Gravitational waves

Gravitational waves are the wave like features of gravity's influence on spacetime. First hypothesized in 1916 by Albert Einstein on the basis of the theory that he created; general relativity. The move energy as gravitational radiation. The coming into being of the waves are a result of the Lorentz invariance of general relativity. This is because it brings the idea of finite speed of propagation in physical interactions. The consequence of such a thing is that gravitational waves cannot coexist with Newtonian theory, which says that physical interactions propagate at infinite speed.

Gravitational waves are able to be picked up by very sensitive instruments that have been build in specific places all over the world. They are built to be able to pick up the gravitational influence on objects around the universe. The most famous observatory one being the Advanced LIGO observatory in North America. Things that they are looking for are binary star systems. These systems being created with white dwarfs, black holes, and neutron stars.

General Relativity

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

In 1916 Albert Einstein created the theory of general relativity, which at its base was the theory of gravitational waves. These waves are a phenomenon coming from the curvature of spacetime. The curvature of the combination of space and time is created by the presence of mass. The idea is that the greater the mass in a certain volume is, results in the greater curvature of spacetime. Also as objects with mass move in spacetime, the distortion of the space around it will reflect the change in location of the objects. In some cases as objects accelerate the generate changes in the spacetime curvature. These changes then propagate away or outwards at the speed of light in a way that looks like a wave. These are gravitational waves.

When gravitational waves are generated, they move outward from the point of origin at the speed of light. These waves pass through things in spacetime, and distort it. If an observer were to look into this they would find that spacetime is distorted by the effects of strain. This allows the distance between objects to increase or decrease rhythmically as the gravitational waves move through it at a specific wave frequency. The magnitude of this effect will decrease in proportion to the inverse distance from the source. In other words, these waves have less of an influence over large distances.

Gravitational waves are able to penetrate regions of space that electromagnetic waves(EM) are not able to. One of the properties of EM are the varying wavelengths. One part

of which we can see as the visible spectrum. A region of the Electromagnetic Spectrum between, 390 and 700 Hz. So due to gravitational waves ability to do this, we are able to construct new images of the universe constructed purely of gravity. It allows us to see things that we might not be able to see with EM.

By studying these waves people would be able to tell with relative accuracy as to what was happening at a singularity(a point in space of infinite spacetime curvature). It is thought that these waves could exist at any frequency. But to detect very high or low frequencies of the waves would be impossible. Werner Israel and Stephen Hawking started to work on this idea and found detectable frequencies for gravitational waves. These ranging anywhere from 10^-7 to 10^11 Hz.

The detection of these waves came out to the public in february of 2016. The detection of these waves was astonishing and shook the world. Even more so it shook the universe in our perspective, because with that information, the last great mystery of Albert Einstein's concept; General Relativity, was proven. This discovery proved that Albert Einstein was correct in his equations with the relations of space time. The detection of these waves was from a source over 1 billion light years away. The source, GW150914, was of two black holes merging. The black holes are points of infinite density and spacetime warping. The perfect candidate to test the hypothesis given by Einstein.

The detection of gravitational waves was shown through the merging of two black holes. The process of this scenario is quite astonishing. Two black holes one about 36 times the mass of the sun and the other about 29 times started to orbit each other over 1 billion years ago. When they did, they were releasing energy and therefore losing mass and coming closer together. As the orbits begin to come closer to each other, they start to go around each other faster and faster. So incredibly fast that it literally rocked the fabric of space and time. The orbit was predicted to be around 250 revolutions per second. But the chaos created by that was nothing in comparison as to what was to come next.

