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General relativistic effects in the structure of massive white dwarfs. (English) Zbl 1392.83012

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Summary: In this work we investigate the structure of white dwarfs using the Tolman-Oppenheimer-Volkoff equations and compare our results with those obtained from Newtonian equations of gravitation in order to put in evidence the importance of general relativity (GR) for the structure of such stars. We consider in this work for the matter inside white dwarfs two equations of state, frequently found in the literature, namely, the Chandrasekhar and Salpeter equations of state. We find that using Newtonian equilibrium equations, the radii of massive white dwarfs ($M > 1.3M_{\odot}$) are overestimated in comparison with GR outcomes. For a mass of $1.415M_{\odot}$ the white dwarf radius predicted by GR is about 33% smaller than the Newtonian one. Hence, in this case, for the surface gravity the difference between the general relativistic and Newtonian outcomes is about 65%. We depict the general relativistic mass-radius diagrams as $M/M_{\odot} = R/(a + bR + cR^2 + dR^3 + kR^4)$, where a, b, c and d are parameters obtained from a fitting procedure of the numerical results and $k = (2.08 \times 10^{-6} R_{\odot})^{-1}$, being $R_{\odot}$ the radius of the Sun in km. Lastly, we point out that GR plays an important role to determine any physical quantity that depends, simultaneously, on the mass and radius of massive white dwarfs.

MSC:

83C15 Exact solutions to problems in general relativity and gravitational theory
85A15 Galactic and stellar structure
83C55 Macroscopic interaction of the gravitational field with matter (hydrodynamics, etc.)

Keywords:

compact stars; general relativistic effects; mass-radius relation; white dwarfs

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