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Modelling compact stars: numerical solutions to the structure equations using Python

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The study of compact stars (CS) is a topic very valuable for the testing of modern physics in order to better understand the behaviour of cold dense nuclear matter. CS (white dwarfs or neutron stars) have no fusion processes occurring within them. The only way these stars are then capable of supporting themselves is through the degeneracy pressure of the fermions that constitute these objects. These stars can then be modelled as a degenerate Fermi gas of either electrons or neutrons. This study aimed to solve for the Newtonian and Tolman-Openheimer-Volkoff (TOV) structure equations through a numerical approach using Python in order to model the behaviour of these stars. White dwarfs were modelled as a fermi gas of electrons while the neutron star was modelled first as a pure neutron gas and then as a mix of neutrons,protons and electrons. A discussion on how realistic these results ensued. It was found that within certain limits, the results obtained particularly for the neutron stars, were relatively close to expected values for the mass of these objects in literature.the masses of white dwarfs in the non-relativistic and relativistic limits were 0.369 solar masses and 1.2469 solar masses respectively. The mass of a pure neutron star in which its constituent neutrons have arbitrary relativity were found for the TOV solution to be 0.771 solar masses and for the Newtonian structure equation to be 1.5312 solar masses. Lastly, the radius to mass ratios for the TOV solution was found to be 7.92442 and for the Newtonian, 9.6852 for a pure neutron star.

Key words: Compact stars (CS), Tolman-Oppenheimer-Volkoff structure equations (TOV), Newtonian structure equations.

Apply to be considered for a student ; award (Yes / No)?

Yes

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