Seventeenth Marcel Grossmann Meeting

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Asymptotically Schwarzschild solutions in $f(R)$ extension of General Relativity

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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.

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