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Tests of general relativity with gravitational waves

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The direct detection of gravitational waves with Advanced LIGO has opened up the possibility of probing the genuinely strong-field dynamics of pure spacetime for the first time. Several tests of general relativity (GR) were carried out with the gravitational wave events GW150914 and GW151226. In the case of GW150914, the merger itself was in the most sensitive part of the detectors' frequency band, allowing for a check of the relation that exists in GR between the masses and spins of the initial component black holes and the mass and spin of the single black hole resulting from their merger. Furthermore, the data following the peak of the signal were consistent with the "ringdown" of this highly excited remnant black hole. From the properties of the signal after propagation from source to observer, it was possible to infer a bound on the graviton mass of $m_g < 1.2 \times 10^{-22}\,\mathrm{eV}/c^2$. In the case of GW151226, many more cycles from the "inspiral" of the initial black holes were in the detectors' sensitive band, allowing for stringent constraints on deviations from GR to high order in an expansion in powers of v/c, with v the characteristic velocity. So far all tests show consistency with GR in the highly non-linear, dynamical regime. Possible future checks, depending on what new kinds of compact binary mergers we will see, will also be discussed.

Summary

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