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Gravitational Wave Astronomy and Astrophysics: Sources of Gravitational Waves

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Extended Abstract

In September and December, 2015, the twin detectors at Hanford WA, and Livingston LA of the Advanced Laser Interferometer Gravitational-wave Observatory (LIGO) [1] in the USA made the first direct detection of gravitational waves and the first ever observation of binary black holes. Gravitational waves were predicted by Einstein in 1916 and experimental efforts began in the 1960s to measure the strain caused by a passing gravitational wave. LIGO's discovery [2,3] has ushered a new era in observational astronomy, fundamental physics and cosmology. In this presentation, I will highlight the main results from LIGO observations so far, astrophysical implications they have brought to bear and the strong field tests of general relativity they have availed.

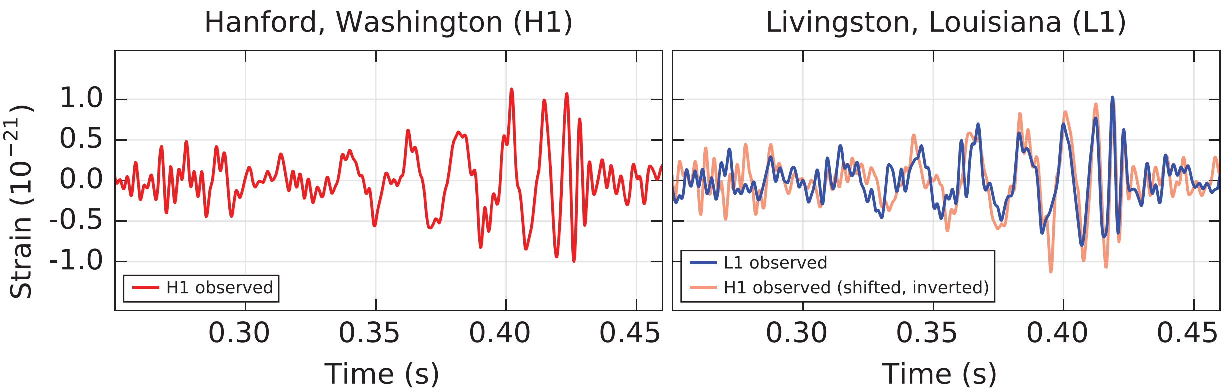

Figure 1. The figure shows the "raw" data from the LIGO Hanford (left) and LIGO Livingston (right) detectors over 200 milliseconds. Times are shown relative to September 14, 2015 at 09:50:45 UTC. For visualization, data are filtered with a 35–350 Hz bandpass filter. The right plot also shows the Hanford data shifted relative to the Livingston data by 6.9 milliseconds inverted to account for the relative orientations of the two detectors.

After a one-year period of commissioning, Advanced LIGO has been taking data since November 2016 and this second observing run will last until summer of 2017. As Advanced LIGO progresses towards its design sensitivity over the next few years and the Virgo interferometer in Italy joins observations, we hope to detect other gravitational wave sources such as coalescing binaries of neutron stars and black holes, supernova, continuous waves from asymmetric spinning neutron stars and stochastic background from a population of point sources as well as gravitational waves from the primordial Universe. Progress in detector development will enable the construction of a new network of detectors that can see some of these sources to the edge of the Universe helping us answer questions about the nature of the dark and energetic processes using the gravitational window.

2. References

1. Aasi, J. et al., "Advanced LIGO," *Classical and Quantum Gravity*, **32**, 7, March 2015, 074001, doi:10.1088/0264-9381/32/7/074001.
2. Abbott, B.P. et al., "Observation of Gravitational Waves from a Binary Black Hole Merger," *Physical Review Letters*, **116**, February 2016, 061102, doi:10.1103/PhysRevLett.116.061102
3. Abbott, B.P. et al., "GW151226: Observation of Gravitational Waves from a 22-Solar-Mass Binary Black Hole Coalescence," *Physical Review Letters*, **116**, June 2016, 241103, doi:10.1103/PhysRevLett.116.241103.