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From nuclear interactions to binary neutron star mergers

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The equation of state (EoS) of dense nuclear matter is a basic ingredient for modeling a variety of astrophysical phenomena related to neutron stars (NSs), as core-collapse supernovae and binary neutron star (BNS) mergers. Determining the correct EoS which describes NSs is thus a fundamental problem of nuclear physics, particle physics and astrophysics, and major efforts have been made during the last few decades to solve it by measuring different NS properties using the data collected by various generations of X-ray and γ-ray satellites and by ground-based radio-telescopes. The recent detection of gravitational waves from the BNS mergers, GW170817 and GW190425 is giving a big boost to the research on dense matter physics. Gravitational wave signals, from BNS inspiral and particularly from the BNS post-merger phase (which could be detected by the 3rd generation of gravitational wave detectors) offer in fact a unique opportunity to test different EoS models. Computing the EoS of nuclear matter from the underlying nuclear interactions is a demanding and challenging theoretical task. Recently, chiral effective field theory (ChEFT) opened a new and systematic way to derive nuclear interactions with a direct connection to QCD via its symmetries.
In this contribution we present fully microscopic calculations of the EoS of dense and hot nuclear matter performed using the Brueckner-Bethe-Goldstone (BBG) many-body theory extended to finite temperature. We next apply our new EoS models to describe non-rotating NSs and the dynamics of BNS mergers.

Primary authors: LOGOTETA, Domenico (Istituto Nazionale di Fisica Nucleare); BOMBACI, Ignazio (PI)

Presenter: LOGOTETA, Domenico (Istituto Nazionale di Fisica Nucleare)

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