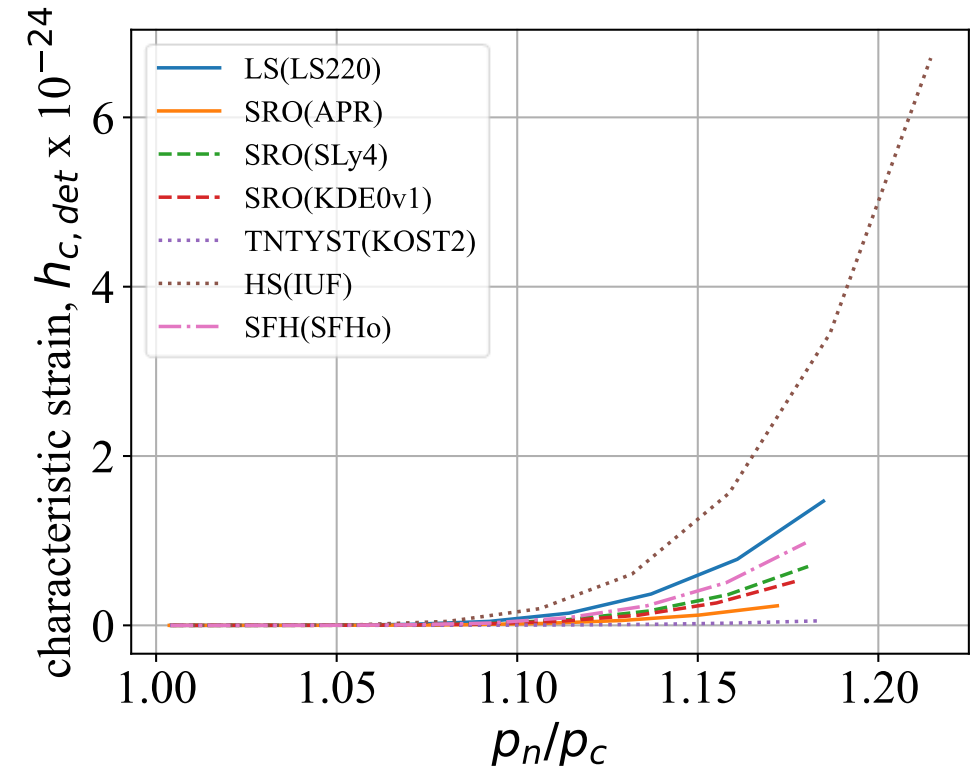
Solve TOV equations

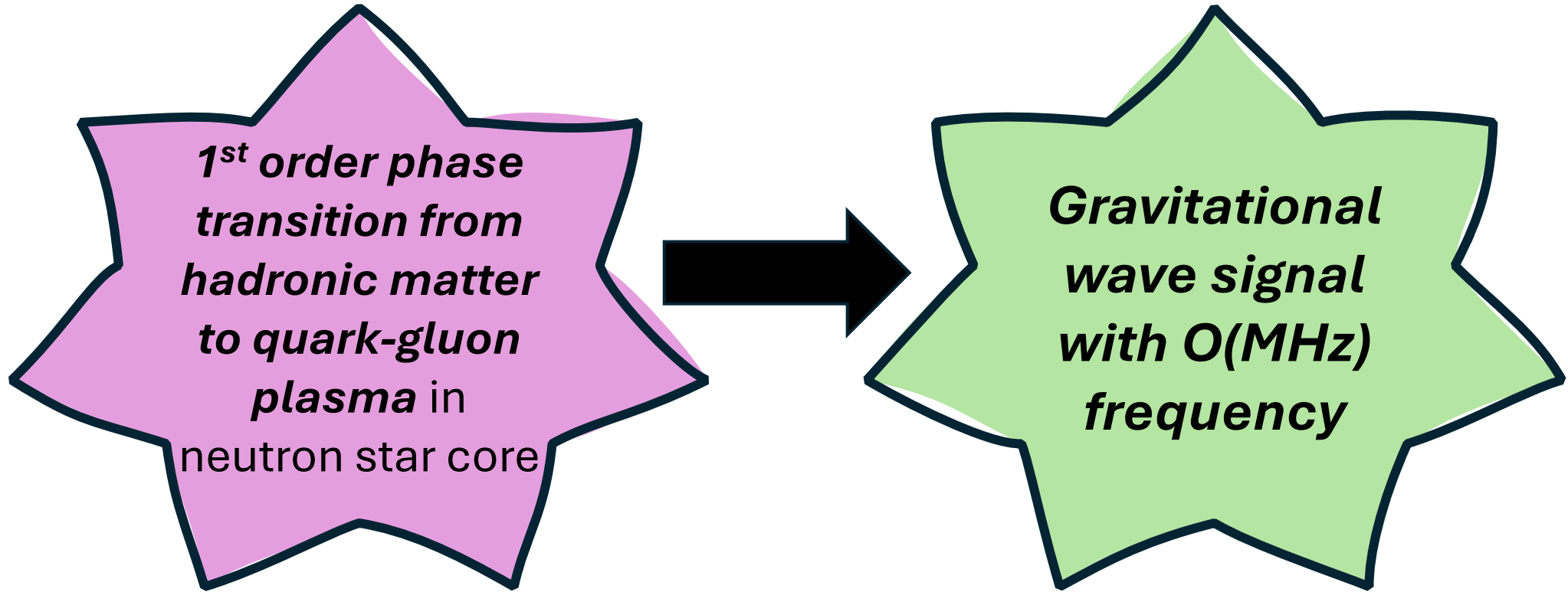
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Calculate bubble wall velocity

(bubble separation, efficiency factor)





Thank you!