SPONTANEOUS SCALARISATION OF CHARGED BLACK HOLES: COUPLING DEPENDENCE AND DYNAMICAL FEATURES

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Spontaneous scalarisation of electrically charged, asymptotically flat Reissner-Nordström black holes (BHs) has been recently demonstrated to occur in Einstein-Maxwell-Scalar (EMS) models. EMS BH scalarisation presents a technical simplification over the BH scalarisation that has been conjectured to occur in extended Scalar-Tensor Gauss-Bonnet (eSTGB) models. It is then natural to ask: 1) how universal are the conclusions extracted from the EMS model? And 2) how much do these conclusions depend on the choice of the non-minimal coupling function? Here we perform a comparative analysis of different forms for the coupling function including: exponential, hyperbolic, power-law and a rational function (fraction) couplings. In all of them we obtain and study the domain of existence of fundamental, spherically symmetric, scalarised BHs and compute, in particular, their entropy. The latter shows that scalarised EMS BHs are always entropically preferred over the RN BHs with the same total charge to mass ratio q. This contrasts with the case of eSTGB, where for the same power-law coupling the spherical, fundamental scalarised BHs are not entropically preferred over Schwarzschild. Also, while the scalarised solutions in the EMS model for the exponential, hyperbolic and power-law coupling are very similar, the rational function coupling leads to a transition in the domain of existence. Furthermore, fully non-linear dynamical evolutions of unstable RN BHs with different values of q are presented. These show: 1) for sufficiently small q, scalarised solutions with (approximately) the same q form dynamically; 2) for large q, spontaneous scalarisation visibly decreases q; thus evolutions are non-conservative; 3) despite the existence of non-spherical, static scalarised solutions, the evolution of unstable RN BHs under non-spherical perturbations leads to a spherical scalarised BH.