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Constraining Quark Matter in Neutron Stars and the prospects of detecting Quark Stars

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Neutron Stars (NSs) make a unique physical laboratory with extreme physical conditions irreproducible in experiments, capable of producing a hadron-to-quark deconfinement phase transition in their interior. Owing to the high densities reached by the cold nuclear matter at the core of NSs, it is speculated that NS cores may be composed of deconfined quark matter (QM). Using state-of-the-art inputs from multi-disciplinary physics (like the chiral effective field theory, astrophysical observations, and perturbative quantum chromodynamics), we impose new constraints on the widely-accepted phenomenological MIT Bag for deconfined QM in NSs and comment on the phase of matter in NS cores. We include strong interactions to the first order and allow for a mixed phase to model the system realistically. It is known that if this deconfined QM is more stable than ordinary nuclear matter, a hypothesis known as the strange quark matter (SQM) hypothesis, such a phase transition would further lead to the formation of exotic compact objects known as Strange Stars (SSs). We demonstrate that the future next-generation gravitational wave (GW) detectors hold the potential to distinguish SS from NSs using simultaneous f-mode and tidal deformability measurements and can settle the long-standing problem in physics concerning the true ground state of matter.

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