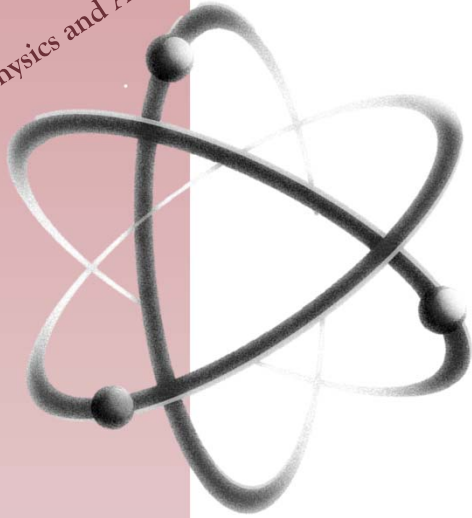


Department of Physics and Astronomy



University of South Carolina

Gravitational Waves

Taekuk Hong

University of South Carolina
Department of Physics and Astronomy



What is the “gravitational waves”?

Gravitation Force

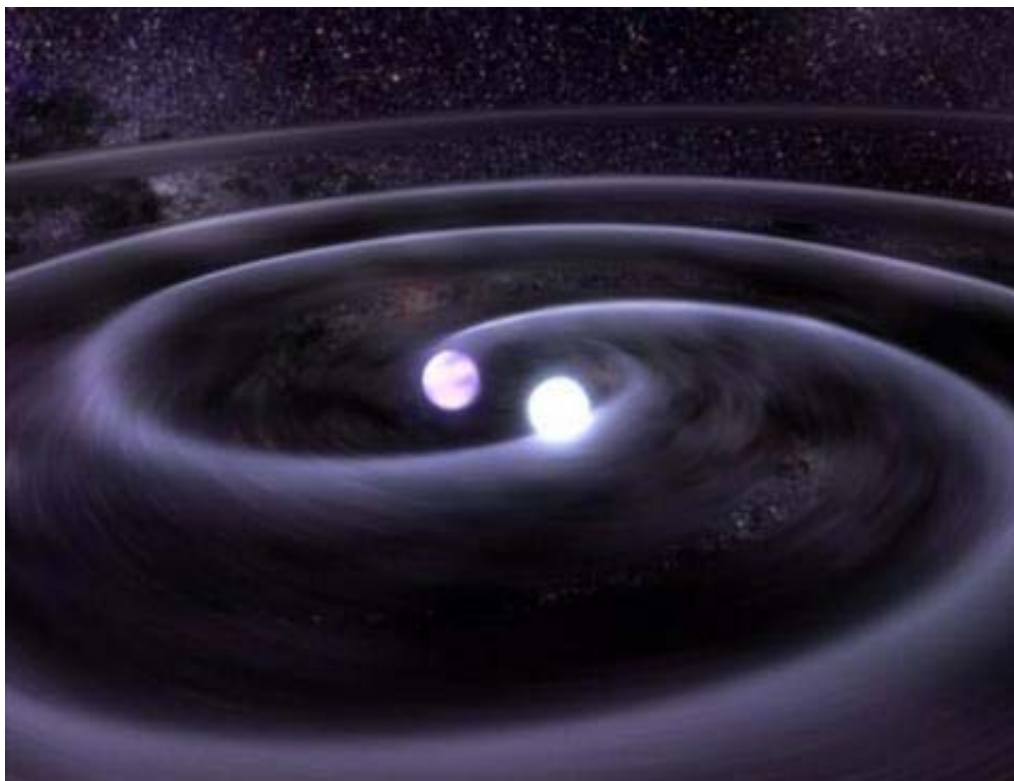
Michelson Interferometer

LIGO Experiment

Result & Analysis



What is the “Gravitational Waves”?



