Testing general relativity using observations of gravitational waves from the inspiral, merger and ringdown of binary black holes

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The recent observations of gravitational waves (GWs) from compact binary coalescences composed of neutron stars and/or black holes (BHs) by the advanced LIGO-Virgo detectors have firmly opened the field of GW astronomy. These observations, for the first time, have also allowed us to test Einstein's theory of general relativity (GR) in the strong-field dynamical regimes of gravity [1]. One of the first strong-field tests of GR performed on an actual GW observation, was the inspiral-merger-ringdown (IMR) consistency test [2, 3], and through the absence of any deviations from the predictions of GR, helped establish the consistency of the first LIGO event (and subsequent detections), with a binary BH (BBH) system described in GR [1, 4, 5, 6]. The IMR consistency test involves inferring the mass and spin of the remnant BH from the inspiral (low-frequency) and the post-inspiral (high-frequency) part of the observed signal independently, and checking for their consistency with the predictions of GR. We study the robustness of this test against reasonable variations of different analysis parameters. Using kludge modified GR waveforms, we demonstrate how this test could identify certain types of deviations from GR if such deviations are present in the signal. Finally, anticipating the large number of detections of BBHs expected in the near future, we show how information from multiple events (observed over the first two science runs of Advanced LIGO-Virgo) can be combined to produce stronger constraints on possible deviations from GR [3].

References

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