Example B abstract

In Advanced LIGO, detection and astrophysical source parameter estimation of the binary black hole merger GW150914 requires a calibrated estimate of the gravitational-wave strain sensed by the detectors. Producing an estimate from each detector’s differential arm length control loop readout signals requires applying time domain filters, which are designed from a frequency domain model of the detector’s gravitational-wave response. The gravitational-wave response model is determined by the detector’s opto-mechanical response and the properties of its feedback control system. The measurements used to validate the model and characterize its uncertainty are derived primarily from a dedicated photon radiation pressure actuator, with cross-checks provided by optical and radio frequency references. We describe how the gravitational-wave readout signal is calibrated into equivalent gravitational-wave-induced strain and how the statistical uncertainties and systematic errors are assessed. Detector data collected over 38 calendar days, from September 12 to October 20, 2015, contain the event GW150914 and approximately 16 days of coincident data used to estimate the event false alarm probability. The calibration uncertainty is less than10% in magnitude and 10° in phase across the relevant frequency band, 20 Hz to 1 kHz.

Example D abstract

On September 14, 2015 at 09:50:45 UTC the two detectors of the Laser Interferometer Gravitational-Wave Observatory simultaneously observed a transient gravitational-wave signal. The signal sweeps upwards in frequency from 35 to 250 Hz with a peak gravitational-wave strain of 1.0 × 10−21. It matches the waveform predicted by general relativity for the inspiral and merger of a pair of black holes and the ringdown of the resulting single black hole. The signal was observed with a matched-filter signal-to-noise ratio of 24 and a false alarm rate estimated to be less than 1 event per 203 000 years, equivalent to a significance greater than5.1σ. The source lies at a luminosity distance 410 Mpc corresponding to a red shift 0.09. In the source frame, the initial black hole masses are 36 M and 29 M , and the final black hole mass is 62M , with 3.0 M c2 radiated in gravitational waves. All uncertainties define 90% credible intervals. These observations demonstrate the existence of binary stellar-mass black hole systems. This is the first direct detection of gravitational waves and the first observation of a binary black hole merger.