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Hybrid metric-Palatini gravity: black holes, wormholes, singularities and stringlike objects

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The hybrid metric-Palatini theory of gravity (HMPG), proposed in 2012 by T. Harko et al., is known to successfully describe both local (solar-system) and cosmological observations. We discuss static. spherically symmetric vacuum solutions of HMPG with the aid of its scalar-tensor representation. This scalar-tensor theory coincides with general relativity with a conformally coupled scalar field (which can be canonical or phantom), therefore the known solutions of this theory are re-interpreted in terms of HMPG. In particular, in the case of zero scalar field potential $V(\phi)$, such that both Riemannian and Palatini Ricci scalars are zero, generic asymptotically flat solutions either contain naked singularities or describe traversable wormholes, and there are only special cases of black hole solutions with extremal horizons. There is also a one-parameter family of solutions with an infinite number of extremal horizons between static regions. Examples of analytical solutions with nonzero potentials $V(\phi)$ are also described, among them black hole solutions with simple horizons which are generic but, for canonical scalars, they require (at least partly) negative potentials. With phantom scalars there are "black universe" solutions that lead, beyond the horizon, to an expanding universe instead of a singularity. Many of the solutions under consideration turn out to be unstable under scalar monopole perturbations. A similar study is carried out on static, cylindrically symmetric stringlike configurations.

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