As the black holes came closer and closer the interactions between them became more and more violent until they finally merged. The merging of these two objects was so incredible massive that LIGO was able to pick up such things from over 1 billion light years away. The energy output of the merge was $3.0^{+0.5}_{-0.5} M_{\odot} \times c^2$. The $M_{\odot}$ standing for solar mass. One solar mass is equal to the mass of the sun, or two nonillion kilograms or 2.20462262184877583e+30 lbs! The equation for such being now multiply that whole number by 2.5 to 3.5, give or take, and then multiply it by the speed of light squared. That is more than the energy of all the light energy of all the stars in the observable universe combined. I the energy emitted was in the form of gravitational waves. the .2 second merge released energy equal to 3.6x10^49 watts. this number to put into perspective is equal to the energy needed to power one home for, 39,517,014,270,030,000,000,000,000,000,000,000,000,000.00 years. That is 39,517 billion

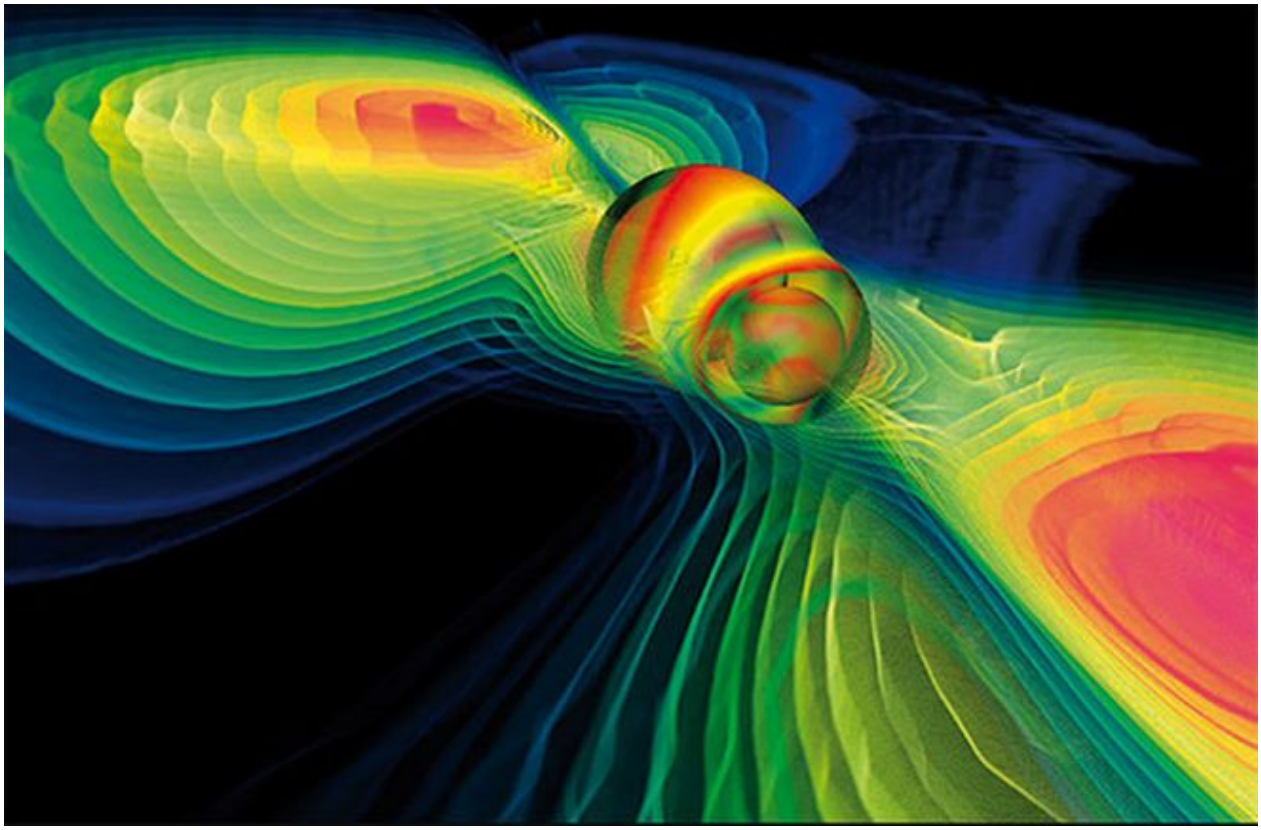
billion billion (3.9517×10^{40}) years and the universe has only existed for as little as 14 billion years.

