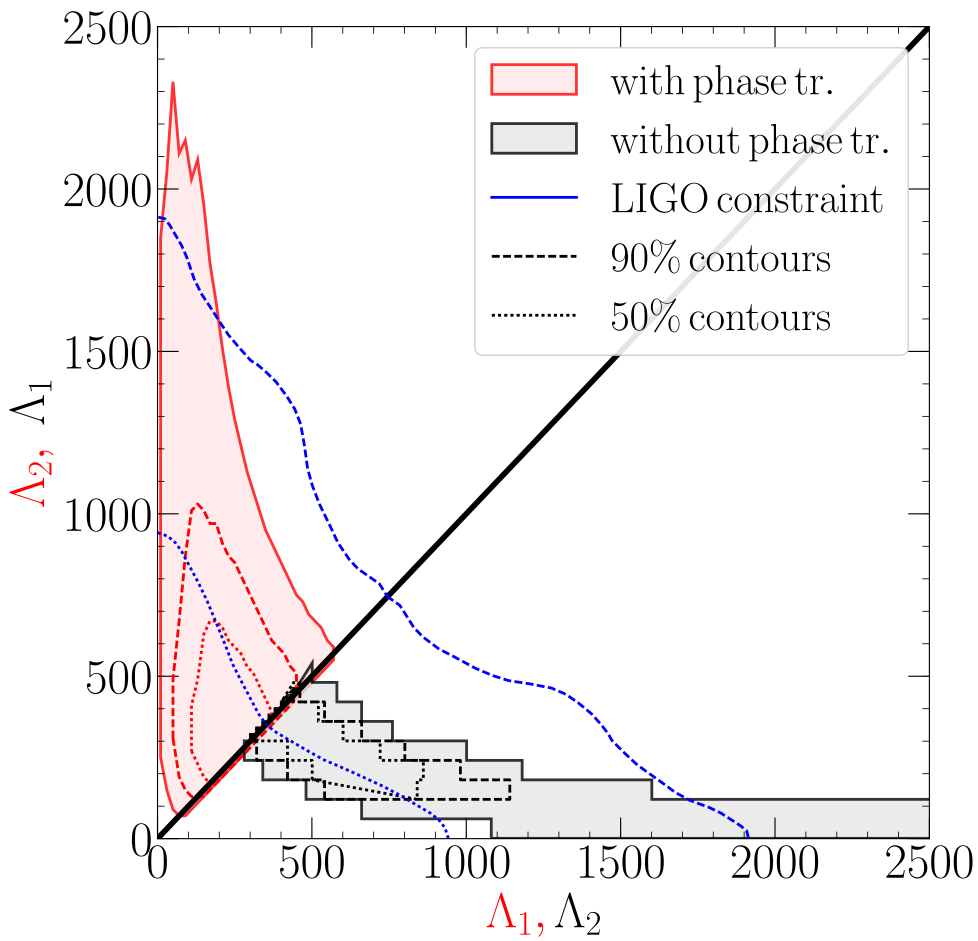
Confronting gravitational waves with modern nuclear physics constraints

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

- We use accurate Quantum Monte Carlo methods and modern and systematic nuclear interactions from chiral effective field theory (EFT) to critically examine the recent constraints on the equation of state from the gravitational wave signal of the neutron-star merger GW170817 with robust theoretical uncertainties.
- We study the impact of phase transitions on the gravitational-wave signal.



Correlation of tidal polarizabilities Λ_1 and Λ_2 of the two neutron stars in GW170817 as observed by LIGO and predicted by two nuclear physics models with and without phase transitions.

Impact

- We confronted recent gravitational-wave observations with modern nuclear-physics constraints from chiral EFT.
- We have shown that state-of-the-art calculations of the equation of state of neutron-star matter are consistent with but more constraining than constraints obtained from the recent neutron-star merger observation of GW170817 by the LIGO-Virgo collaboration.
- We have constrained the radius of a 1.4 solar-mass neutron star to be between 8.7-12.6 km (10.9-12.0 km) when phase transitions are present (not present).
- We have determined ranges for tidal polarizabilities that will allow to shed light on the existence of phase transitions to exotic forms of matter in the core of neutron stars when future neutron-star merger observations become available.

Accomplishments

- Publication: I. Tews, J. Carlson, S. Gandolfi, and S. Reddy, Astrophys.J. 860 (2018) 149.
- Publication: I. Tews, J. Margueron, and S. Reddy, Phys.Rev. C98 (2018) no.4, 045804.
- Highlighted as Editor's Suggestion.
- Publication: I. Tews, J. Margueron, and S. Reddy, arXiv:1901.09874.