Spontaneous scalarization of black holes in scalar-tensor theories with derivative couplings

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We investigate spontaneous scalarization of static and spherically symmetric black hole (BH) solutions in scalar-tensor theories with derivative couplings to the spacetime curvature and the scalar field. The former part of our presentation will follow the recent paper [1] and consider the coupling to the Gauss-Bonnet (GB) term, $\xi(\phi)(R^2-4R^{\alpha\beta}R_{\alpha\beta}+R^{\alpha\beta\mu\nu}R_{\alpha\beta\mu\nu})$. It was recently shown that in these theories static and spherically symmetric scalarized BH solutions with nontrivial profiles of the scalar field can be realized [2–4], but for the pure quadratic order coupling, $\xi(\phi)=\eta\phi^2$, scalarized BHs solutions are unstable against radial perturbation [5]. We will show that the presence of the coupling function $\xi(\phi)$ with a higher order power of ϕ could realize scalarized BHs which are stable against radial perturbations. The latter part of our presentation will address the possibility of the existence of scalarized BH solutions in more generic classes of the Horndeski theory [6, 7]. We will show that only the restricted derivative couplings can cause tachyonic instability of Schwarzschild BHs, signaling the existence of scalarized BH solutions.

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[1] M. Minamitsuji and T. Ikeda, Phys. Rev. **D99**, 044017 (2019), arXiv:1812.03551 [gr-qc].

[2] D. D. Doneva and S. S. Yazadjiev, Phys. Rev. Lett. **120**, 131103 (2018), arXiv:1711.01187 [gr-qc].

[3] H. O. Silva, J. Sakstein, L. Gualtieri, T. P. Sotiriou, and E. Berti, Phys. Rev. Lett. **120**, 131104 (2018), arXiv:1711.02080 [gr-qc].

[4] G. Antoniou, A. Bakopoulos, and P. Kanti, Phys. Rev. Lett. **120**, 131102 (2018), arXiv:1711.03390 [hep-th].

[5] J. L. Blzquez-Salcedo, D. D. Doneva, J. Kunz, and S. S. Yazadjiev, Phys. Rev. **D98**, 084011 (2018), arXiv:1805.05755 [gr-qc].

[6] G. W. Horndeski, Int. J. Theor. Phys. **10**, 363 (1974).

[7] T. Kobayashi, M. Yamaguchi, and J. Yokoyama, Prog. Theor. Phys. **126**, 511 (2011), arXiv:1105.5723 [hep-th].