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Gravitational wave propagation in hybrid metric-Palatini gravity

In this work we analyze the propagation properties of gravitational waves in the hybrid metric-Palatini gravity theory. We introduce the scalar-tensor representation of the theory to make explicit the scalar degrees of freedom of the theory and obtain their equations of motion in a form decoupled from the metric tensor. Then, we introduce linear perturbations for the metric tensor and for the two scalar fields and obtain the propagation equations for these three quantities. We analyzed the theory both at non-linear and at linear level through the Newman-Penrose formalism so to find the polarization states. We show that the tensor modes propagate at the speed of light and feature the usual $+-$ and $\times-$polarization modes also present in General Relativity (GR), plus two additional polarization modes: a longitudinal mode and a breathing mode, described by the same additional degree of freedom. On the other hand, the theory features two additional scalar modes not present in GR. These modes are massive and, thus, propagate with a speed smaller than the speed of light. The masses of the scalar modes depend solely on the interaction potential between the two scalar fields in the theory, which suggests that one can always fine-tune the potential to make the scalar modes massless and reduce their propagation speed to the speed of light. This feature potentially renders the theory unfalsifiable in the context of gravitational wave propagation.

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