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Structural Implications of the Chameleon Mechanism on White Dwarfs

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Abstract

We study the impact of the chameleon mechanism on the structure of white dwarfs. We numerically solve the equilibrium equations in General Relativity and Newtonian gravity for a spherically symmetric star, verifying that the relativistic contribution is negligible, as expected. Using a shooting method of our design, we solve the corresponding scalar-tensor equilibrium equations in the Newtonian limit for Chandrasekhar's equation of state, exploring various energy scales and couplings of the chameleon field to matter and identifying, for the first time in the literature, a similarity relation for the radially normalised scalar field gradient. Our analysis reveals that the chameleon mechanism significantly alters the internal pressure of white dwarfs, leading to a notable reduction in the stellar radii and masses and shifting the mass-radius curves below those predicted by Newtonian gravity. In addition, we find that the chameleon field within white dwarfs follows the thick-shell regime description. Finally, we derive parametric expressions from our results to expedite future analyses of white dwarfs in scalar-tensor theories.

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