Advanced LIGO and the Detection of Gravitational Waves

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1. Extended Abstract

The Laser Interferometer Gravitational-wave Observatory (LIGO) consists of two 4-km gravitational-wave detectors in Hanford, WA, USA, and Livingston, LA, USA, operated in unison by the LIGO Scientific Collaboration. Using laser interferometry, these detectors measure minute distortions in space-time caused by the passage of gravitational waves from cataclysmic cosmic events. In 2015, LIGO observed two distinct gravitational wave signals, GW150914 and GW151226, each from the merger of two black holes. These were the first direct measurements of gravitational waves, the first observations of binary stellar-mass black hole systems, and the first observations of black hole binary mergers.

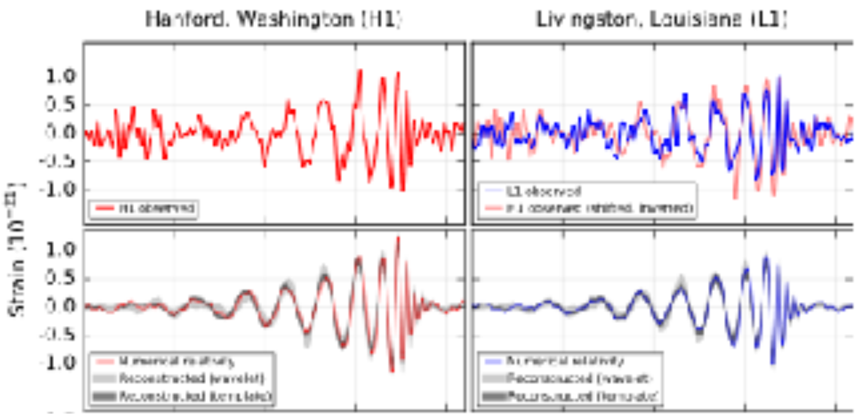

Figure 1. The GW150914 signal as observed in the Hanford (H1, left) and Livingston (L1, right) detectors.

The GW150914 signal had a peak gravitational wave strain of 1 x 10^{-21}, equivalent to measuring a differential change between the interferometer arms of 10^{-18} m. Achieving this level of sensitivity requires extensive seismic isolation and attention to noise sources. Radio frequency photonics systems are critical for the sensing and control of Advanced LIGO interferometers.

The detection of gravitational waves marks the beginning of the field of gravitational wave astronomy. Gravitational wave observations have already enabled tests of general relativity in the strong field regime and estimations of the rates of mergers involving black holes and neutron stars. Future gravitational wave events and their electromagnetic counterparts promise insight into the nature of gamma-ray bursts, neutron star equations of state, and supernovae.

This talk will give an overview of the detection of gravitational waves, the LIGO observatories, and prospects for the future of gravitational wave astronomy, including results from the recently concluded second observing run.

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.