

Gravitational Waves

by Arnab Bordoloi - Monday, October 03, 2016

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The activities of the universe are truly mysterious. In its folds lie the knowledge of the past, the present and the course of the future. Science has always endeavored to unfold the true nature of our universe, and yet after centuries of human evolution we are to some extent unsuccessful but to a much greater extent successful. This degree of success reached a new magnitude of levitation on September 14, 2015 at 5:51 AM through the discovery of Gravitational Waves (G-Waves). Yes, one of the most remarkable discoveries of the 21st century can be attributed to the detection of Gravitational Waves or as they are better known as G-Waves.

These G-waves are curvatures of space and time which take place due to any increased speed of mass be it a "rail road train or a whirling galaxy" as explained by Stephen Hawking for Time in 1999. In layman's terms G waves are like ripples in the surface of time and space. **Albert Einstein**, undoubtedly the greatest physicist of all time, with his remarkable intuitive mind predicted the existence of G-waves, in his well known paper "Theory of Relativity" in 1916. However limited by the technology of his age, Einstein passed away before being given a concrete evidence of the existence of G-Waves.

Yet as time passed by, many other scientists investigated further for concrete evidence to prove the existence of these waves. One of the nearly successful attempts was made by **Joe Webber**. He declared in a summer of 1969 that he had finally detected G-Waves. However his readings were dismissed later due to the fact that other laboratories had built similar experimental set up and yet were not able to match his results.

The second pioneering step in the detection of G-waves was endeavored by **Rainer Weiss**, from MIT (Massachusetts Institute of Technology). He had a totally different concept in mind, he decided to build a detector by himself. However all by himself was not possible, and this is where **Kip Thorne** now an emeritus professor at Caltech comes into the picture. Weiss met Kip Thorne in a hotel room in Washington D.C. in 1975. Chatting for the entire night over a pipe of tobacco, the duo had realized that they had much similar train of thoughts. Back in their home states they started building the prototype for what later came to be known as **LIGO (Laser Interferometer Gravitational Wave Observatory)**. The construction was overseen by a Scottish physicist **Ronald Drever**.

Having completed the prototype, Weiss, Thorne and Drever approached the National Science Foundation (N.S.F) in 1990 to fund their project. However at those times G-Waves were considered a myth and for N.S.F to fund a 272 million dollar project upon a myth was too much. And the proposed design consisted some of the most sensitive measurement devices and techniques that had not been invented till then. Yet over many meetings and discussions the final nod from the N.S.F came in 1994. This was because of Rich Isaacson, a firm believer in G-waves and to set up a G-wave detector was his dream.

I cannot help but quote this beautiful line "*It took years for the most sensitive instrument on earth to come insensitive to everything else*". And yes, LIGO has got one of the most accurate and precision methods of

measurement till date. LIGO has got the purest vacuum space in earth. It had to be made insensitive to a weak cell phone signal ringing thousands of kilometers away. The lasers had to be made constant even to slightest variation in the power grid nearby. Above all obstacles LIGO was finally up and working in 2001. However as the LIGO team calls it the Initial LIGO, the first set up of LIGO was not able to detect any G- Waves. As a result it was taken down in 2010 for an advanced set of modifications now called the Advanced LIGO.

Now here is where the mysterious universe comes into play. To create a detectable set of G-Waves the cosmic activity taking place in the universe must be of “remarkable” nature, such as collision of black holes, or birth of new stars, etc. Such an event to take place in the observable area of the Initial LIGO was very rare i.e. 1 in 10,000. However the Advanced LIGO could cover a volume of space approximately 0.1x times larger than the initial LIGO. This made it much more prone to the happening of cosmic activities in the nearby space.

LIGO

There are two sites of the LIGO observatory, one in Louisiana and the other in Washington DC. Each LIGO observatory has two 4 km long vacuum tubes that are arranged perpendicular to each other. In each of this tube laser beams are passed through that are reflected back through mirrors. Einstein predicted that if G-waves pass through a body, the body would squeeze and stretch through space and time. The magnitude of squeeze and stretch is in the magnitude of one billionth of the diameter of an atom. Be it as may, if at all the G-waves squeeze and stretch any mass, this should also be the case for the lasers in LIGO. And this is exactly what happens, when any G-waves pass through the lasers, they produce an interference pattern that is detected in the observatory. This is how LIGO works.

No doubt the detection of gravitational is till now the most remarkable discovery of the century. The true potential as to what these waves can give us are yet to be fully determined. These G-waves are the language with which the universe talks with itself. Till now the scientists have always used light as the yardstick to study the universe. However now with the detection of G waves we have extended our limit of reach to much larger boundaries. These G-waves will now give us a much broader and deeper look into some of the most important phenomena of the universe such as black holes, birth and death of a star, etc.

With the detection of G-waves one of last and most important predictions of Einstein have been proved to come true. Weiss, Thorne and Drever are most likely to get a nod for the Nobel Prize in physics for their role in the detection of G-Waves. Yes, it is an agreed fact that our universe has a lot of things in its store that are yet to be discovered, but G-waves has set a new boundary to our limits of knowledge of the universe.

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