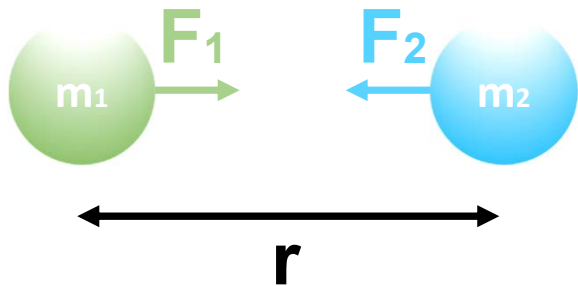
The Nobel Prize in Physics 2017

Gravitational waves are waves that are carried out at the speed of light by fluctuating curvature of the gravitational field in space-time by mass.



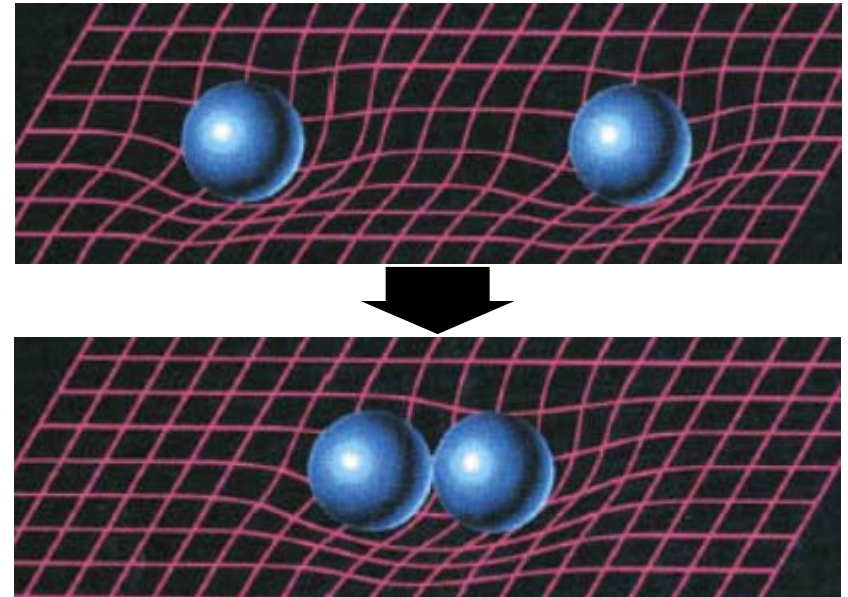
Gravitation Force

Newton's gravitation force perspective



$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$

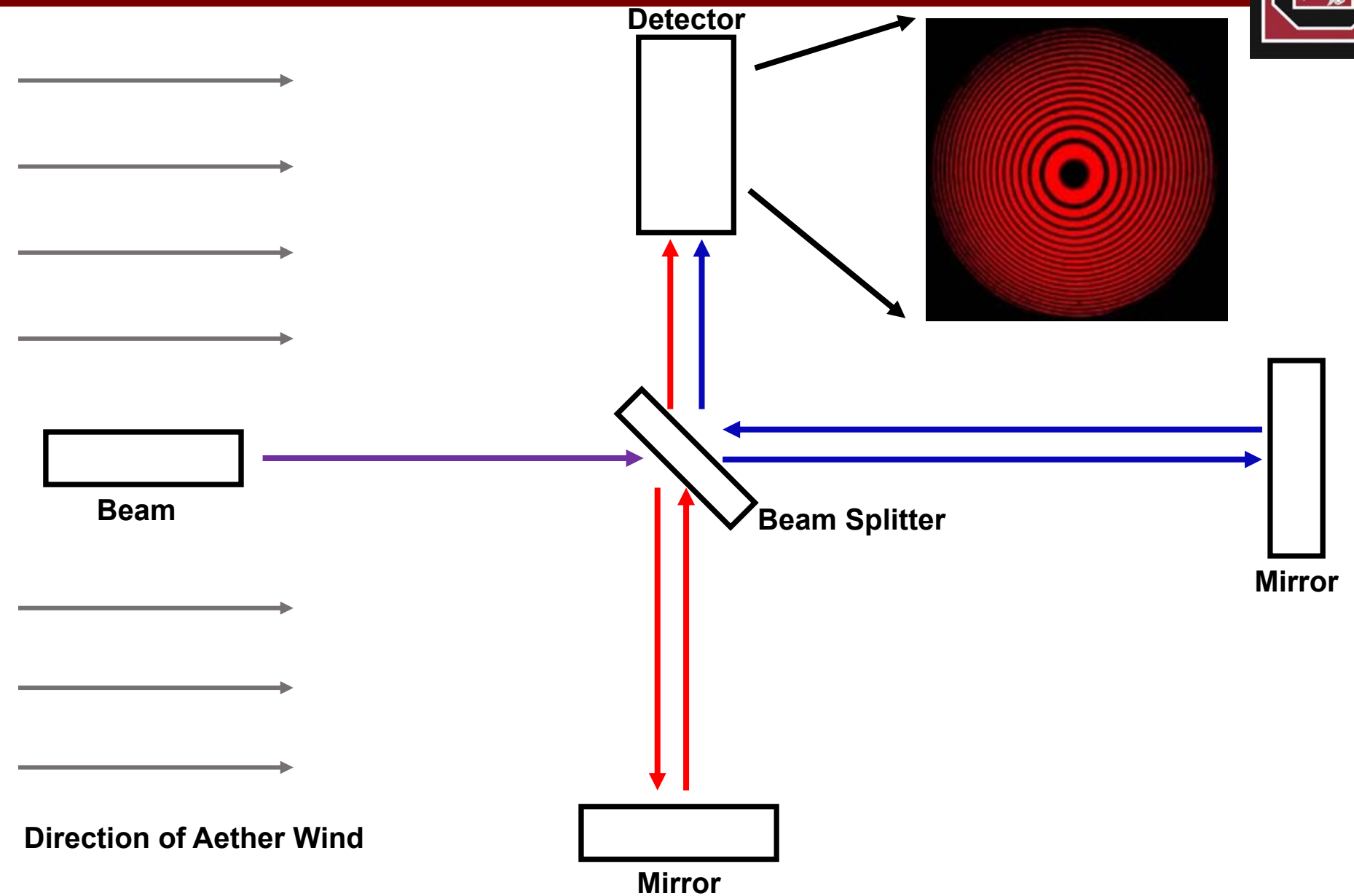
Einstein's gravitation field perspective



