LIGO: the Laser Interferometer Gravitational-wave Observatory

LIGO-G1100046

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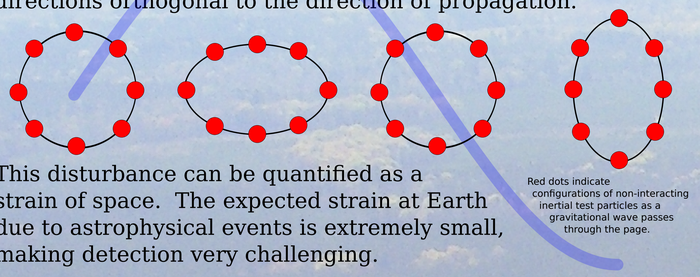
Gravitational waves

Gravitational waves are a propagating disturbance in the metric tensor. The effect of a passing gravitational wave is to periodically stretch and compress space in the two directions orthogonal to the direction of propagation.



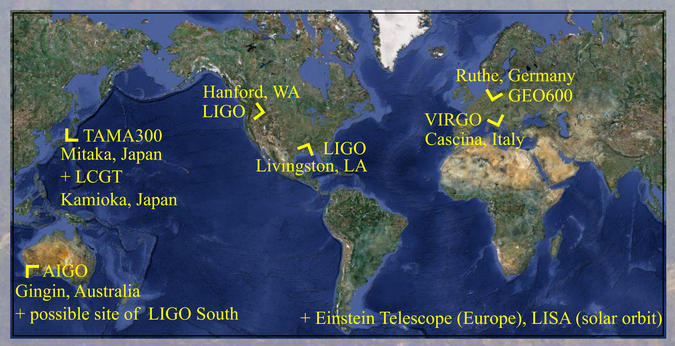
Red dots indicate configurations of non-interacting inertial test particles as a gravitational wave passes through the page.

This disturbance can be quantified as a strain of space. The expected strain at Earth due to astrophysical events is extremely small, making detection very challenging.

Network of detectors

LIGO is part of an **international network** of gravitational wave detectors. Multiple detector sites located around the globe are crucial in providing source localization.

LIGO operates two observatories, one on the Hanford Site near Richland in eastern Washington state, and the other in Livingston Parish, Louisiana. A third site, in Australia, has been proposed for Advanced LIGO.

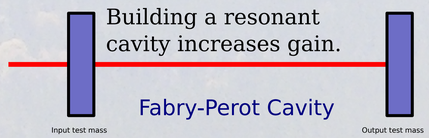


LIGO recently completed its most sensitive observing run so far. In October 2010 construction of the vastly more sensitive **Advanced LIGO** began.

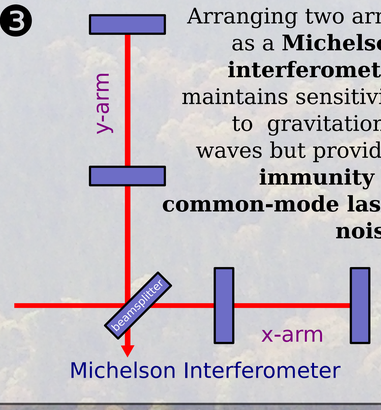
Principle of operation

❶ Light reflecting from an inertial test mass converts gravitational wave strain to optical phase.

❷ Building a resonant cavity increases gain.

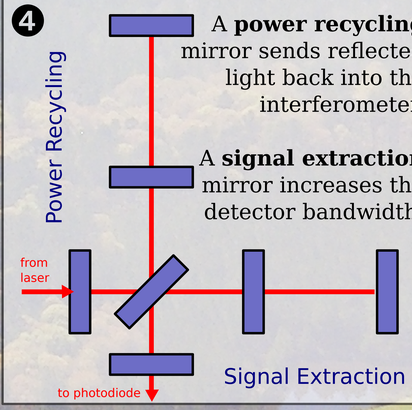


❸ Arranging two arms as a **Michelson interferometer** maintains sensitivity to gravitational waves but provides **immunity to common-mode laser noise**.

