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Relativistic polytropic spheres with electric charge: Compact stars, compactness and mass bounds, and quasiblack hole configurations

We study the static stellar equilibrium configurations of uncharged and charged spheres composed by a relativistic polytropic fluid, and compare with those of spheres composed by a non-relativistic polytropic fluid, the later case already being studied in a previous work [J. D. Arbañil, P. S. Lemos, V. T. Zanchin, Phys. Rev. D 88, 084023 (2013)]. For the two fluids under study, it is assumed an equation of state connecting the pressure p and the energy density ρ. In the non-relativistic fluid case, the connection is through a non relativistic polytropic equation of state, $p=\omega\rho^{\gamma}$, with ω and γ being respectively the polytropic constant and the polytropic exponent. In the relativistic fluid case, the connection is through a relativistic polytropic equation of state, $p=\omega\delta^{\gamma}$, with $\delta=\rho-p/(\gamma-1)$, and δ being the rest mass density of the fluid. For the electric charge distribution, in both cases, we assume that the charge density ρ_e is proportional to the energy density ρ, $\rho_e=\alpha\rho$, with α being a constant such that $0\leq\mid\alpha\mid\leq 1$. The study is developed by integrating numerically the hydrostatic equilibrium equation, i.e., the modified Tolman-Oppenheimer Volkoff equation for the charged case. Some properties of the charged spheres such as mass, total electric charge, radius, redshift, and the speed of sound are analyzed. The dependence of such properties with the polytropic exponent is also investigated. In addition, some limits that arise in general relativity, such as the Chandrasekhar limit, the Oppenheimer-Volkoff limit, the Buchdahl bound and the Buchdahl-Andr\'easson bound, i.e., the Buchdahl bound for the electric case, are studied. As in a charged non-relativistic polytropic sphere, the charged relativistic polytropic sphere with $\gamma\to\infty$ and $\alpha\to 1$ saturates the Buchdahl-Andréasson bound, thus indicating that it reaches the quasiblack hole configuration. We show by means of numerical analysis that, as expected, the major differences between the two cases appear in the high energy density region.

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