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We consider the gravitational field outside a static, spherically symmetric source in the context of a general $f(R)$ extension of General Relativity. We study the modified Einstein equations (EE), which involve the two free potentials of the metric together with $f(R)$ and its derivative $\phi = \frac{\partial f}{\partial R}$, without making any preliminary assumption on f as a function of the scalar curvature. Instead, we do require complete agreement with the usual Schwarzschild solution far from the source and minimal regularity of both the potentials and ϕ as functions of the coordinates.
Under these conditions we are able to perturbatively solve the modified EE, explicitly compute the leading correction to the Schwarzschild line element and retrieve a posteriori the corresponding $f(R)$. This is non analytical in $R = 0$ and depends on two parameters: a universal coupling c_1 and an integer number $n \geq 2$, which determines the order of the correction.

In the second part of the work, we firstly compute the parametrized post Newtonian parameters for the modified Schwarzschild line element: while γ agrees by construction with the strict Cassini bound for every n, the constraint on β from the precession of Mercury places a severe upper bound on c_1 for $n = 2$. We then compute the leading correction to the gravitational redshift and use observations of the sunlight gravitational redshift to set numerical upper bounds on c_1 at varying n. The corrections to the bending of light from a distant star by the Sun, to the precession of Mercury and to the Shapiro delay are also computed.

The result is a class of $f(R)$ theories built from a purely bottom-up approach and compatible with the local tests. This result can also help constraining exact $f(R)$ models working in Cosmology, since it provides the correct local limit.

Theories of gravity: alternatives to the cosmological and particle standard models / 258

The effects of intrinsic spin of matter in relativistic cosmology

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We discuss general solutions of the Einstein-Cartan theory sourced by a cosmological perfect fluid composed of particles with intrinsic spin. In the considered model, the metric tensor is described by a general FLRW solution, however, the Weyl tensor might not vanish. The coupling between the intrinsic spin and the Weyl tensor excludes spatially closed solutions, and the universe must either be flat or open. In the open case, it is shown that the magnetic part of the Weyl tensor verifies a wave equation, such that, in a dynamic universe, the intrinsic spin of matter leads to the generation and emission of gravitational waves. The properties of these waves are discussed, with an emphasis on their decay rate at late time. Lastly, we discuss that, in the considered cosmological model, the intrinsic spin of matter contributes to a positive accelerated expansion of the universe.

First stars and their remnants as dark matter probes / 259

The Formation of Supermassive Black Holes from Pop III.1 Protostars powered by Dark Matter Annihilation

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