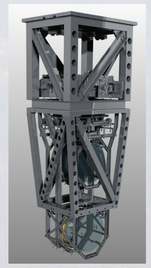


❹ A **power recycling** mirror sends reflected light back into the interferometer.

A **signal extraction** mirror increases the detector bandwidth.

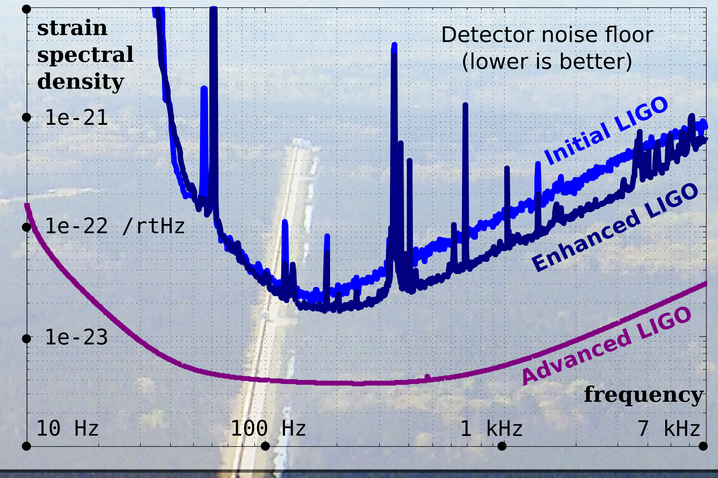


Suspending an optic via a pendulum allows the optic to act as an inertial test mass above the pendulum's resonant frequency.



⓪ Suspended Test-masses

Sensitivity - achieved and projected



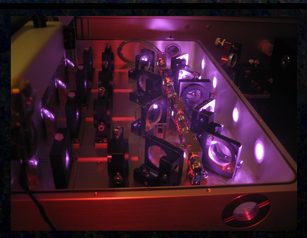
Sources and searches

Gravitational waves are produced by distributions of mass with acceleration in the quadrupolar or higher moments. Searches are underway for:

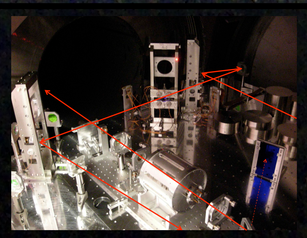
- Inspiral of binary systems of black holes or neutron stars.
- Unmodeled bursts, such as supernovae.
- Stochastic background - either astrophysical or cosmological in origin; isotropic or localized.
- Spinning neutron stars and known pulsars.

Donate spare computer time to LIGO searches via the "Einstein at Home" project:

http://EinsteinAtHome.org/

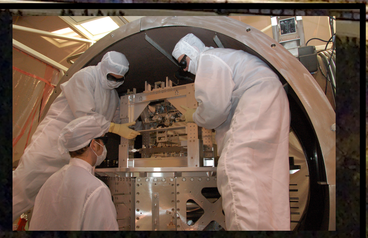


High-power 1064 nm Enhanced LIGO **laser amplifier** supplied by Laser Zentrum Hannover. Photo by A. Effler.



In-vacuum **input optics** supplied by University of Florida.

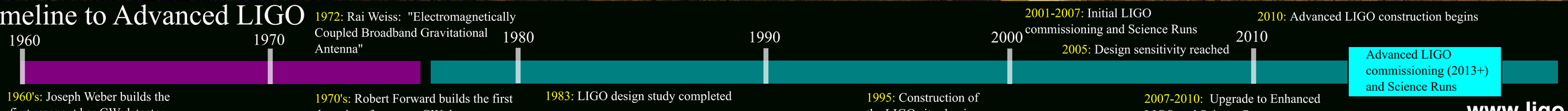
Hanford **control room** during 5th science run



Installing the in-vacuum **output mode cleaner** at Livingston.

Background image: Aerial photograph of the LIGO Livingston Observatory by Stefan Ballmer, March 2008.

Timeline to Advanced LIGO



www.ligo.org