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Unitarity, Causality, and Solar System Bounds, Significantly Limit Using Gravitational Waves to Test General Relativity

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The prospect of detecting/constraining deviations from general relativity by studying gravitational waves (GWs) from merging black holes has been one of the primary motivations of GW interferometers like LIGO/Virgo. Within pure gravity, the only possible way deviations can arise is from the existence of higher order derivative corrections, namely higher powers of the Riemann curvature tensor, in the effective action. Any observational bounds imply constraints on the corresponding Wilson coefficients. At the level of the action, one can imagine the coefficients are sufficiently large so as to be in principle detectable. However, from the point of view of some fundamental principles, namely causality and unitarity, this is much less clear, as we examine here. We begin by reviewing certain known bounds on these coefficients, which together imply a low cut off on the effective theory. We then consider a possible mechanism to generate such terms, namely in the form of many minimally coupled light scalars that can be integrated out to give these higher order operators. We show that a by product of this is the generation of quantum corrections to Newton's potential, whose observable consequences are already ruled out by solar system tests. We point out that over 7 orders of magnitude of improvement in interferometer sensitivity would be required to avoid such solar system constraints.

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