$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu}$$



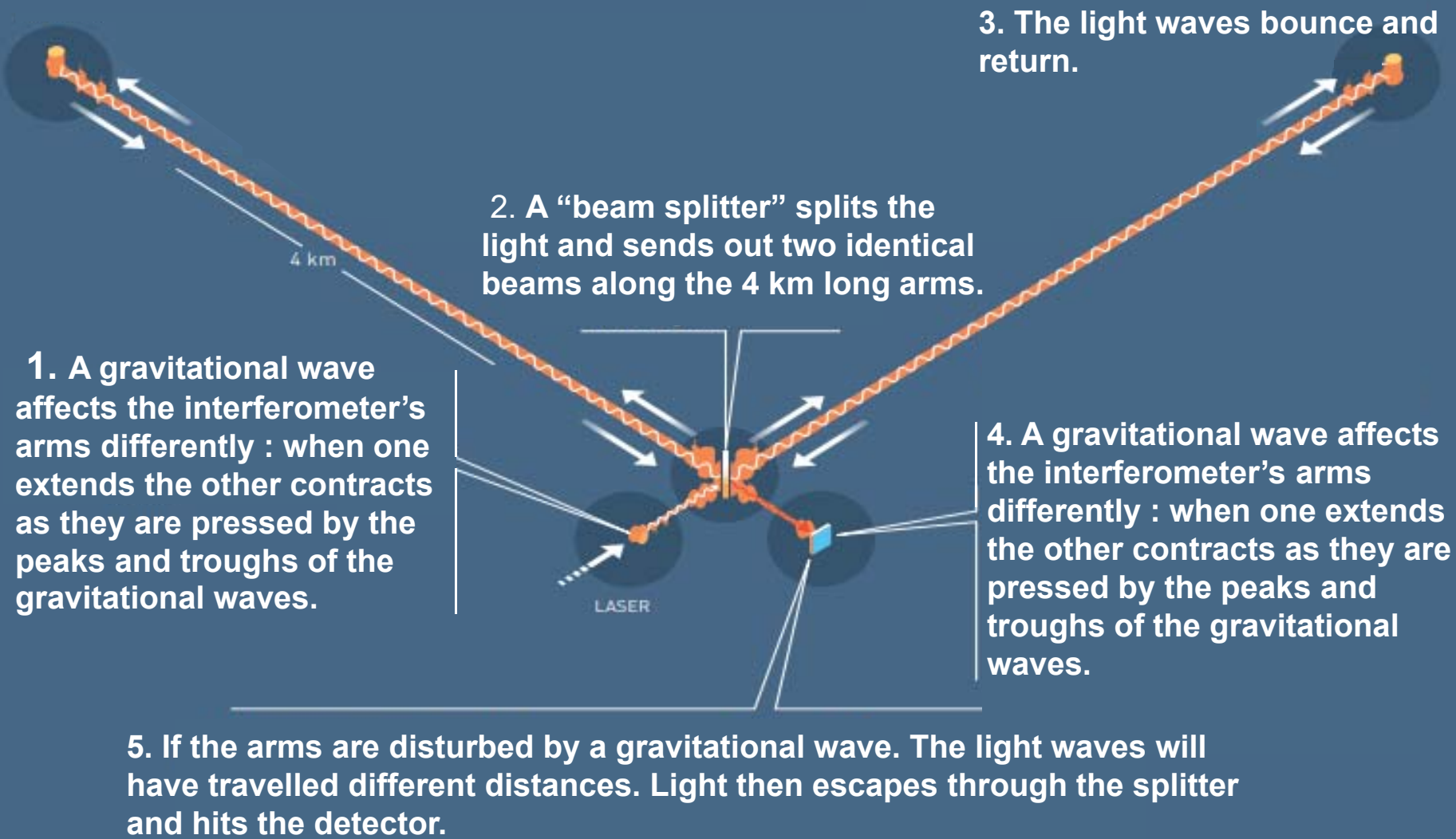
Michelson Interferometer





LIGO Experiment

LIGO – A GIGANTIC INTERFEROMETER



1. A gravitational wave affects the interferometer's arms differently : when one extends the other contracts as they are pressed by the peaks and troughs of the gravitational waves.

