

Scalarization of Bardeen spacetime

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We study the scalarization of the entire Bardeen spacetime which is constructed from a nonlinear magnetic monopole. For the pure Bardeen model, it is well known that there exist not only the general horizonless, nonsingular Bardeen spacetime solutions but also regular black hole (BH) solutions. When considering the Bardeen model coupled to a scalar field, we find that under the premise of solving throughout the entire spacetime (i.e., the radial coordinate $r \in [0, \infty)$), there are two scenarios: one is the trivial pure Bardeen solution with a vanishing scalar field, and the other is a horizonless, nonsingular scalarized Bardeen spacetime (SBS) solution. Depending on the value of the magnetic charge q , these non-trivial solutions can be further divided into two categories: (1) When the magnetic charge q is below a certain critical value q_c and the scalarization parameter a approaches the scalarization threshold a_t from above (i.e., $a \rightarrow a_t^+$), the scalar field vanishes, and the spacetime reduces to the horizonless, nonsingular pure Bardeen spacetime. This behavior indicates that this solution exhibits the general spontaneous" scalarization phenomenon. (2) When $q \geq q_c$, in the limit $a \rightarrow a_t^+$, the scalar field is non-vanishing and the SBS approaches a frozen" SBS. Considering the importance of photon orbits in astronomical observations, we analyze the trajectories of photons around SBSs by analyzing null geodesics.

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