

Interferometric gravitational-wave detectors: Optomechanics on the kilowatt, kilometre and kilogram scale

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For the first time, scientists have observed ripples in space-time, called gravitational waves, produced by a cataclysmic event from the far Universe, arriving to Earth after a long journey [1]. This result, a signal from two merging black holes (Figure 1a), confirms a major prediction of the Theory of General Relativity made by Albert Einstein in 1915, and opens a completely new window into the Cosmos. These gravitational waves were detected by the two LIGO (*Laser Interferometer Gravitational-wave Observatory*) interferometers in the United States (Figure 1b) [2], amongst the first of the second-generation interferometric detectors that are now coming on line. This global network will use state-of-the-art technologies, including kilowatt laser power circulating in kilometre-long optical cavities that are formed by kilogram mirrors on pendula suspensions (Figure 1c). Further, these detectors are expected to be broadly quantum noise limited in their sensitivity. These are optomechanical systems on the kilowatt, kilometre and kilogram scale.

First, I will present a brief introduction to gravitational waves and the published observation. Then, I will detail interferometric gravitational-wave detectors instruments, highlighting their technologies and optomechanical properties. Finally, I will focus on future prospects and plans for these instruments, including quantum-enhanced operation.

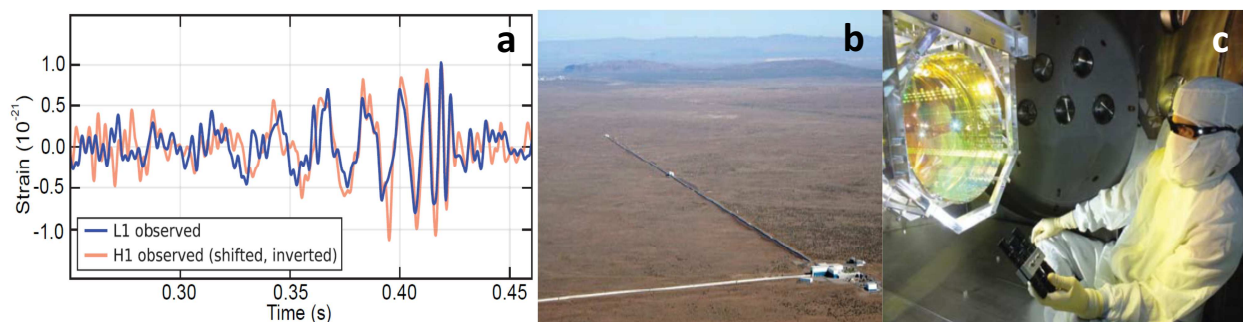


Fig 1: **a.** Gravitational-wave signal detected from a binary black-hole merger **b.** The LIGO detector facility at Hanford, Washington State USA **c.** One of the 40 kg mirrors of the LIGO gravitational-wave detector

1. Abbott B. P. et al. (LIGO Scientific Collaboration and Virgo Collaboration), *Observation of gravitational waves from a binary black hole merger*, Phys. Rev. Lett 116, 061102, 2016
2. Abbott B. P. et al. (LIGO Scientific Collaboration and Virgo Collaboration), *GW150914: The Advanced LIGO Detectors in the Era of First Discoveries*, Phys. Rev. Lett 116, 131103, 2016