

Durgapal Gravastar solutions

Meghanil Sinha, S. Surendra Singh

Department of Mathematics, National Institute of Technology Manipur,
Imphal-795004, India

Email: meghanil1729@gmail.com, ssuren.mu@gmail.com

Abstract

This work presents a novel gravastar configuration constructed within a (3+1) dimensional spacetime, employing the Durgapal-Fuloria metric ansatz as a physically motivated alternative to conventional black hole solutions. Building upon the foundational Mazur-Mottola framework, wherein gravitational vacuum condensation, analogous to Bose-Einstein condensate physics, replaces the classical singularity with a de Sitter interior, our model successfully circumvents both the central singularity and event horizon associated with the standard black hole descriptions. The stellar framework comprises of three distinct regions—a vacuum dominated de Sitter core, an intermediate shell of ultra-stiff, ultra-relativistic fluid, and an exterior Schwarzschild vacuum, with the thin shell mediating the transition between interior and exterior geometries. Adopting the Durgapal-Fuloria metric function allows the remaining metric function to be derived self consistently, yielding a solution free of pathological singularities throughout. Within the shell, we have investigated that how proper length, total energy content, and entropy evolve with shell thickness, finding that all three quantities grow monotonically as the shell expands. Complementing this, the junction conditions bridging the interior and exterior spacetimes reveal that surface energy density and surface pressure diminish with increasing thickness, a behaviour consistent with a physically reasonable, thinning boundary layer. Crucially, a stability analysis via the sound speed criterion confirms that the configuration remains dynamically stable across the parameter space explored. Taken together, these results establish a complete, singularity-free, and stable family of exact gravastar solutions, reinforcing the gravastar paradigm as a compelling, mathematically and physically consistent alternative to black holes.

Keywords: Gravastar, Durgapal-Fuloria metric ansatz, black holes.