Gravitational Waves Detection: Arranging for Detectable Shift in the Fringe Pattern

Dhananjay P. Mehendale
Sir Parashurambhau College, Tilak Road, Pune 411030, India

Abstract

We propose a new technique for detecting gravitational waves that rests on Weber-like setup plus a specially arranged double slit experiment in which we suggest to make distance between the slits as much small as possible with present state of the technology. We make these two slits in the Weber bar itself, equidistant from center of thin Weber bar, to be suspended along y-axis and kept in the y-z plane and suppose the gravitational waves will be falling perpendicularly on this suspended Weber bar having specially made two slits near the center as mentioned along x-direction. This technique is based on detecting oscillations produced in the fringe pattern formed due to interference between light waves passing through two slits made in the suspended Weber bar due to squeezing and elongation of this antenna leading to variation in the distance between the slits made in this antenna when this antenna will get exposed to incoming gravitational waves, in the x-direction. Let the separation between slits be d say. When plane gravitational waves will be passing this apparatus by falling perpendicularly on y-z plane there will be switching of direction of elongation and contraction periodically in such a way that there will be elongation along y-direction and contraction along z-direction and then the reversal of these conditions, i.e. there will be contraction along y-direction and elongation along z-direction. Due to this the separation between these parallel slits will be changing periodically. This variation will essentially amount to variation in the fringe pattern. If this variation that is expected in the fringe pattern could be found then it will conclude the arrival and passing of gravitational waves!

1. **Introduction:** Experimental detection of gravitational waves is a big challenge of this time and enormous efforts are on world over by people working in highly sophisticated gravitational wave detection laboratories. Gravitational wave laboratories will be leading laboratories in the coming future to offer new important insights in our study of large scale phenomena. Detection and study of gravitational waves of different types and of different intensity and frequency will make revolutionary contributions to our knowledge about galactic dynamics. It will add greatly to our knowledge about astrophysical sources and about processes driven by strong gravitational fields. Objects of fundamental importance, such as astrophysical black holes, merge and radiate with luminosity larger than the entire electromagnetic

universe, and these events will become clearly detectable only through a tool for detection of gravitational waves that are mainly associated with detectable amplitude with such unimaginably huge events [2]. When observed with gravitational waves these intrinsically interesting astronomical sources such as massive black holes and their merger, extremely compact stellar binaries and their collisions, supernovae events etc will surely yield many new surprises. Thus, the discovery potential associated with detection of gravitational waves is immense.

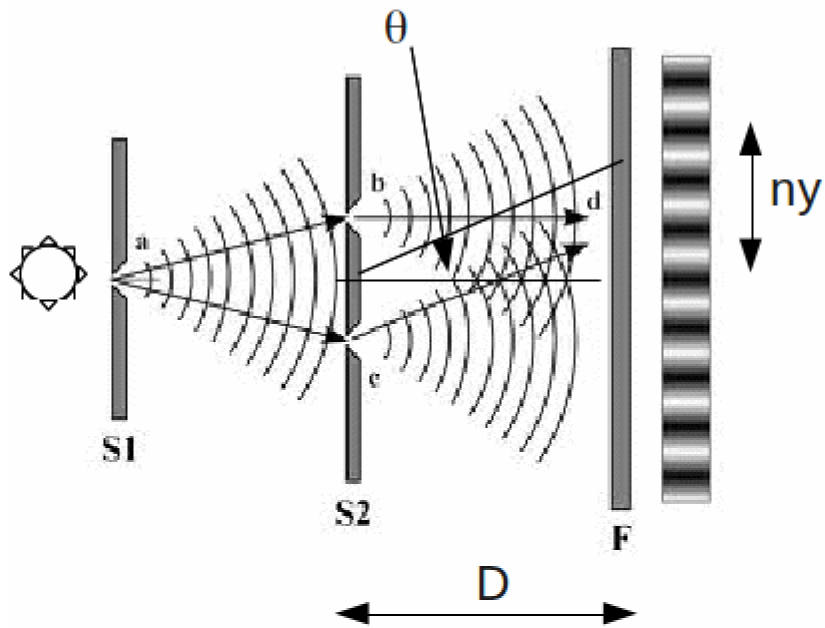
Gravitational radiation was detected indirectly in 1974 by J. Taylor and R. Hulse, who observed its effects on the orbital period of a binary system containing two neutron stars, one of them a pulsar (PSR 1913 + 16). Efforts to detect gravitational waves directly have been severely challenged by the extreme weakness of the waves impinging on the Earth. However, as the 21st century begins, observations of the gravitational waves from astrophysical sources such as black holes, neutron stars, and stellar collapse are expected to open a new window on the universe [3].

There are two major gravitational wave detection concepts: acoustic and interferometric detection [4]. The acoustic method deals with a resonance response of massive elastic bodies on gravitational wave excitations. Historically the acoustic method was proposed first by J. Weber [1] where he suggested using long and narrow elastic cylinders as Gravitational Wave Antennas. Although a significant progress has been achieved in fabrication and increasing sensitivity of such type of detectors [5, 6, 7] the interpretation of obtained data is still far to claim undoubtedly the detection of gravitational waves. Extraordinarily weak effect produced by gravitational waves requires exceedingly high detector sensitivity for both acoustic as well as interferometric detectors. Any new idea associated with marked improvement causing increase, may be in the indirect way, in the size of the quantity to be measured for getting conclusive evidence for the presence of gravitational waves will be a welcome thing.

