GR22 Abstract: Numerical Treatment of the Ellis Wormhole in Maximal Isotropic Coordinates

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Abstract

This is the preliminary work in a broader program to investigate horizonless compact objects numerically, with the goal of finding Horndeski-like theories that support stable traversible wormholes. Ultimately, we hope to study the gravitational wave signatures of wormhole mergers in general relativity and related theories. In this work, we examine the full nonlinear evolution in Einstein gravity of a perturbed Ellis wormhole (1971, rediscovered in 1987 by Morris and Thorne). The wormhole is sourced by a Klein-Gordon scalar field that is negatively coupled to gravity. We explore the effects of perturbations in this "ghost" field and of sending normally-coupled Klein-Gordon scalar pulses into the wormhole. Our results agree with the conclusions of Hayward and Shinkai (2002), who used a double-null treatment to find that the perturbed Ellis wormhole is unstable to collapse or divergent expansion, depending on the type of perturbation. Gonzalez, Guzman, and Sarbach (2008) performed a similar study using a shift-free 3+1 decomposition, and we compare their results to our treatment with maximally sliced isotropic coordinates.

Keywords

numerical relativity, horizonless compact object nonlinear stability, traversible wormhole perturbation, maximal isotropic coordinates