Self-interactions and spontaneous black hole scalarization

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It has recently been shown that nontrivial couplings between a scalar and the Gauss-Bonnet invariant can give rise to black hole spontaneous scalarization. Theories that exhibit this phenomenon are among the leading candidates for testing gravity with upcoming black hole observations. All models considered so far have focused on specific forms for the coupling, neglecting scalar self-interactions. In this work, we take the first steps towards placing this phenomenon on a more robust theoretical footing by considering the leading-order scalar self-interactions as well as the scalar-Gauss-Bonnet coupling. Our approach is consistent with the principles of effective field theory and yields the simplest and most natural model. We find that a mass term for the scalar alters the threshold for the onset of scalarization, and we study the mass range over which scalarized black hole solutions exist. We also demonstrate that the quartic self-coupling is sufficient to produce scalarized solutions that are stable against radial perturbations, without the need to resort to higher-order terms in the Gauss-Bonnet coupling function. Our model therefore represents a canonical model that can be studied further, with the ultimate aim of developing falsifiable tests of black hole scalarization.

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