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Testing the strong-field dynamics of general relativity with gravitational wave signals from compact binary coalescences

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The observations of the presumed binary black hole coalescences GW150914 and GW151226 during the first observing run of Advanced LIGO have allowed us to probe the genuinely strong-field dynamics of Einstein's general theory of relativity (GR) for the first time. We give a brief overview of the tests carried out on the detected signals, which showed consistency with GR within the measurement uncertainties. As the detectors undergo further upgrades, more and louder signals are likely to be observed. This will enable us to not only put tighter constraints on the inspiral-merger-ringdown dynamics of the binary coalescence process, but also more directly probe the nature of the compact objects themselves, in complementary ways. During inspiral, massive objects that deviate from standard black holes (e.g. boson stars or dark matter stars) may give away their non-standard nature through tidal effects. Observation of the "ringdown" of the merger remnant allows for a test of the black hole no-hair theorem. Finally, certain quantum modifications to black holes (e.g. firewalls) are speculated to have macroscopic consequences, in the form of gravitational wave "echoes", or bursts of radiation that appear at regular time intervals after the ringdown has ended. Thus, the direct observation of gravitational waves opens up unique possibilities to put ideas in fundamental physics and cosmology to the test.

Experimental Collaboration

Virgo Collaboration

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