Now the detection of these waves was from a very far away source. That means that the wavelength of the waves decrease over that distance. But even at the shift it was detectable, changing the length of a 4km(2.5 miles) long arm at LIGO by a 10,000th the width of a proton, it also happens to be proportional to the one hair width of change over the distance to the nearest star outside our own solar system.

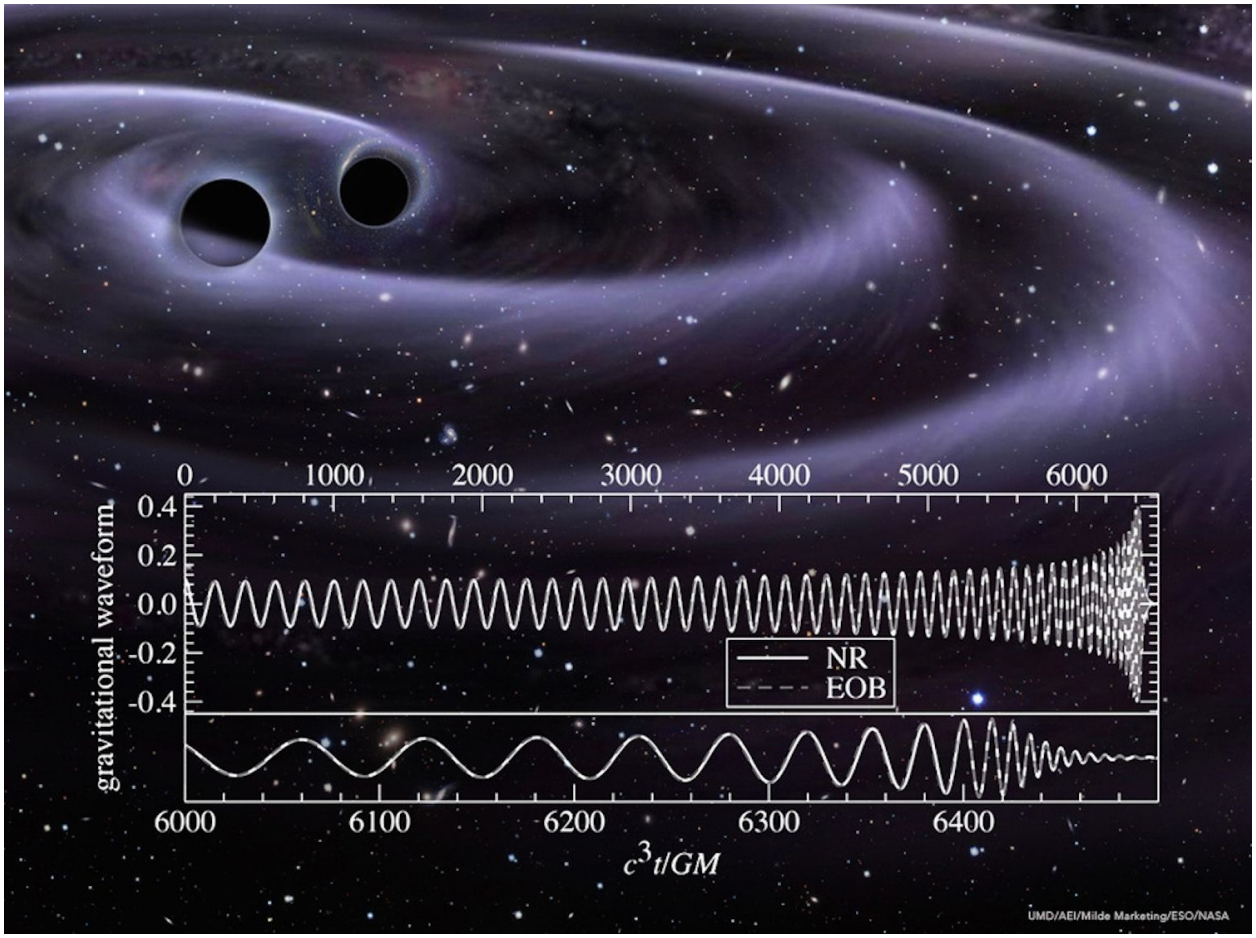
With the discovery of gravitational waves people will be able to push forward the exploration of deep space from the comfort of earth.

