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Dense Matter Phases inside Neutron Stars: Constraints from Observations

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The measurement of tidal deformability from GW170817 and the existence of pulsars with $\sim 2M_{\odot}$ pose great challenges to the usual way of understanding the equation of state (EOS) of dense nuclear matter. We have studied a large set of relativistic mean field EOSs and found that only few can survive these constraints which predict a stiff overall equation of state but with a soft neutron-proton symmetry energy. Based on this analysis, we have also found an upper bound on the radius of a $1.4M_{\odot}$ star as $R_{1.4} \sim 12.9$ km. These evidences further indicate to the possibility of a hadron-quark phase transition inside the star. We have also studied the possible existence of nucleon superfluidity and its effect on the fluid nature of the neutron star. We have seen that entrainment between different fluids inside the star affects the tidal deformability.

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