2. **Detection through Detecting Shift in the Fringe Pattern:** In this technique we propose to detect possible variation in the fringe pattern on arrival and passing of gravitational waves due to expected variation in the distance between two narrow slits made centrally in the suspended thin Weber-like antenna kept along y-axis at the instance of arrival and passing of gravitational waves that will be running along x-axis with the help of the following experimental arrangement. We suspend thin Weber-like bar along y axis. As long as this system is not exposed to any gravitational waves there will be no deformation of any kind, i.e. extension or contraction of Weber-like antenna, and so there will be no variation in the separation between the two slits made in this bar for monochromatic and coherent light of wavelength, λ say, to pass through. We fix a point like sharp laser source equidistant from two slits on one side of the y-z plane at some distance to create two point like coherent sources at slits made in the Weber bar and fix the screen to form fringe pattern on the other side of the y-z plane and parallel to it at distance D, say. Now, suppose plane gravitational waves start passing along x axis and falling perpendicularly to y-z plane. Now the deformations will be introduced, i.e. there will be periodic switching of directions of elongation and contraction in such a way that

when there will be contraction along y-axis there will be elongation along z axis and vice versa. This periodic switching of directions of contractions and elongations leads to variation in the distance, d, between the slits leading to variation in the fringe pattern formed on the screen kept parallel to y-z plane at distance D. This variation in the fringe pattern when detected will indirectly prove the existence of gravitational waves! We choose the values of the wavelength λ , distance between the slits, d, and the distance between the source and screen, D, with such values that the variation in the fringe width, y say, becomes large enough to take a detectable value with variation in the value of slit separation, d.

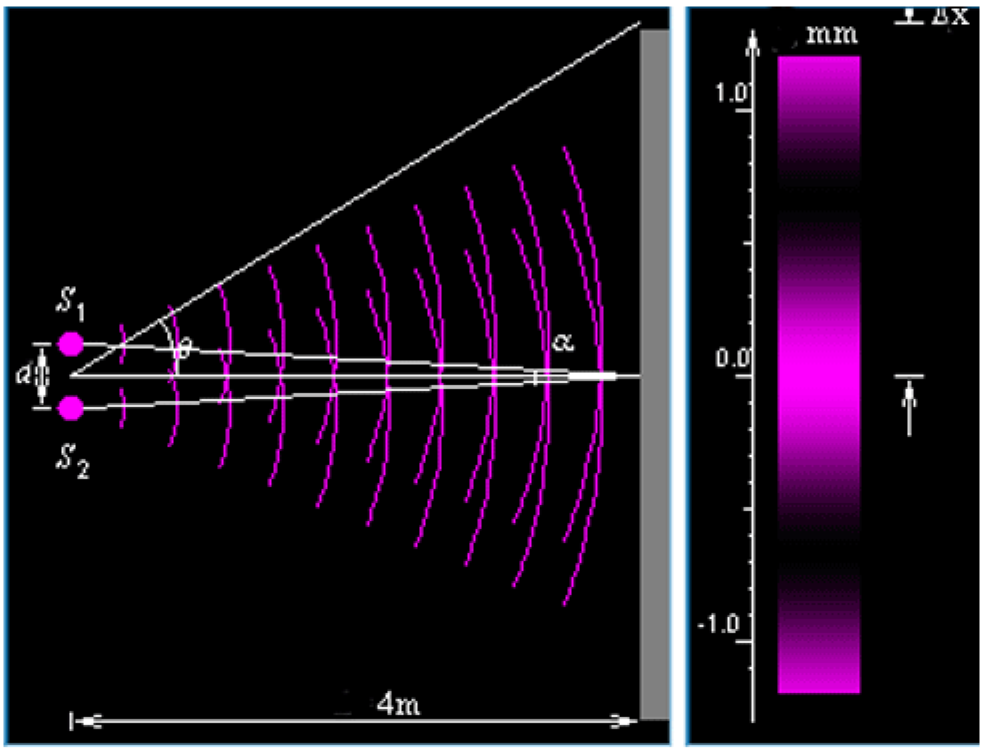
The double slit experiment due to Thomas Young can be illustrated as shown in the below given nice figure taken by courtesy of IB Physics Notes [8]:



One can easily derive an expression for the distance between successive fringes, the so called fringe width and can be found in any text book of optics and obtain following simple formula, namely,

$$y = \frac{\lambda D}{d} \tag{1}$$

The derivation basically makes use of the fact that for a bright fringe, constructive interference needs to occur, and so the path difference for light from the slits (acting as sources) needs to be a whole number of wavelengths. Similarly, for a dark fringe, destructive interference needs to occur, and so the path difference for light from the slits needs to be a half integer multiple of wavelengths. Now we suggest here to take following care during the experiment: (i) Try to have the value of *d* as much small as possible so that variation in the value of *d* on passing of gravitational waves will not be extraordinarily smaller than the value of *d* itself and, (ii) Choose $D >> d$, i.e. choose D very very large that *d*, so that we can bring the fringe width in centimeter range. In short, as depicted by equation (1), the separation between two successive fringes, y, depends upon the wavelength of the source λ , distance between the slits, d, and the distance between the source and screen, D. The effect of variation in the separation between two successive fringes, y, is very nicely demonstrated in the visual form by h2Physics.org [9]. To illustrate the main point of this paper I am going to make use of a figure in the part of the beautiful visual demonstration that shows effect of variation of *d* on y at courtesy of h2Physics.org. I request to see the link [9] given below to actually have a fill of the variation of various parameters appearing on the right side of equation (1) on the variation in fringe width.



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Email: dhananjay.p.mehendale@gmail.com