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Probing the QCD critical end point through multi-messenger observations of compact stars and heavy ion collisions.

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In order to prove the existence of a critical end point (CEP) in the QCD phase diagram it is sufficient to demonstrate
that at zero temperature $T = 0$ a first order phase transition exists as a function of the baryochemical potential μ,
since it is established knowledge from ab-initio lattice QCD simulations that at $\mu = 0$ the transition on the temperature axis is a crossover.

We present the argument that the observation of a gap in the mass-radius relationship for compact stars which proves the
existence of a so-called third family (aka “mass twins”) will imply that the $T = 0$ equation of state of compact star
matter exhibits a strong first order transition with a latent heat that satisfies $\Delta\epsilon/\epsilon_c > 0.6$.
Since such a strong first order transition under compact star conditions will remain first order when going to symmetric
matter, the observation of a disconnected third family branch of compact stars in the mass-radius diagram proves the
existence of a CEP in QCD.

To quantify the mass twins phenomenon, I will show a recent developed EoS that features of a color superconducting
chiral quark model with nonlocal, covariant interactions bearing density dependent vector meson coupling and a
density-dependent bag pressure. This model allows for a scenario where the compact stars of the GW170817 event are
either both hadronic, both hybrid, or simultaneously hadronic and hybrid configurations, expected to be identified
through the detection of gravitational radiation produced by compact star mergers.

In order to study the information derived from compact star observations, I shall review the method of estimation of
tidal deformabilities of compact stars (encoded in gravitational radiation of mergers) and present results for pure
hadronic as well as hybrid stars that include the mass twins case. In particular, the recent detection of gravitational
radiation from the GW170817 event shed light on the properties of the neutron star equation of state (EoS), thus
comprising both the study of the symmetry energy, stellar radius and the mass twins scenario. Along these lines, at the
end of my talk I shall present an analysis of star rotations aimed at probing the compact star maximum mass which turns
out to strongly constrain the maximum density found in star cores.

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