LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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Devoloping Phase Map of Cavity Mirrors using Laser Mode Spectroscopy

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1 Introduction

1.1 Gravitational Waves

Einstein's general theory of relativity explains gravity as a distortion of spacetime caused by the presence of matter or energy. A massive object generates a gravitational field by warping the geometry of the surrounding spacetime. Due to some of the most violent and energetic processes in the universe the gravitational field around it varies with respect to time and this produces ripples in the fabric of space-time. These ripples are known as the Gravitational Waves. Einstein's mathematics showed that the waves produced by massive accelarating objects like neutron stars or black holes will have sufficient energy to get radiated from the source. These ripples would travel at the speed of light through the Universe. The ripple carry information about their origin, as well as invaluable clues to the nature of gravity. Thus study of gravitational waves provide us better understanding of the existing Universe and also about the early universe shortly after the Big Bang. This emerging branch of Physics is known as the Gravitational-wave astronomy. Even though the existence of Gravitational waves were first predicted in 1916, the first direct detection of Gravitational Waves occurred on September 14, 2015 using the Laser Interferometer Gravitational Observatory (LIGO). This work earned three scientist the 2017 Nobel Prize in Physics.

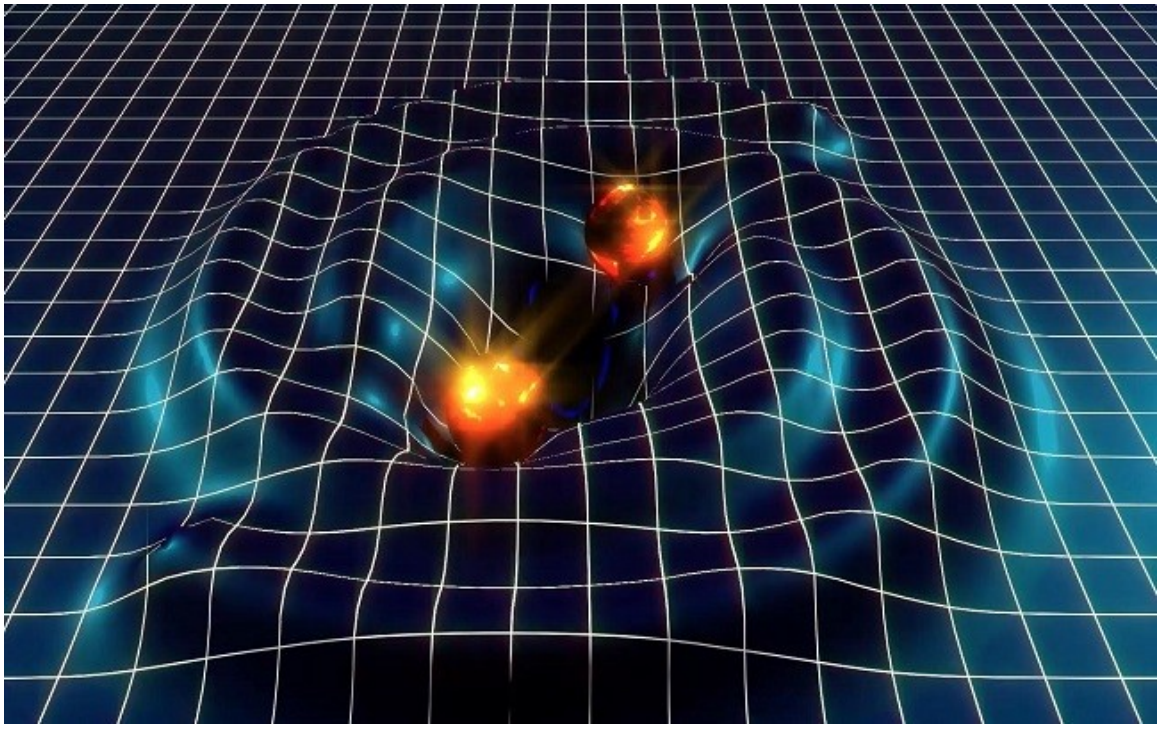

Figure 1: A simulation of production of Gravitational waves from binary stars orbiting around each other

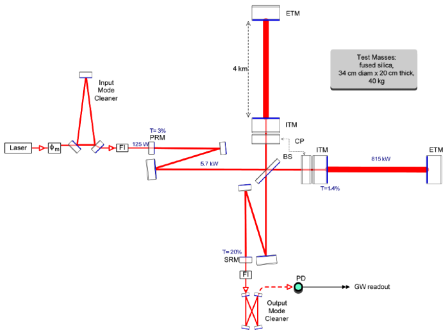

Figure 2: Modified Micheldon Interferometer with Fabry-Perot cavity used for the detection of Gravitational waves in LIGO

1.2 Detection of gravitational waves in LIGO

LIGO works with the help of two detectors located in the United states. One in Livingston, Louisiana and the other in Hanford, Washington. These detectors are modified Michelson Interferometer with Fabry-Perot cavity introduced to it. Each detector is shaped like a gigantic L, in which each arm is 4 Km long. Usually both the arms are of same length. Thus, laser beam takes the same time to travel down each. We now know that Gravitational waves are the ripples formed in the space time. When Gravitational Wave pass through Earth, the Interferometer get affected as it makes the detector arms expanded and contracted by as much as 1/10,000 the diameter of a proton. At the very moment we can measure the split-second difference in time taken by the laser beam to travel down one arm of the detector versus other. From this time measurements we can calculate the change in length of the arms and thus the properties of the wave arrived.

References

[1] Author, *Title of the Article or Book*. Physical Review XXXX, XXXXX (2010).

[2] http://blue.ligo-wa.caltech.edu:8000/40m/40mHomePage