Journal of Physics and Astronomy

Opinion | Vol 10 Iss 12

The New Astronomy: Viewing the Cosmos through Light and Gravity

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Received date: 09-December-2022, Manuscript No. tspa-22-87104; **Editor assigned:** 15-December-2022, PreQC No. tspa-22-87104 (PQ); **Reviewed:** 17-December-2022, QC No. tspa-22-87104 (Q); **Revised:** 23-December-2022, Manuscript No. tspa-23-87104 (R); **Published:** 26-December-2022, DOI. 10.37532/2320-6756.2022.10(12).314

Abstract

Astronomers from all over the world learned about a spectacular collision of two stars in the distant past on a summer day in 2017. A group of astronomers from the Virgo and LIGO observatories transmitted the communication. In comparison to the telescopes we have used in the past to investigate the universe, these new observatories are considerably different. The gravitational wave observatories LIGO and Virgo watch out for subtle alterations in spacetime brought on by far-off black holes and neutron stars colliding. Astronomers identified the signal from the collision of two neutron stars, known as GW170817 that LIGO and Virgo discovered on August 17, 2017. A gamma-ray burst signal was picked up by NASA's Fermi satellite less than two seconds later, and within minutes, telescopes all around the world were scanning the sky. South American telescopes discovered the collision site in the far-off galaxy NGC 4993. Astronomers observed the galaxy and the waning light from the collision for the following weeks and months. This is a novel use of multi-messenger astronomy in which gravitational waves and light simultaneously observed the same event.

Keywords: Gravitation; Astronomy

Neutron Stars

Although it may seem as though the stars in the night sky have always existed, each star was actually formed as gravity brought together gas and dust in space. A newborn star shines brightly until its fuel supply runs out. White dwarf stars, which are the blazing remnants of the star's core, are the last state of small- and medium-sized stars like our Sun. During their spectacular demise, stars larger than our Sun explode as supernovae. A dense, dark core, such as a neutron star, is what remains after a supernova explosion. The remnant of a huge star's collapse that is exceedingly dense. A pulsar is a spinning neutron star with a strong magnetic field that periodically emits a radio pulse that travels toward the Earth. On Earth, radio telescopes may observe these pulses, which come in a continuous stream like a ticking clock. Binary neutron star systems, which consist of two neutron stars orbiting one another, have also been discovered by astronomers. Scientists intended to discover gravitational wave signals from some of these binary neutron star systems when they planned to build the new LIGO and Virgo gravitational wave detectors.

Citation: Andersan C. The New Astronomy: Viewing the Cosmos through Light and Gravity.2022;10(12):314.

Gravitational Waves

The Theory of General Relativity, a description of gravity that foretells black holes and curled spacetime, was first proposed by Albert Einstein more than a century ago. As a result of the acceleration of enormous objects like black holes and neutron stars, the theory also predicts the existence of gravitational waves, which are ripples in space and time that move at the speed of light. The first gravitational wave signal from the collision of two black holes in a distant galaxy was discovered in September 2015 by the National Science Foundation's Advanced LIGO detectors, which have recently undergone upgrades. The gravitational wave (GW) signal discovered on September 14 of 2015 inspired the event's designation as GW150914. Hanford, Washington and Livingston, Louisiana are the two U.S. locations for the Laser Interferometer Gravitational Wave Observatory (LIGO) detectors. In their initial two observing sessions from 2015 to 2017, they formed a network of gravitational wave observatories with the European Virgo detector in Italy. During these runs, the network discovered ten different gravitational wave signals from pairs of merging black holes. A new kind of signal, one that resulted from the collision of two neutron stars, was discovered by observatories in the northern hemisphere summer of 2017.

