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Physical Realizations of the Tolman-VII Solution

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The Tolman˜VII solution for a static perfect fluid sphere to the Einstein equations is reexamined, and a closed form class of equations of state (EOSs) is deduced for the first time. These EOSs allow further analysis to be carried out, leading to a viable model for compact stars with arbitrary boundary mass density to be obtained. Explicit application of causality conditions places further constraints on the model, and recent observations of masses and radii of neutron stars prove to be within the predictions of the model. The adiabatic index predicted is $\gamma \geq 2$, but self-bound crust solutions are not excluded if we allow for higher polytropic indices in the crustal regions of the star. The solution is also shown to obey known stability criteria often used in modeling such stars. It is argued that this solution provides realistic limits on models of compact stars, maybe even independently of the type of EOS, since most of the EOSs usually considered do show a quadratic density falloff to first order, and this solution is the unique exact solution that has this property.

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