"LIGO Lab | Caltech | MIT." *LIGO Lab*. IPAC Communications & Education Team, n.d. Web. 12 Apr. 2016.
"Solar Mass." *Wikipedia*. Wikimedia Foundation, n.d. Web. 12 Apr. 2016.
"Gravitational Wave." *Wikipedia*. Wikimedia Foundation, n.d. Web. 12 Apr. 2016.

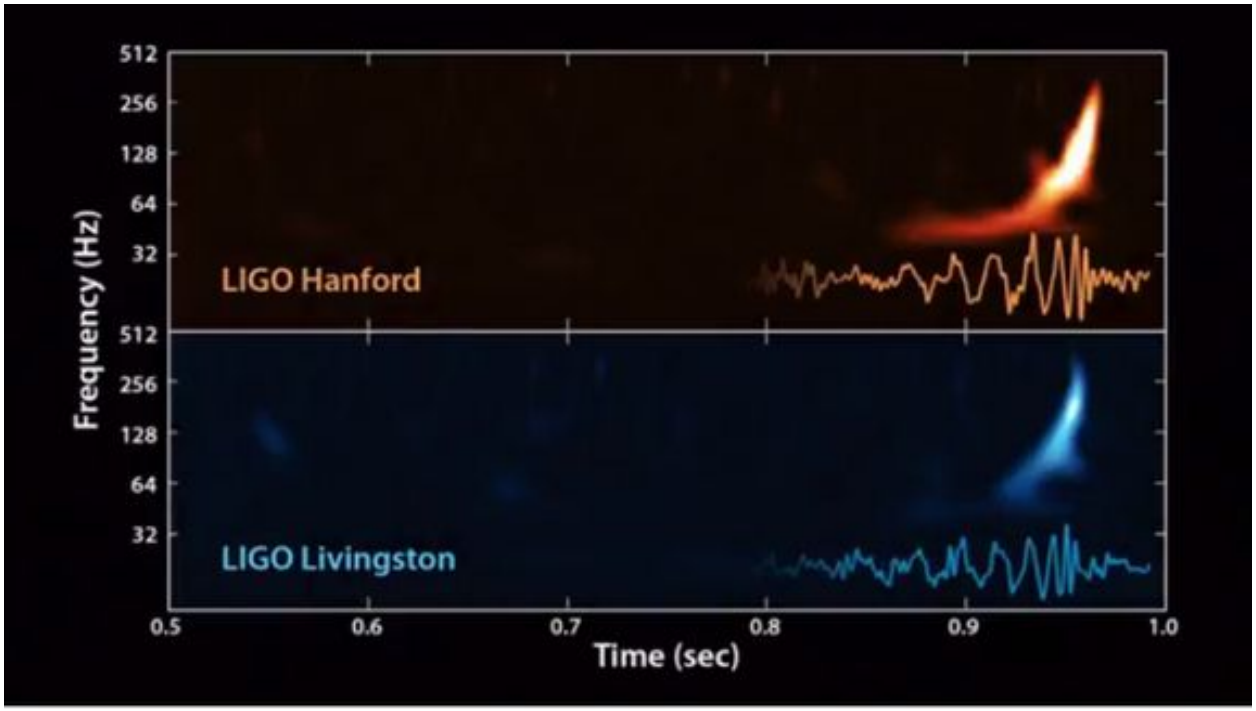
James Webb Space Telescope
http://www.sciencechannel.com/



http://www.space.com/images/i/000/053/219/original/gravitational-waves-simulation.jpg?interpolation=lanczos-none&fit=inside%7C660:*



http://motherboard-images.vice.com/content-images/article/30616/1455634740234656.jpg



http://www.space.com/images/i/000/053/180/i02/ligo-gravitational-waves-detection.jpg?1455206273?interpolation=lanczos-none&downsize=640:*