Gamma-Ray bursts

Gamma-rays even more energetic than X-rays is the highest energy light, sometimes referred to as electromagnetic radiation. Gamma-Ray Bursts (GRBs) were first identified by the Vela satellites in the middle of the 1960s. Later, astronomers discovered that these GRBs originated from space, but what could produce gamma-ray bursts with such great energy? Since then, one of the major difficulties in high-energy astrophysics has been identifying the sources of GRBs. Short-duration Gamma-Ray Bursts (sGRBs), which were first identified in 2005 as coming from a distant galaxy, may have been caused by the merging of a neutron star and a black hole or by the collision of two neutron stars. The neutron star collision that produced the GW170817 gravitational wave signal and the GRB detected by the NASA Fermi satellite on August 17, 2017, is one of these extremely distant events that is difficult to find, so it took new astronomy and the development of sensitive gravitational wave detectors to make this discovery. The neutron star collision that produced the GW170817 gravitational wave signal and the GRB detected by the NASA Fermi satellite on August 17, 2017, is one of these extremely distant events that is difficult to find, so it took new astronomy and the development of sensitive gravitational wave detectors to make this discovery.

A Multiple Messenger Finding

Gamma-ray burst signal GRB170817A was the subject of an automatic alert from NASA's Fermi satellite on August 17, 2017. The Hanford observatory almost simultaneously detected a gravitational wave signal, and it took the LIGO computers around 6 minutes to realize this. Two seconds before the gamma-ray burst signal, a gravitational wave signal that appeared to be the result of two neutron stars colliding was detected. After alerting astronomers worldwide, LIGO and Virgo researchers provided a map of the region of the sky that was most likely the source of the gravitational wave and gamma-ray burst signals.

This event, which was seen by both gravity waves and light, also known as electromagnetic waves, was the first gravitational wave multi-messenger discovery. By the time darkness fell, telescopes in South America were in a good position to look for light from the crash because it was afternoon in the Western Hemisphere at the time of the alert. Several telescopes discovered a brand-new brilliant source in the galaxy NGC 4993 during the first few hours of night. As the next event unfolded, telescopes all around the world focused on NGC 4993. A network of ground- and space-based telescopes and observatories investigated the first findings over the course of the following two weeks. Telescopes that could measure signals from ultraviolet, optical, and infrared light were used to conduct observations in all spectrums of light. The new source of light was identified by astronomers as a kilonova, a brilliant but brief event brought on by the collision of two neutron stars. With X-ray and radio telescopes, that region of the sky was monitored after the kilonova to learn more about the collision. Important details concerning the explosion's energy output, the material that was expelled, and the collision's environment were disclosed by these observations. These results confirmed the previously untested concept that heavy metals, including gold, can be produced by neutron star collisions. tiny, electrically neutral particle known as a neutrino. Observatories looked for high-energy neutrinos originating from the region of GW170817, but they were unsuccessful. The aim of multi-messenger astronomy is this. to find gravity waves, electromagnetic radiation, and neutrinos from the same cosmic event using electromagnetic, gravitational-wave, and astro-particle data combined. We now have proof that Einstein's theory that gravity waves and light waves move at the same speed, over millions of kilometres, was accurate because the gravitational wave and gamma-ray burst signals appeared at almost equal timings. High-energy neutrinos emanating from the region of GW170817 were sought after by neutrino observatories but were unsuccessful. The aim of multi-messenger astronomy is this to find gravity waves, electromagnetic radiation, and neutrinos from the same cosmic event using electromagnetic, gravitational-wave, and astro-particle data combined. We now have proof that Einstein's theory that gravity waves and light waves move at the same speed, over millions of kilometers, was accurate because the gravitational wave and gamma-ray burst signals appeared at almost equal timings.

The Fermi satellite discovered the gamma-ray burst and gravitational wave signal GW170817 on August 17, 2017, and it was the first time that gravitational waves and light from a single astronomical source had been seen together. Global astronomers were notified to look for light coming from the collision of two neutron stars by the gravitational wave observatories LIGO and Virgo. Astronomers monitored and recorded the fading light from the impact over the ensuing weeks and months after telescopes located the event's location in a far-off galaxy. In a new era of multi-messenger astronomy, this event marks the first time the same event was witnessed by gravity waves as well as light, demonstrating how crucial it is for astronomers to collaborate in order to create novel and interesting discoveries.