

# Theory-agnostic searches for non-gravitational modes in black hole ringdown

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In any extension of General Relativity (GR), extra fundamental degrees of freedom couple to gravity. Besides deforming GR forecasts in a theory-dependent way, this coupling generically introduces extra modes in the gravitational-wave signal. We propose a novel theory-agnostic test of gravity to search for these nongravitational modes in black hole merger ringdown signals. To leading order in the GR deviations, their frequencies and damping times match those of a test scalar, vector, or tensor field in a Kerr background, with only amplitudes and phases as free parameters. This test will be highly valuable for future detectors, which will achieve signal-to-noise ratios higher than 100 (and as high as 1000 for space-based detectors such as LISA). By applying this test to GW150914, GW190521, and GW200129, we find that the current evidence for an extra mode is comparable to that for the first gravitational overtone, but its inclusion modifies the inferred remnant spin.

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