2. A "beam splitter" splits the light and sends out two identical beams along the 4 km long arms.

3. The light waves bounce and return.

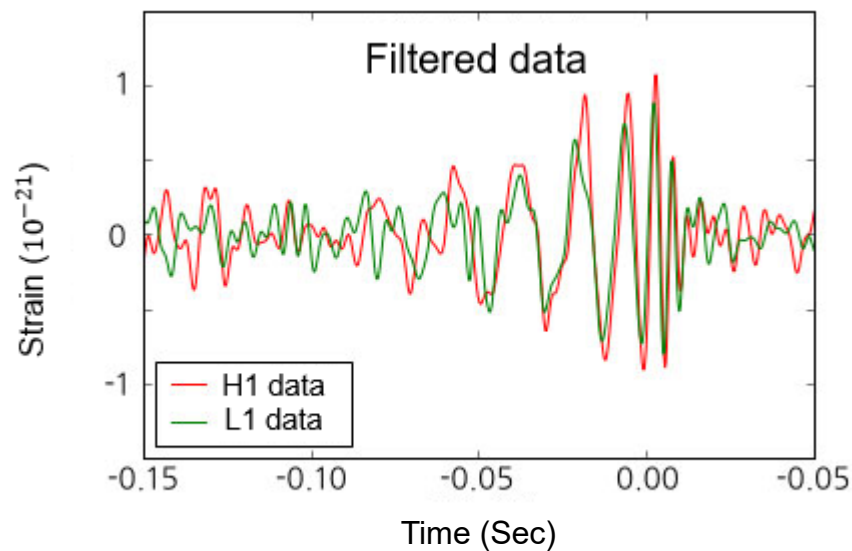
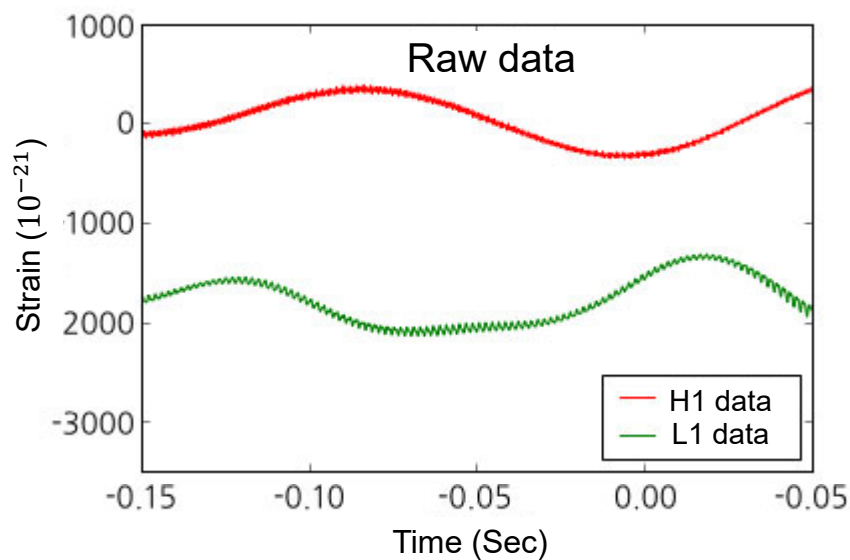
4. A gravitational wave affects the interferometer's arms differently : when one extends the other contracts as they are pressed by the peaks and troughs of the gravitational waves.

5. If the arms are disturbed by a gravitational wave. The light waves will have travelled different distances. Light then escapes through the splitter and hits the detector.



Results & Analysis

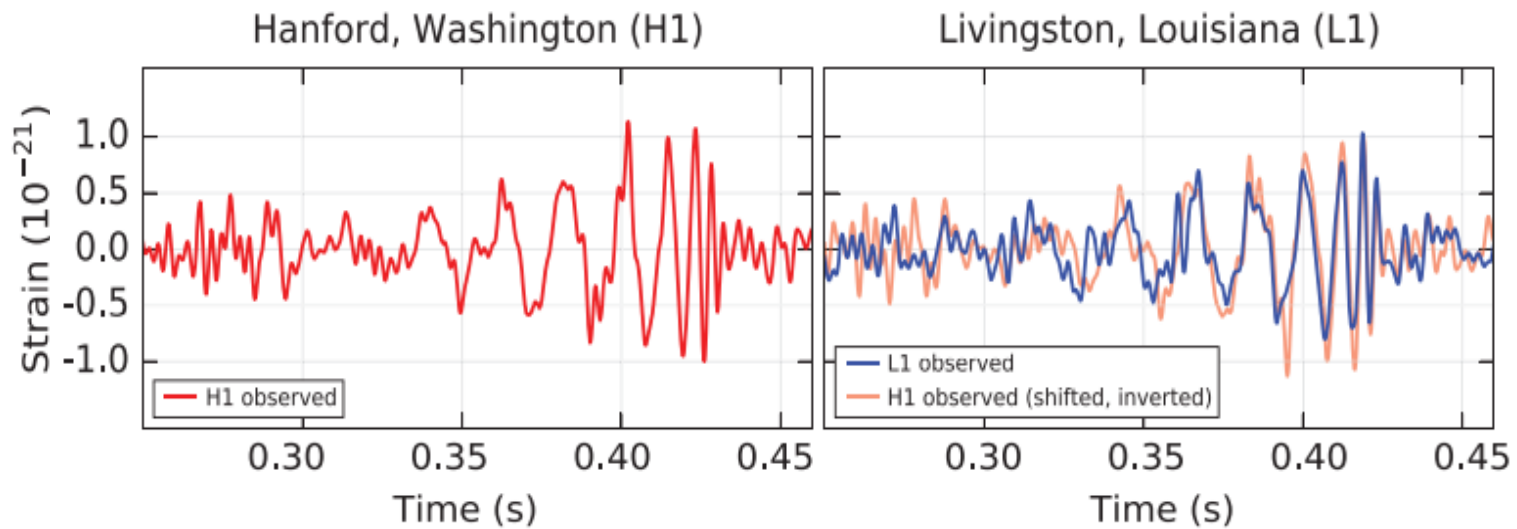
$$\text{Strain} = \frac{\text{Distance difference}}{\text{LIGO length}} (10^{-21})$$



Hanford, Washington (H1)
Livingston, Louisiana (L1)

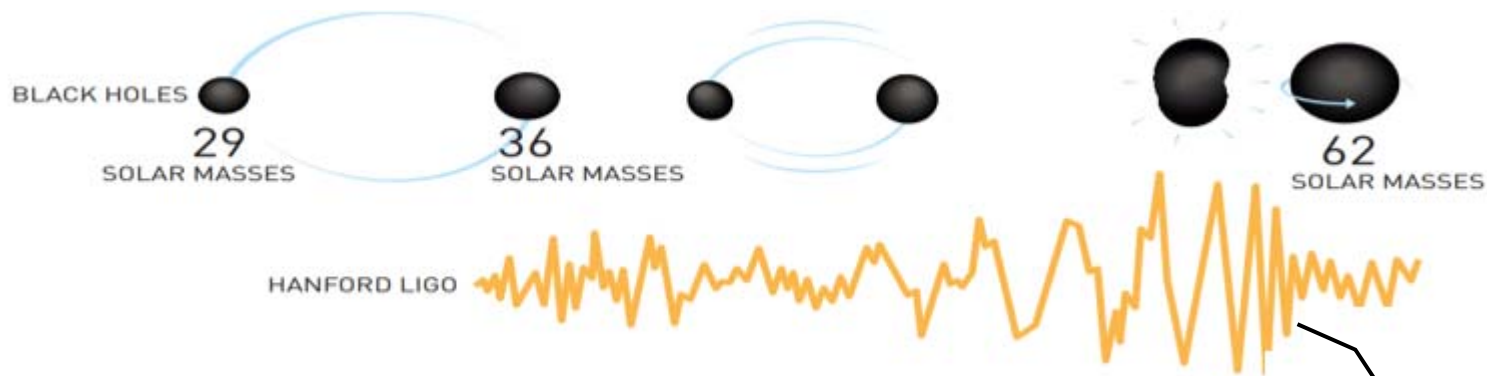


Results & Analysis

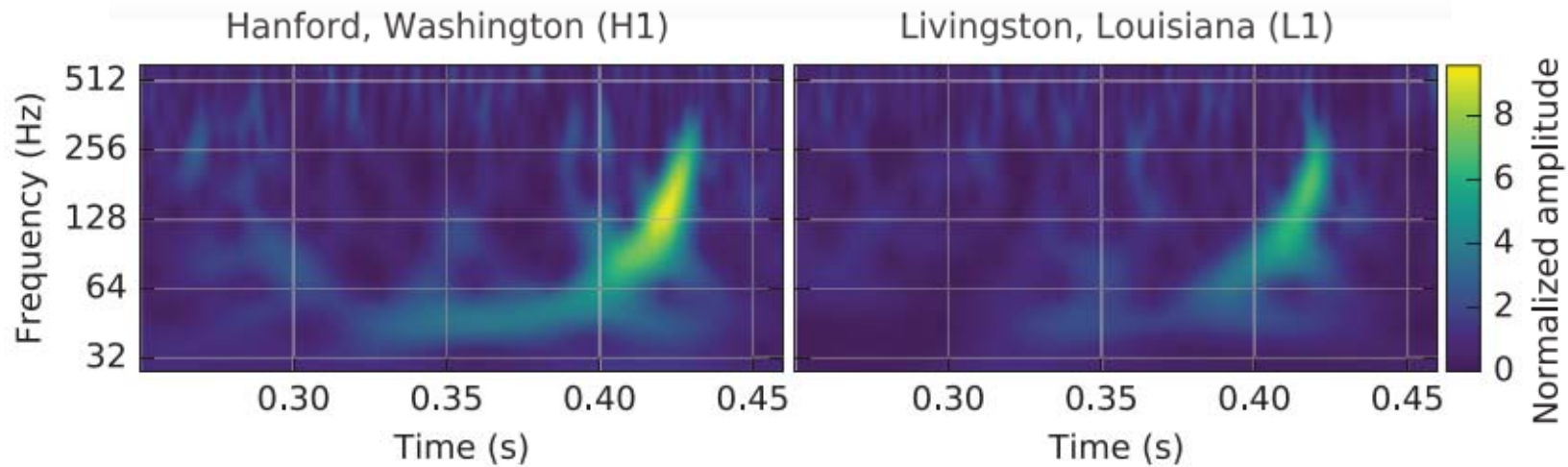




Results & Analysis

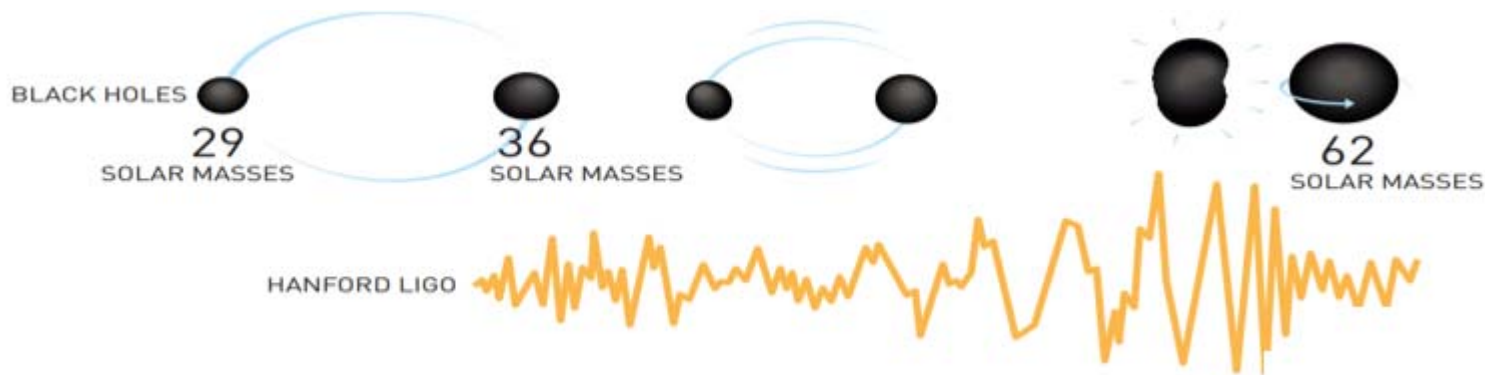


Chirp mass : When two black holes are coalescing with each other by orbital evolving, the loss of energy is occurred to as a gravitational wave, and this occurred energy loss determines chirp mass.





Results & Analysis



$$\mu = \frac{(m_1 m_2)^{\frac{3}{5}}}{(m_1 + m_2)^{\frac{1}{5}}} = \frac{C^3}{G} \left[\frac{5}{96} \pi^{\frac{-8}{3}} f^{\frac{-11}{3}} \dot{f} \right]^{\frac{3}{5}}$$

μ : Chrip mass , $m_1 = m_2 =$ Mass of blackhole, f : Observed frequency,
 \dot{f} : Observed frequency time derivative, G : Gravitational constant, C : Speed of light

Primary black hole mass	$36^{+5}_{-4} M$
Secondary black hole mass	$29^{+4}_{-4} M$
Final black hole mass	$62^{+4}_{-4} M$



“Novel Prize” website

**Dissertation named “Observation of Gravitational
Waves from a Binary Black Hole Merger”**

LOGO website